

Closure of the procedure in respect of application No. 08741668.1 - 1221

29.09.18

1. The procedure in respect of the above application is closed for the following reason:

ADWI 11/29.06.18 The time limit under Rule 112(2) EPC has expired.
No request for a decision under Rule 112(2), or for further processing under Article 121 EPC or for re-establishment of rights under Article 122 EPC has been filed.

2. The EPASYS situation has been verified in respect of item 1:

DFIL: 25.04.08

NOAP: ///

RDEC: ///

RFPR: 16.05.12/16.05.12/3

REES: ///

REFU 3/ADWI 3 and DEAD 1 coded. Date of legal effect 29.05.18

3. Position regarding fees:

DEST03	005	00798669	04.11.09	EUR	500,00
EXAM02	006	00798669	04.11.09	EUR	626,00
FFEE01	020	00798669	04.11.09	EUR	100,00
RFEE 03	033	00624276	26.03.10	EUR	400,00
RFEE 04	034	00671995	21.04.11	EUR	525,00
RFEE 05	035	00645324	23.03.12	EUR	735,00
RFEE 06	036	00709013	22.04.13	EUR	995,00
RFEE 07	037	00701833	25.03.14	EUR	1 105,00
RFEE 08	038	00772297	21.04.15	EUR	1 265,00
RFEE 09	039	00728060	29.03.16	EUR	1 380,00
RFEE 10	040	00794394	21.04.17	EUR	1 575,00
RFPR02	122	00167714	16.05.12	EUR	240,00

☒ Examination started on _____ (EXDS51).

☐ Refund(s) ordered:

☐ 100% EXAM fee**

☐ 75% EXAM fee**

☐ 50% EXAM fee**

☐ DEST fee*

☐ RFEE(s): _____

☐ Other fees: _____

Note: Attention is to be paid to potential automated refund proposal(s).

* Refund of DEST fee if date of legal effect is before/on SEPU or PACT6 date.

** PLEASE REVIEW REFUND OF EXAMINATION FEE (100% or 75% or 50%)

4. Mark "DEAD" on the paper file and:

☐ Check whether a divisional application is pending and if so attach the DEAD file to it.

☐ Any **models** still in the Office's possession were returned on _____
(for dealing with models, please refer to Fil d'Ariane).

☒ Keep paper file in file store (separate place) until next action for file destruction.

08.10.2018

Date

Kellner, Alexandra

Formalities Officer

Questions about this communication ?

Contact Customer Services at www.epo.org/contact



V.O.
P.O. Box 87930
2508 DH Den Haag
PAYS-BAS

Date

29.06.2018

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1221 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor toegepast- natuurwetenschappelijk onderzoek TNO	

Noting of loss of rights pursuant to Rule 112(1) EPC

The European patent application is deemed to be withdrawn under Article 94(4) EPC, because the invitation to file observations on the communication from the Examining Division dated 17.11.17 was not complied with.

Means of redress

Request for a decision (R. 112(2) EPC)

If the applicant considers that the finding of the European Patent Office is inaccurate, he may, within a (non-extendable) period of **two months** after notification of this communication, apply in writing for a decision on the matter. The application can only lead to the finding being reversed if this does not actually correspond to the factual or legal situation.

Further processing (Art. 121 EPC)

The legal consequence of the failure to observe the time limit shall be deemed not to have ensued if, within a (non-extendable) period of **two months** after notification of this communication, further processing is requested by payment of the fee prescribed under Article 2(1)12 of the Rules relating to Fees and the omitted act is completed (R. 135(1) EPC).

Making payments

For payments made via deposit account, please note that as from 1 December 2017 debit orders will only be carried out if filed in an electronically processable format (xml), using an accepted means of filing as laid down in the Arrangements for deposit accounts (ADA), published in the Supplementary publication in the Official Journal.

All relevant information related to the modes of payment of fees to the EPO can be retrieved from the EPO website at **"Making Payments"**.

Information concerning fee amounts

Procedural fees are usually adjusted every two years, on even years, with effect from 1 April. Therefore, before making a payment, parties should verify the amounts actually due on the date of payment using the applicable version of the Schedule of fees and expenses, published as a Supplement to the Official Journal of the EPO, available on the EPO website (www.epo.org) at www.epo.org/schedule-of-fees. The "Schedule of fees" table allows the viewing, downloading and searching of individual fee amounts, both current and previous.

Important note to users of the automatic debiting procedure

The fee for further processing will be debited automatically on the day on which the above-mentioned omitted act is completed.

For the Examining Division

Questions about this communication ?

Contact Customer Services at www.epo.org/contact



V.O.
P.O. Box 87930
2508 DH Den Haag
PAYS-BAS

Date

05.06.18

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1221 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor toegepast- natuurwetenschappelijk onderzoek TNO	

**Notice drawing attention to Rule 51(2) EPC, Article 2 No. 5 of the Rules relating to Fees,
- Payment of the renewal fee plus additional fee -**

The renewal fee for the 11. year fell due on 30.04.18 unless this date falls within the period covered by an interruption of the proceedings in accordance with Rule 142(1) EPC, or a request for re-establishment of rights is pending (Art. 122, R. 51(4) EPC).

The current rate of the renewal fee amounts to **EUR 1575,00** (see current Schedule of fees and costs).

The renewal fee was not paid by the due date.

The renewal fee may still be validly paid **up to the last day of the sixth calendar month** following the due date, provided that the additional fee (50% of the renewal fee) is paid at the same time, see OJ EPO 2008, 5.

Within the above period, which cannot be extended, the following fees are to be paid:

Renewal fee for the 11. year:	EUR	1575,00
Additional fee:	EUR	787,50

TOTAL AMOUNT	EUR	2.362,50

If the renewal fee and the additional fee are not paid in due time, the European patent application shall be deemed to be withdrawn (Art. 86(1) EPC).

Note to users of the automatic debiting procedure

The basic time limit for payment of the above renewal fee had already expired when the automatic debit order was received. The renewal fee and the surcharge will be debited automatically on the last day of the six-month period.

Making payments

For payments made via deposit account, please note that as from 1 December 2017 debit orders will only be carried out if filed in an electronically processable format (xml), using an accepted means of filing as laid down in the Arrangements for deposit accounts (ADA), published in the Supplementary publication in the Official Journal.

All relevant information related to the modes of payment of fees to the EPO can be retrieved from the EPO website at **"Making Payments"**.

Information concerning fee amounts

Procedural fees are usually adjusted every two years, on even years, with effect from 1 April. Therefore, before making a payment, parties should verify the amounts actually due on the date of payment using the applicable version of the Schedule of fees and expenses, published as a Supplement to the Official Journal of the EPO, available on the EPO website (www.epo.org) at www.epo.org/schedule-of-fees. The "Schedule of fees" table allows the viewing, downloading and searching of individual fee amounts, both current and previous.

Important information in case of a PACE request

If, for an application being processed under the PACE programme the payment of the renewal fee has not been received by the due date stipulated in Rule 51(1) EPC, the accelerated prosecution of the application is suspended until the payment of the renewal fee with additional fee has been received (see OJ EPO 2015, A93, point 5).

For the Examining Division

Questions about this communication ?

Contact Customer Services at www.epo.org/contact



V.O.
P.O. Box 87930
2508 DH Den Haag
PAYS-BAS

Date

29.03.18

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1221 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor toegepast- natuurwetenschappelijk onderzoek TNO	

Extension of time limit pursuant to Rule 132(2) EPC

Examination procedure

With reference to your request, the time limit for replying to the communication pursuant to Article 94(3) EPC dated 17.11.17 has been extended

by 2 months

to a total of 6 months

from the date of notification of the above-mentioned communication.

Please note: To the extent that your request exceeded the above extension, your request has been refused.

Note

The granting of extensions to time limits is governed by the Implementing Regulations to the EPC and the Guidelines for Examination in the EPO, E-VIII, 1.6. A request for extension, which would result in the total period set exceeding six months, must be reasoned and supported by evidence.

If no reply to the communication is received in due time, the European patent application will be deemed to be withdrawn (Art. 94(4) EPC).

Important information in case of a PACE request

If a PACE request has been validly filed for the application, the applicant is herewith informed that with the grant of the request for extension of time limit the application is removed from the PACE programme. A second PACE request for that application during the same stage of the procedure will not be processed (see OJ EPO 2015, A93, point 4).

For the Examining Division

Acknowledgement of receipt

We hereby acknowledge receipt of the following subsequently filed document(s):

Submission number	6171839	
Application number	EP08741668.1	
Date of receipt	23 March 2018	
Receiving Office	European Patent Office, The Hague	
Your reference	P81166EP20	
Applicant	All applicants as on file	
Documents submitted	package-data.xml epf1038.pdf (1 p.)	ep-sfd-request.xml EXRE92-1.pdf\P81166EP20 Request for extension.pdf (1 p.)
Submitted by	CN=Laurens de Haas 34459	
Method of submission	Online	
Date and time receipt generated	23 March 2018, 17:37 (CET)	
Message Digest	67:2D:30:E4:66:53:D3:2E:43:F8:0F:AD:0E:A7:69:F8:73:F7:39:EC	

Correction by the EPO of errors in debit instructions filed by eOLF

Errors in debit instructions filed by eOLF that are caused by the editing of Form 1038E entries or the continued use of outdated software (all forms) may be corrected automatically by the EPO, leaving the payment date unchanged (see decision T 152/82, OJ EPO 1984, 301 and point 6.3 ff ADA, Supplement to OJ EPO 10/2007).

/European Patent Office/



Letter accompanying subsequently filed items

Representative:

V.O.

106850

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Germany

Tel. +49(0)30 25901-0 | Fax -840

The document(s) listed below is (are) subsequently filed documents pertaining to the following application:

Application number

08741668.1

Applicant's or representative's reference

P81166EP20

	Description of document	Original file name	Assigned file name
1	Request for extension of time limit during examination procedure	P81166EP20 Request for extension.pdf	EXRE92-1.pdf

	Payment	
1	Method of payment	Not specified

Annotations

deposit-account(V.O.; 23.03.2018)

1. Remark(Annotate)

I herewith authorize the European Patent Office to deduct all necessary fees that are involved in this specific action from my deposit-account
No. 2809.0002

Signatures

Place: 's-Gravenhage
Date: 23 March 2018
Signed by: /L.J. de Haas/
Association: V.O.
Representative name: L.J. de Haas
Capacity: (Representative)

P81166EP20

European Patent Office
D-80298 München
Germany

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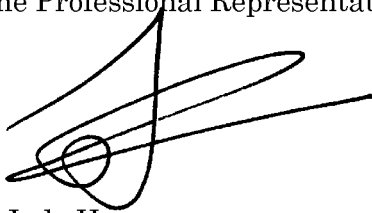
Your ref. 08741668.1/1879
Our ref. P81166EP20

The Hague,
23 March 2018

Re.: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast-
natuurwetenschappelijk onderzoek TNO

I herewith request you to grant me a two months' extension of time for filing my
observations to your Communication dated 17 November 2017.

The Professional Representative,



L.J. de Haas

The examination is being carried out on the **following application documents**

Description, Pages

1-10 as originally filed

Claims, Numbers

1-14 received on 18-05-2012 with letter of 16-05-2012

Drawings, Sheets

1 as originally filed

1. In independent claim 1, the amendment "for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters" relates to the mentioned "classifier in a machine learning system".

It is not limiting the scope of protection to a step of "classifying physical objects based on feature data [...] by the classifier under the control of the hyperparameters [...]" The mentioned "machine learning system" is any physical entity suitable for carrying out such a classification. This is in line with the indication, in dependent claim 10, of limiting steps for "- obtaining feature data from the objects - classifying the physical objects based on the feature data, under the control of the hyper parameters".

As a result, claim 1 is still directed to abstract activities ("drawing a random sample of [...] vectors [...] updating the estimate of [...] vectors [...] computing results [...] defined by a function producing a [...] value based upon [...] vector [...] selecting [...] a [...] vector [...]") performed in relation to "hyperparameters of a classifier", *i.e.* abstract entities of a learning model, with the sole technical limitation that the model is implemented as/in a system.

The other amendment "computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector" is not defining additional technical limitations on the scope of protection.

The examining division maintains the objections raised under **Art. 56 EPC**, in points **6-8** of the first communication dated 19-07-2011: the feature distinguishing claim 1 from the disclosure in **D4** can only be seen to contribute to solving (with known technical means, "a machine learning system") a non-technical problem.

2. In a letter dated 16-05-2012, the applicant explains that:

- "Many of the objections appear to be due to the fact that the examiner is unsatisfied because the application gives no detailed examples of technical use of the invention. Applicant agrees that more detailed examples would have been convenient, but they are not strictly necessary. The application describes the application field of classification of physical objects based on feature data obtained from these objects [...] This form of classification has been known for at least half a century and forms part of the basic knowledge in the art of pattern recognition, and certainly of the common general knowledge in that field. For this reason the application field is clearly disclosed, even though it is agreed that a more detailed description could have been more convenient" (cf. page 2)
- "The application mentions an example of use to make a distinction between ripe fruit from unripe fruit. But for the definition of this invention it is not essential what is classified" (cf. page 5)
- "a classifier as defined by amended claim 1 is not in a field excluded from patentability. The classifier produces effects that are not limited to the normal effects of a computer: it receives feature data obtained from physical objects and uses this data to classify the objects [...] Classifiers are in the field of automatic pattern recognition (recognition of data) [...] in which many European patents have been granted" (cf. page 8)
- "The contribution to the art of the present invention is that it enables more accurate machine classification of physical objects based on feature data obtained from this object, by providing an improved way to adapt hyperparameters" (cf. page 3)
- "the present invention provides a solution to the problem of achieving improved classification accuracy by determining hyperparameters, even when the hyperparameters are not continuous and their effects are not transparent [...] The solution of this problem has an effect on the classifier: it produces a more accurate classifier" (cf. page 7)

We maintain that the scope of claim 1 has not been limited by amendment to a step of classifying physical objects (nor obtaining feature data from such objects).

Amended claim 1 is directed to determining hyperparameters of a classifier where, according to the applicant, "In the present case, a hyperparameter of a classifier is a parameter of the classifier that is not a parameter of the pattern that is classified (see page 1 line 11-13 of the application)" (cf. page 4; while the classifier is "common general knowledge": see above).

As such, the alleged effect in "improved classification accuracy" is not supporting an inventive step within the sense of **Art. 56 EPC**.

3. As already noted in point **1**, the missing steps are indicated in dependent claim 10. However, its scope of protection covers any possible kind of "physical objects" (or "feature data" extracted from them), and there is no definition in claim 10 of classes (*i.e.* their interpretation) that would correspond to "classifying the physical objects based on the feature data".

As a result, the classification of *e.g.* a dress as beautiful, does fall within the terms of claim 10, which can only be seen to solve (with known technical means, *i.e.* the computer/s implementing the claimed method) a non-technical problem. Claim 10 is not inventive over the disclosure in **D4**. (**Art. 56 EPC**)

4. Insofar as the applicant does not consider as essential (see above) the embodiment relating to classification of fruits as ripe or unripe, based on their color and size obtained from image data, it cannot support a technical effect associated with a technical problem. However, as acknowledged by the applicant, there is not more detailed examples of technical use in the description. The examining division is willing to give an additional opportunity to the applicant, before issuing summons for oral proceedings, to reconsider limiting an amended claim 1 to said embodiment.

If the applicant decides to file such an amended claim 1, he is expected to submit convincing argument as to why "selecting [...] a hyperparameter vector producing the best result in the present and any previous iterations" would not be obvious over "selecting [...] a hyperparameter vector producing the best result in the present invention" as disclosed in **D4**. Considering that using a memory of the selected vectors and their results is straightforward to implement for a person skilled in computer science, the applicant may want to further limit the scope of protection to a specific "updating" step and/or "classifier" that would not be obvious from the disclosure in **D4**.

If after reviewing the objections raised so far in the procedure, the applicant would like to discuss the case over the phone, the primary examiner would be happy to oblige.

The preceding analysis is only made for assisting the applicant in his decision on how to proceed. It in no way precludes consideration of alternative solutions submitted by the applicant. The responsibility for determining the text of the application and in particular for defining the subject-matter for which protection is sought remains with the applicant (Art. 113(2) EPC).

In case the applicant submits such an amended claim 1 with convincing arguments towards inventiveness, he is expected to bring the description into conformity with the amended claims, in particular by deleting any statement throwing doubt on the scope of protection by directly contradicting features of the amended claims.

5. In the description, documents **D3** and **D4** have already been acknowledged. In view of the explanation given in page 2 of the description, that **D4** would not use the cross-entropy method (abbrev. CE) but a simple grid search for determining hyperparameters, reference is further made to the following documents (copies are annexed to the present communication)

D5: Pai, Hong; Software reliability forecasting by support vector machines with simulated annealing algorithms; The Journal of Systems and Software, vol. 79, pp. 747-755; pub. in 2006; sent as XP005419659;

D6: Pai, Hong; Forecasting regional electricity load based on recurrent support vector machines with genetic algorithms; Electric Power Systems Research, vol. 74, pp. 417-425; pub. in 2005; sent as XP004877818;

D7: Friedrichs, Igel; Evolutionary tuning of multiple SVM parameters; Neurocomputing, vol. 64, pp. 107-117; pub. in 2005; sent as XP004804784;

D8: Guo et al; PSO-based hyper-parameters selection for LS-SVM classifiers; LNCS, vol. 4233, pp. 1138-1147; pub. in 2006; sent as XP019046533.

Every document discloses determining hyperparameters of a classifier (SVM) by simulated annealing (SA, in **D5**) or evolutionary computing (GA, ES, PSO in **D6-D8**) instead of a grid search.

All these randomized methods are well-known alternative to CE, as taught in the tutorial **D3** (cf. page 20), involving *inter alia* drawing random samples, updating estimates and selecting best candidates as currently claimed in generic terms.

As already noted in point **4**, the applicant may want to further limit the scope of protection to a specific "updating" step and/or "classifier" that would not be obvious from the disclosure in **D5-D8**.

6. The preceding notwithstanding, the applicant declines providing copies of **ref1** and **ref2**, authored by the inventor designated for the present invention, and disagrees with the finding of point **12** of the first communication that their disclosure were available to the public before the claimed priority date of 09-07-2007 (document **prioB**). Insofar as the distinguishing feature discussed in relation to **D4** is one which is not directly and unambiguously derivable from the priority

Datum
Date 17.11.2017
Date

Blatt
Sheet 5
Feuille

Anmelde-Nr:
Application No: 08 741 668.1
Demande n°:

document **prioA** (filed 25-04-2007), it would be relevant to check the disclosure in **ref1** and **ref2**. Since the examiner cannot look into this matter, the reasoning made in points **14-17** of the first communication is set aside; the public having been informed of the existence of such disclosure.



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Substantive Examiner
Name: Douarche, Nicolas
Tel: +31 70 340 - 4636

Application No. 08 741 668.1 - 1879	Ref. P81166EP20	Date 17.11.2017
Applicant Nederlandse Organisatie voor toegepast- natuurwetenschappelijk onderzoek TNO		

Communication pursuant to Article 94(3) EPC

The examination of the above-identified application has revealed that it does not meet the requirements of the European Patent Convention for the reasons enclosed herewith. If the deficiencies indicated are not rectified the application may be refused pursuant to Article 97(2) EPC.

You are invited to file your observations and insofar as the deficiencies are such as to be rectifiable, to correct the indicated deficiencies within a period

of 4 months

from the notification of this communication, this period being computed in accordance with Rules 126(2) and 131(2) and (4) EPC. One set of amendments to the description, claims and drawings is to be filed within the said period on separate sheets (R. 50(1) EPC).

If filing amendments, you must identify them and indicate the basis for them in the application as filed. Failure to meet either requirement may lead to a communication from the Examining Division requesting that you correct this deficiency (R. 137(4) EPC).

Failure to comply with this invitation in due time will result in the application being deemed to be withdrawn (Art. 94(4) EPC).



Douarche, Nicolas
Primary Examiner
For the Examining Division

Enclosure(s): 5 page/s reasons (Form 2906)
XP005419659, XP004877818, XP004804784, XP019046533

Questions about this communication ?

Contact Customer Services at www.epo.org/contact



V.O.
P.O. Box 87930
2508 DH Den Haag
PAYS-BAS

Date
08.10.15

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1951 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor toegepast- natuurwetenschappelijk onderzoek TNO	

Communication of amended entries concerning the representative (R. 143(1)(h) EPC)

As requested, for the above-mentioned European patent application / European patent the entries concerning the representative have been amended as follows:

V.O.
P.O. Box 87930
2508 DH Den Haag
NL

The amendment will be recorded in the Register of European Patents.

For the Examining Division





European Patent Office
D-80298 München
Germany

Attn. Mrs. Claudia Weber

fax +49 89 2399 4465

Versenigde Octrooibureaux N.V.
Carnegieplein 5
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2508 DH The Hague
The Netherlands

Telephone +31 70 416 67 11
Telefax +31 70 416 67 99

NL_EP_PCT_patents@vo.eu

www.vo.eu

Your ref.
Our ref. RvE/E100EPEP

The Hague,
29 September 2015

Re.: Registration of the Association and change of address

Please exclusively use the registration of our Association V.O. No. 106850 solely for all our cases.

All correspondence is to be headed to :

V.O.
P.O. Box 87930
2508 DH Den Haag
the Netherlands

The professional representative,

A handwritten signature in black ink, appearing to be 'C.M. Jansen'. The signature is written in a cursive, somewhat stylized manner with a large loop at the end.

C.M. Jansen

Questions about this communication ?

Contact Customer Services at www.epo.org/contact



Hatzmann, Martin
V.O.
Johan de Wittlaan 7
2517 JR Den Haag
PAYS-BAS

Date

18.03.15

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1951 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor toegepast- natuurwetenschappelijk onderzoek TNO	

C o m m u n i c a t i o n

concerning the registration of amendments relating to

☐ a transfer (R. 22 and 85 EPC)

☒ entries pertaining to the applicant / the proprietor (R. 143(1)(f) EPC)

As requested, the entries pertaining to the applicant of the above-mentioned European patent application / to the proprietor of the above-mentioned European patent have been amended to the following:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV
MC MT NL NO PL PT RO SE SI SK TR
Nederlandse Organisatie voor toegepast-
natuurwetenschappelijk onderzoek TNO
Anna van Buerenplein 1
2595 DA 's-Gravenhage/NL

The registration of the changes has taken effect on 09.03.15.

In the case of a published application / a patent, the change will be recorded in the Register of European Patents and published in the European Patent Bulletin (Section I.12 / II.12).

Your attention is drawn to the fact that, in the case of the registration of a transfer, any automatic debit order only ceases to be effective from the date of its express revocation (cf. point 14(c) of the Arrangements for the automatic debiting procedure, Supplementary publication 4 - OJ EPO 2014).

Receiving Section / For the Examining Division / For the Opposition Division / For the Legal Division *)



*) See note.

Note

This communication is issued by/for the department with whom responsibility lies. The Legal Division is responsible for the registration of transfers, changes of name (Articles 71, 72 and 74 EPC and Rules 22 and 85 EPC) as well as for the rectification of the designation of the inventor (Rule 21 EPC) (see Decision of the President of the EPO, OJ EPO 2013, 600). In all other cases, the Receiving Section, the Examining Division or the Opposition Division is responsible, depending on the stage in proceedings.

The Hague • Groningen • Arnhem • 's-Hertogenbosch
Amersfoort • Eindhoven • Munich • Regensburg • Leuven



Patents & Trademarks

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Your ref.
Our ref. ADOV/E603146NL62

The Hague,
12 March 2015

Re.: European patent applications in the name of
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO

Dear Ms Weber,

I refer to my letter of 9 March 2015 regarding the change of address of the applicant for **426** (correct number) European patent applications.

I also refer to your telephone conversation of today with Marijke Groenendaal of my firm. I herewith confirm that the change of address can be recorded for **all live** European patent applications (and patents still within the opposition period or pending opposition proceedings) in which this party is (co-)applicant.

I re-confirm the correct spelling of the name and address of the applicant:

Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO
Anna van Buerenplein 1
2595 DA 's-Gravenhage
The Netherlands

I would ask you to record the correct spelling of the name and the new address for all the pertinent applications/patents and to inform me of the recordal as soon as possible. Kindly send me a list of the amended cases which I can forward to my client.

IN VIEW OF THE FACT THAT THE GRANT OF SOME CASES IS IMMINENT, I WOULD KINDLY ASK YOU TO HANDLE THIS RECORDAL WITH URGENCY.

Please acknowledge receipt of this letter with enclosure.

The professional representative,

C.M. Jansen

The Hague • Groningen • Arnhem • 's-Hertogenbosch
Amersfoort • Eindhoven • Munich • Regensburg • Leuven



Patents & Trademarks

European Patent Office
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Your ref.
Our ref. ADOV/E603146NL62

The Hague,
9 March 2015

Re.: European patent applications indicated on the attached list (462x) in the name of
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO

I herewith inform you that the address of the applicant has changed into :

Anna van Buerenplein 1
2595 DA 's-Gravenhage
The Netherlands

I would ask you to record this change for the cases mentioned on the attached list and to inform me of the recordal as soon as possible.

**IN VIEW OF THE FACT THAT THE GRANT OF SOME CASES IS IMMINENT, I
WOULD KINDLY ASK YOU TO HANDLE THIS RECORDAL WITH URGENCY.**

Please acknowledge receipt of this letter with enclosure.

The professional representative,

A handwritten signature in black ink, appearing to read 'C.M. Jansen', written over a horizontal line.

C.M. Jansen

Encl.:
(x) list of cases (9 pp.)

P782EP

VO ref E603146NL62

European patent applications in the name of
Nederlandse Organisatie voor
toegepast-natuurwetenschappelijk onderzoek TNO;
change of address into
Anna van Buurenplein 1
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	P64176EP10	02-04-2001	01943217.8		
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325	P96588EP10	04-06-2013	13732646.8		
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335	P101787EP00	27-08-2013	13181805.6		
	P98524EP10	29-08-2013	13759873.6		
	P101896EP00	30-08-2013	13182479.9		

VO ref E603146NL62

European patent applications in the name of
Nederlandse Organisatie voor
toegepast-natuurwetenschappelijk onderzoek TNO;
change of address into
Anna van Buerenplein 1
2595 DA 's-Gravenhage
The Netherlands

09-03-2015

	case_number	appl_date	appl_no	reg_date	reg_no
	P102228EP00	30-08-2013	13182352.8		
	P102018EP00	04-09-2013	13183009.3		
	P102624EP00	04-09-2013	13182992.1		
340	P100088EP10	10-09-2013	13770716.2		
	P101909EP00	13-09-2013	13184246.0		
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345	P102213EP00	10-10-2013	13188129.4		
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350	P102543EP00	29-11-2013	13195144.4		
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355	P101962EP00	16-12-2013	13197479.2		
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360	P103307EP00	03-02-2014	14153717.5		
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	P102636EP00	18-02-2014	14155552.4		
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370	P103550EP00	31-03-2014	14162671.3		
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375	P104523EP00	04-04-2014	14163621.7		
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380	P102512EP00	28-04-2014	14166220.5		
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	P104012EP00	01-05-2014	14166794.9		
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VO ref E603146NL62

European patent applications in the name of
 Nederlandse Organisatie voor
 toegepast-natuurwetenschappelijk onderzoek TNO;
 change of address into
 Anna van Buerenplein 1
 2595 DA 's-Gravenhage
 The Netherlands

09-03-2015

	case_number	appl_date	appl_no	reg_date	reg_no
385	P104159EP00	01-05-2014	14166797.2		
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395	P104684EP00	25-06-2014	14173878.1		
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400	P105015EP00	09-07-2014	14176373.0		
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405	P105875EP00	15-08-2014	14181142.2		
	P105171EP00	02-09-2014	14183276.6		
	P104545EP00	05-09-2014	14183814.4		
	P105646EP00	22-09-2014	14185727.6		
	P105302EP00	30-09-2014	14187098.0		
410	P105600EP00	06-10-2014	14187831.4		
	P105354EP00	29-10-2014	14190858.2		
	P105598EP00	30-10-2014	14191075.2		
	P104822EP00	13-11-2014	14192989.3		
	P106106EP00	19-11-2014	14193835.7		
415	P105627EP00	20-11-2014	14194062.7		
	P105726EP00	16-12-2014	14198191.0		
	P105942EP00	17-12-2014	14198615.8		
	P104535EP00	18-12-2014	14198901.2		
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420	P104112EP00	23-12-2014	14200183.3		
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425	P107500EP00	19-02-2015	15155829.3		
	P107500EP01	20-02-2015	15156027.3		

08741668.1 - 1951 / 2156377

23.04.13

Client Database System (CDS) - clean up.

Application Nr.: 08741668.1

Following clean up action in CDS the entries concerning the **Representative for the applicant** have been amended and are now as follows:

Hatzmann, Martin
V.O.
Johan de Wittlaan 7
2517 JR Den Haag
NL

Where appropriate, the Register of European Patents will be updated to show the amended details.

For questions please contact the Client Data Registration department of the European Patent Office in Munich, telephone +49 (0)89 2399 2780.

EPO - Munich
11
02. April 2013



European Patent Office
Dir. 523
Legal Division
Patent Administration
D-80298 Munich
Germany

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⇒ CDR (GDS erl!)

Your ref.

Our ref. NM/change of name

26 March 2013

Re: Request for recording a change in name of representative

I herewith inform you that as of **2 April 2013** the name of our firm shall be V.O.
instead of Vereenigde. Consequently, our new name and address details are as follows:

5 Jansen, Ir. C.M.
V.O.
Johan de Wittlaan 7
2517 JR Den Haag
The Netherlands

10

Telephone No.: + 31 70 416 67 11

Facsimile No.: +31 70 416 67 99

E-mail: patent@vo.eu

- 15 The list of additional representatives belonging to our firm is enclosed herewith.
I would herewith kindly request you to amend your registers accordingly so that the
current name of our firm, Vereenigde, will be changed into our new name, V.O.

Σ
FREP
E3, 10 / cdk.

Page 2
Your ref.
Our ref. NM/change of name
Date 26 March 2013

Patents • Trademarks • Designs



Furthermore, could you please forward this information to your Certification and Validation Unit (CVU), attn.. Mr. Eric Bihl, for linking our files to our new company name.

5

Please acknowledge receipt of this letter by facsimile or e-mail and do not hesitate to contact us in case you require any further information. Ms. Natascha van Mill from our firm is handling this matter and she can be reached by e-mail,

n.vanmill@vereenigde.com, telephone +31 70 416 68 03, or fax +31-70 416-67-99.

10

The professional representative,

C.M. Jansen

SUPPLEMENTARY SHEET

Weiterer Vertreter – Additional representatives – Autres mandataires

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Ir H.A. Witmans
Drs H.A.M. Marsman
Ir L.J.J. Jessen
Drs K.M.L. Bijvank
Ir B.Ch. Ledeboer
Dr Ir O.L. Oudshoorn
Dr M.P.W. Einerhand
Drs H. Kraak
Mr Drs J.C.C. van Melle
Dr F. Schut
Dr L.J. de Haas
Mr Drs L.A.C.M. van Wezenbeek
Ir M. van Rooij
Ir M.C. Molling
Drs S.T. van Doorn
Dr Ir K.F.I. Haak
Ir C. Box
Ir T.B. Sazonova
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Dr Ir K. de Jong
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Mr Ir R.A.K. van Doornum
M.D. Dokter, MSc
Dr N.G. Panina
Dr T.J. Elmore
Dr M.J. Luys

==



Hatzmann, Martin
Vereenigde
Johan de Wittlaan 7
2517 JR Den Haag
PAYS-BAS

**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

18.06.12

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1225 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor Toegepast -Natuurwetenschappelijk Onderzoek TNO	

Decision on the request for further processing under Rule 135(3) EPC

The request for further processing received on 16.05.12 has been granted (Art. 121(2) EPC).

- ☒ The legal consequence notified in the communication dated 07.03.12 that the application was deemed to be withdrawn shall not ensue.
- ☐ The legal consequence shall not ensue.
- ☐ The refusal of the application dated shall not ensue.
- ☐ The legal consequence notified in the communication dated that the particular loss of rights occurred shall not ensue.
- ☐ The time limit set in the communication dated is deemed to have been met.

The procedure shall be continued/the particular loss of rights shall not ensue (Art. 121(3) EPC).

For the Examining Division



Amended Claims

1. A method of determining hyperparameters (HP), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning system (10), for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control
5 of the hyperparameters as control parameters, the method comprising by
iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - 10 - updating the estimate of the target hyperparameter vector by using the random sample,
- the method being **characterised** in that each iteration comprises the step of:
- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector
15 - selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.
- 20 2. The method according to claim 1, further comprising the steps of:
- selecting a further hyperparameter vector producing the best result in any previous iterations, and
 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

25

3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.

5 4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

10 5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

6. The method according to any of the preceding claims, wherein the step
15 of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the selected hyperparameter vector X^t_i at iteration t producing the best result
20 $S(X^t_i)$, the selected hyperparameter vector X^t_i having elements X^t_{ij} , wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v^t_j , where

$$v^t_j = \frac{\sum_{i=1}^n I\{S(X^t_i) \geq \gamma^t\} W(X^t_i; E^t) X^t_{ij}}{\sum_{i=1}^n I\{S(X^t_i) \geq \gamma^t\} W(X^t_i; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

25

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X'_i; E') = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E'_j)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E'_j)^2}}$$

9. The method according to any of the preceding claims, carried out by computer apparatus.

10. A computer implemented method of classifying physical objects based on feature data obtained from the physical objects, the method comprising
- determining hyperparameters (HP) as control parameters of a classifier, the hyperparameters (HP) being determined according to the method of any one of
claims 1-8,

- obtaining feature data from the objects

- classifying the physical objects based on the feature data, under control of the hyperparameters (HP).

110. A computer program product for carrying out the method according to any of ~~the preceding~~ claims 1-9.

124. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein the hyperparameters (HP) have been determined by the method according to any of claims 1-9, the classifier (1) being arranged to classify physical objects based on feature data from the objects, under control of the hyperparameters (HP).

132. A device (2) for determining hyperparameters), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning

system (10)), for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters, the device comprising a processor (21) arranged for iteratively producing an estimate of a target

5 hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the hyperparameter vector by using the random sample,

10 the device being **characterised** in that the processor is arranged such that each iteration comprises the step of:

- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector

15 - selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

20 ~~143.~~ The device according to claim ~~132~~, wherein the processor (21) is further arranged for:

- selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.

25

~~14. A machine learning system (10), comprising a device (2) according to claim 12 or 13.~~

Amended Claims

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1. A method of determining hyperparameters (HP), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning system (10), for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters, the method comprising iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - 10 - updating the estimate of the target hyperparameter vector by using the random sample,
- the method being **characterised** in that each iteration comprises the step of:
- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector
 - 15 - selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.
- 20 2. The method according to claim 1, further comprising the steps of:
- selecting a further hyperparameter vector producing the best result in any previous iterations, and
 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

25

3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.

5 4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

10 5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

6. The method according to any of the preceding claims, wherein the step
15 of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the selected hyperparameter vector X^{t_i} at iteration t producing the best result
20 $S(X^{t_i})$, the selected hyperparameter vector X^{t_i} having elements $X^{t_{ij}}$, wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v^{t_j} , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

25

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X'_i; E') = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E'_j)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E'_j)^2}}$$

9. The method according to any of the preceding claims, carried out by computer apparatus.

5

10. A computer implemented method of classifying physical objects based on feature data obtained from the physical objects, the method comprising
- determining hyperparameters (HP) as control parameters of a classifier, the hyperparameters (HP) being determined according to the method of any one of
10 claims 1-8,

- obtaining feature data from the objects

- classifying the physical objects based on the feature data, under control of the hyperparameters (HP).

15 11. A computer program product for carrying out the method according to any of claims 1-9.

12. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein
20 the hyperparameters (HP) have been determined by the method according to any of claims 1-9, the classifier (1) being arranged to classify physical objects based on feature data from the objects, under control of the hyperparameters (HP).

25 13. A device (2) for determining hyperparameters), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning system (10)), for classifying physical objects based on feature data obtained

from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters, the device comprising a processor (21) arranged for iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- 5 - drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the hyperparameter vector by using the random sample,

the device being **characterised** in that the processor is arranged such that

- 10 each iteration comprises the step of:
- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector
- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- 15 and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

14. The device according to claim 13, wherein the processor (21) is further arranged for:

- 20 - selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.



Payment of fees and expenses

EPO - DG 2

18. 05. 2012

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80298 München
Germany
Fax +49(0)89 2399-4465

51

Please complete in typescript only

01	Name of payer VEREENIGDE	Payer's reference P81166EP20
	Address Johan de Wittlaan 7 2517 JR The Hague The Netherlands	Mode of payment ☐ Bank payment/transfer to* Name of bank where EPO account held 2809.0002
02	Patent application/patent No. (please use a separate form for each application)	
03	EP 08741668.1	PCT 03

	Code		Currency	Amount
04	001	Filing fee – EP direct ³	EUR	
05	002	Search fee	EUR	
06	005	Designation fee(s) ⁴	EUR	
07	015	Claims fee(s) (Rules 45(1), 162(1) EPC) ⁵	EUR	
08	055	Additional copy	EUR	
09	006	Examination fee	EUR	
10	007	Fee for grant ⁶	EUR	
11	008	Additional fee for printing specification (more than 35 pages) ⁷	EUR	
12	033	Renewal fee for the 3rd year	EUR	
13	034	Renewal fee for the 4th year	EUR	
14	035	Renewal fee for the 5th year	EUR	
15	020	Filing fee – entry EP phase ³	EUR	
16		Extension fee(s) for ⁸ :	EUR	
17	122	Fee for further processing	EUR	240.00
18			EUR	
19			EUR	
20			EUR	
21			EUR	
22		Total	EUR	240.00

Signature L.J. de Haas

Notes 1 - 8 see overleaf.

The Hague, 16 May 2012

Place, date



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EPO - DG 2

18. 05. 2012

51

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Confirmation Copy

Your ref. 08741668.1/1225
Our ref. LH/P81166EP20

The Hague,
16 May 2012

Re: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast
natuurwetenschappelijk onderzoek TNO

In reply to the communication dated 19/07.2011 applicant files a set of amended claims, to replace the claims on file. As an Auxiliary Request, Oral Proceedings are requested.

5

I herewith request further processing of the European patent application 08741668.1.

Please, debit the amount of the fee for further processing from our deposit account No. 2809.0002. A voucher for the amount of the fee for further processing is enclosed.

10

Claim amendments

Claim 1 has been amended first of all to make it more explicit that the claim is directed at a method of determining hyperparameters. The phrase defining the hyperparameters has been relegated to a subordinate clause. This is based on claim 1 as filed. See also page 1 lines 15-16 of the application as filed. Secondly, claim 1 has

15



been amended to elaborate the nature of the classifier, based on page 5 line 29 to page 6 line 5 of the application. Thirdly, a phrase has been added about the computation of “results” based on page 7 lines 14-16 of the application.

5 A new claim 10 has been added, involving computer implemented execution of hyperparameter determination in combination with classification. See claims 1 and 9 as well as page 5 line 29 to page 6 line 17 of the application.

10 Claim 12 has been amended to specify that the classifier is a classifier that is arranged to classify physical objects based on feature data from the objects, under control of the hyperparameters (see the basis of the amendments of claim 1).

Claim 13 has been amended in correspondence with claim 1.

15 Submissions in response to the communication

Many of the objections appear to be due to the fact that the examiner is unsatisfied because the application gives no detailed examples of technical use of the invention. Applicant agrees that more detailed examples would have been convenient, but they
20 are not strictly necessary. The application describes the application field of classification of physical objects based on feature data obtained from those objects. The application discloses a classifier that can be used in that field, the classifier being based upon thresholding of an aggregate value. This concerns a well known classification algorithm, also known as “linear classification” in the art (see Wikipedia).
25 This form of classification has been known for at least half a century and forms part of the basic knowledge in the art of pattern recognition, and certainly of the common general knowledge in that field. For this reason the application field is clearly disclosed, even though it is agreed that a more detailed description could have been more convenient.



In this field it is conventional to distinguish parameters and hyperparameters.

Parameters are the parameters of the physical objects that are used as input for the classification and hyperparameters are control parameters, such as the thresholds,

5 that are used to control classification. The contribution to the art of the present invention is that it enables more accurate machine classification of physical objects based on feature data obtained from this object, by providing for an improved way to adapt hyperparameters (e.g. threshold values).

10 In order to express this more clearly the claims have been amended to indicate the field of classification of physical objects based on feature data obtained from these objects and it has been made explicit that the hyperparameters are control parameters of the classifier.

15 Point 1 of the communication first of all objects that claim 1 did not make clear whether protection is sought for a method, a classifier, a machine learning system or a combination thereof.

Claim 1 has been amended in an attempt to overcome the objection of point 1 by adding
20 an unambiguous statement that “the hyperparameters (HP) being hyperparameters (HP) of a classifier in a machine learning system”. But it is noted that the objection is not fully understood: the claim clearly speaks of “a method of determining hyperparameters”. It is true that this method claim mentions aspects of products, but that is not uncommon for method claims, since many methods concern handling,
25 control or testing of products without detracting from the method category. In the present case, it is not understood how the addition of “of a classifier” after hyperparameters could be said to suggest that a classifier is claimed, or that the addition of “in a machine learning system” could be said to suggest that a machine



learning system is claimed. It is submitted that the words “of” and “in” clearly make the classifier and the machine learning system subordinated to the claimed method.

Next, point 1 of the communication objects that

- 5 (1) no claim defines any feature of the classifier or the machine learning system;
(2) it is not clear what hyperparameters refers to
(3) it is not clear what is “classified and/or learned” and how this is done

All these objections are accompanied by the mention of article 84 EPC.

- 10 (1) It is noted that “classifiers” and “machine learning” system are terms that have a definite meaning in the art, which is understandable without recourse to specific embodiments. For example, the definitions of the ECLA classes under G06K9 are replete with use of the words “classification” used for a definite step in recognition processes, without seeing a need for further definition. Therefore, the claims are not
15 unclear merely because it defines no features of the classifier or the machine learning system. The publications in these ECLA classes show that there is ample support for “classifiers”.

- (2) The prefix “hyper” in hyper parameters distinguishes from parameters of an
20 underlying system under analysis. The term “hyperparameter”, although less common than classification, is also known from the art. For example, at the day of writing, the term produced 183000 hits with Google, 86 published US patent application used the term. Wikipedia has a lemma for use of hyperparameters in Bayesian statistics. In the present case, a hyperparameter of a classifier is a parameter of a classifier that is not a
25 parameter of the pattern that is classified (see page 1 line 11-13 of the application). The classification process is controlled by hyperparameters which determine, for example, decision criteria such as threshold values.



(3) The fact that the ECLA uses the term “classification” in ECLA classes for different recognition applications does not mean that the term cannot be used without limitation to such embodiments. On the contrary, the ECLA shows that it can. The invention concerns a way of selecting hyperparameters. The application mentions an example of use to make a distinction between ripe fruit from unripe fruit. But for the definition of this invention it is not essential what is classified (cd T1055/92). Therefore, the claims do not become unclear merely because this what and how is not mentioned.

Point 2 of the communication objects that claim 1 violates article 84 because it mentions “iteratively producing” without defining a termination criterion. This would make it unclear whether the iterations are meant to terminate. In response it is contested that the absence of a termination criterion makes the term “iteratively” unclear. The invention concerns the way in which individual iteration steps are performed, i.e. how new values are selected. The termination criterion is not needed to define this invention (cf Guidelines C III 4.5). As is well established in the case law of the boards (e.g. T1055/92), the fact that a feature like a termination criterion may be essential for a device that makes use of the invention does not yet make it an essential feature for defining the invention as required under article 84 EPC.

Point 3 of the communication raises a number of objections concerning

- (a) “a set of possible hyperparameter vectors”
- (b) “updating the estimate...using the random sample”
- (c) “selecting .. a hyperparameter vector producing the best result... ”
- (d) “the best result in the present and any iterations”
- (e) “updating...”

(a) The objection to feature (a) is that it is not clear what “possible hyperparameter vectors” refer to or how a set thereof is obtained. In response it is noted that “possible” merely indicates “suitable for use”. It is submitted that this term is clear, because



given a learning system, the skilled person will readily be able to determine whether it uses hyperparameters that can be used. For the definition of the invention it is not essential to define how the set is obtained.

5 (b) and (e) It appears that these objections arise from the use of the two part form. If the examiner is of the opinion that this form is not appropriate in this case, applicant is willing to recast the claim into one part form. With respect to the two part form it is submitted that it is well understood that later mention of a step in the characterizing part does not create uncertainty about the order (objection e) and that any step in the
10 pre-characterizing part should be read in combination with its elaboration in the characterizing part. As to the step of “updating the estimate of the target hyperparameter vector” it is noted that this term is used in the pre-characterizing part of claim 1 and that the updating is elaborated in the characterizing part, It is submitted that the characterizing part makes clear how the random sample is used for
15 the update.

(c) and (d) The definition of the “best result” has been clarified by adding a clause that specifies that the results are computed using a function. Ranking of function result values inherently defines a best result (cf. page 7 lines 17-18 of the application).

20 Point 4 of the communication picks up from the objection in point 1. It is submitted that this objection has been overcome due to the amendment of claim 1. In any case the objection is not fully understood: claim 9 is clearly a dependent claim and claims 10-11 (a computer program product, a classifier) have clearly different categories compared to
25 claim 1 (a method).

Mutatis mutandis the preceding response to points 1-3 also applies in response to point 5 of the communication.



Points 6-8 of the communication raise an inventive step objection against claim 1 on the basis of D4. Point 7 acknowledges that claim 1 is distinguished from D4 at least because D4 does not teach the feature that the “selected hyperparameter vector” is also “producing the best result in ... [any] previous iterations”.

5

Point 8 of the communication rejects inventive step with the argument that this feature cannot be seen to produce an unexpected special technical effect. The objection continues with an argument that the effect can impossibly be technical because it can only contribute to the solution of a non-technical problem because

10

- (i) it is an implementation of an abstract method, and
- (ii) combination with an arbitrary “classifier” and/or “machine learning system” can only contribute to a non-technical problem

The communication refers to the Guidelines C IV 11.5.2, second paragraph (solution of a non-technical problem, for instance a problem in a field excluded from patentability),
for a justification of these observations.

15

In response, it is noted that the present invention provides a solution to the problem of achieving improved classification accuracy by determining hyperparameters, even when the hyperparameters are not continuous and their effects are not transparent (cf
page 2 lines 25-32) of the application. The solution of this problem has an effect on the classifier: it produces a more accurate classifier.

20

The Guidelines C IV 11.5.2, concerns contributions in a field excluded from patentability. However, it is submitted that a *classifier* as defined by amended claim 1
is not in a field excluded from patentability. The classifier produces effects that are not limited to the normal effects of a computer: it receives feature data obtained from physical objects and uses this data to classify the objects. A classifier is a pattern recognition device (usually a programmed computer) for classifying physical objects and/or their digital representations (cf. page 1 lines 6-7). Classifiers are in the field of

25



automatic pattern recognition (recognition of data), a field for which there is an extensive ECLA class (G06K) in which many European patents have been granted.

5 Accordingly, the distinguishing feature that was identified in point 7 of the communication must be taken into account for assessing inventive step. The communication has not identified any reason why it would be obvious to the skilled person to use this feature in the method of D4.

10 In view of the inventive step of claim 1 there is no need to address point 9 of the communication, which concerns the identification of technical problems solved by the dependent claims.

15 Point 10 of the communication contains a review of the description, which ends in an observation “this might be a sign of lack of enabling disclosure (art 83 EPC)”. As noted in point 10, the description gives an example wherein the hyperparameters are threshold values of a decision function used to classify input feature data. Point 10 faults the application for not giving a single enabling embodiment of a decision function or an aggregate value.

20 In response, it is noted first of all that the decision function and the aggregate value are aspects of the classifier used for pattern recognition. They are mentioned in the description because they constitute examples of hyperparameters. The use of decision functions (thresholding) and aggregate values has belonged to the basic skills in the field of pattern recognition and has been extremely well known for classifiers for
25 pattern recognition for more than half a century. These concepts are explained for example in Wikipedia (Linear classifier), which speaks of a “linear combination” of characteristics and use of a “threshold”.



Page 6 line 13-17 mention the decision function and the aggregate value s an example of hyperparameter values. It is submitted that anyone with basic skills in the field of pattern recognition, let alone a skilled person, will immediately understand what is meant by this. Giving an embodiment would be adding the obvious, more or less like requiring that “adding” should be enabled by giving embodiments with specific numbers. Given basic skills, the skilled person does not need such specific examples of adding, or in the present case of decision functions and aggregation, to be able to implement adding decision functions or aggregation, let alone that claims should be limited to such examples.

Points 11-17 contain observations about priority, culminating in an invitation to submit technical notes from applicant’s organization (TNO) that have allegedly been available on the word wide web. In response it is submitted that these documents are not prior art. As recently decided in T1553/06, given enormous size of World Wide Web, the fact alone that a document exists there does not go beyond mere theoretical accessibility. In order to conclude that the document is available to the public, it must further be established that direct and unambiguous access to it by known means and methods is possible.

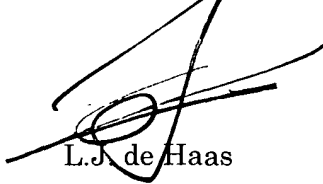
The communication cites only the references to these documents in D1 and D2, which postdate the priority date recognized by the communication. Therefore, these publications do not make ref1 and ref 2 available to the public before the relevant priority date. There is no indication that the documents could have been retrieved via a search engine with relevant keywords, as required by T1553/06. This means that ref1 and ref2 are not part of the state of the art.

Points 11-17 also contain arguments about the validity of priority. the second priority is valid and the first priority is invalid. It is noted that the EPC does not provide for a decision on priority by the European patent office, other than as part of a decision to



refuse the patent application, and that accordingly no review in appeal if applicant disagrees. If the issue of priority does not give rise to a reason for refusal, arguments about priority as no more than a personal opinion of the primary examiner. Because in the present case the arguments about priority do not give rise to a reason for refusal,
5 applicant declines to take a position on this opinion.

The professional representative,



L.J. de Haas

Enclosures: set of amended claims (clean version + track changes version)
voucher

Eur. pat. appln. no. 08741668.1
Our letter of 16 May 2012
P81166EP20

Amended Claims

1. A method of determining hyperparameters (HP), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning system (10), for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control
5 of the hyperparameters as control parameters, the method comprising by-
iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - 10 - updating the estimate of the target hyperparameter vector by using the random sample,
- the method being **characterised** in that each iteration comprises the step of:
- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector
15 - selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.
- 20 2. The method according to claim 1, further comprising the steps of:
- selecting a further hyperparameter vector producing the best result in any previous iterations, and
 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

25

2

3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.

5 4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

10 5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

6. The method according to any of the preceding claims, wherein the step
15 of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the selected hyperparameter vector X^{t_i} at iteration t producing the best result
20 $S(X^{t_i})$, the selected hyperparameter vector X^{t_i} having elements $X^{t_{ij}}$, wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

25

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X'_i; E') = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E'_j)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E'_j)^2}}$$

9. The method according to any of the preceding claims, carried out by computer apparatus.

10. A computer implemented method of classifying physical objects based on feature data obtained from the physical objects, the method comprising
- determining hyperparameters (HP) as control parameters of a classifier, the hyperparameters (HP) being determined according to the method of any one of
claims 1-8,
- obtaining feature data from the objects
- classifying the physical objects based on the feature data, under control of the hyperparameters (HP).

110. A computer program product for carrying out the method according to any of the preceding claims 1-9.

121. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein the hyperparameters (HP) have been determined by the method according to any of claims 1-9, the classifier (1) being arranged to classify physical objects based on feature data from the objects, under control of the hyperparameters (HP).

132. A device (2) for determining hyperparameters), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning

system (10)), for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters, the device comprising a processor (21) arranged for iteratively producing an estimate of a target

5 hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the hyperparameter vector by using the random sample,

10 the device being characterised in that the processor is arranged such that each iteration comprises the step of:

- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector

15 - selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

20 143. The device according to claim 132, wherein the processor (21) is further arranged for:

- selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.

25

~~14. A machine learning system (10), comprising a device (2) according to claim 12 or 13.~~

Eur. pat. appln. no. 08741668.1
Our letter of 16 May 2012
P81166EP20

Amended Claims

1. A method of determining hyperparameters (HP), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning system (10), for classifying physical objects based on feature data obtained from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters, the method comprising iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - updating the estimate of the target hyperparameter vector by using the random sample,
- the method being characterised in that each iteration comprises the step of:
- computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector
 - selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.
2. The method according to claim 1, further comprising the steps of:
- selecting a further hyperparameter vector producing the best result in any previous iterations, and
 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

25

2

3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.

5 4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

10 5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

6. The method according to any of the preceding claims, wherein the step
15 of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the selected hyperparameter vector X^{t_i} at iteration t producing the best result
20 $S(X^{t_i})$, the selected hyperparameter vector X^{t_i} having elements $X^{t_{ij}}$, wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

25

8. The method according to claim 7, wherein the weighting function W is given by

3

$$W(X'_i; E') = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_i - E'_j)^2}}{\sqrt{\sum_{j=1}^m (X'_i)^2} \sqrt{\sum_{j=1}^m (E'_j)^2}}$$

9. The method according to any of the preceding claims, carried out by computer apparatus.

5

10. A computer implemented method of classifying physical objects based on feature data obtained from the physical objects, the method comprising

- determining hyperparameters (HP) as control parameters of a classifier, the hyperparameters (HP) being determined according to the method of any one of

10 claims 1-8,

- obtaining feature data from the objects

- classifying the physical objects based on the feature data, under control of the hyperparameters (HP).

15 11. A computer program product for carrying out the method according to any of claims 1-9.

12. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein

20 the hyperparameters (HP) have been determined by the method according to any of claims 1-9, the classifier (1) being arranged to classify physical objects based on feature data from the objects, under control of the hyperparameters (HP).

25 13. A device (2) for determining hyperparameters), the hyperparameters (HP) being hyperparameters (HP) of a classifier (1) in a machine learning system (10)), for classifying physical objects based on feature data obtained

from physical objects, the classifying being performed by the classifier under control of the hyperparameters as control parameters, the device comprising a processor (21) arranged for iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- 5 - drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the hyperparameter vector by using the random sample,

the device being characterised in that the processor is arranged such that

10 each iteration comprises the step of:

 - computing results of the hyperparameter vectors defined by a function producing a result value based upon hyperparameter vector

 selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

15 and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

14. The device according to claim 13, wherein the processor (21) is further arranged for:

- 20 - selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.



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03	Patent application/patent No. (please use a separate form for each application) EP 08741668.1	PCT

	Code		Currency	Amount
04	001	Filing fee – EP direct ²	EUR	
05	002	Search fee	EUR	
06	005	Designation fee(s) ⁴	EUR	
07	015	Claims fee(s) (Rules 45(1), 162(1) EPC) ⁵	EUR	
08	055	Additional copy	EUR	
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14	035	Renewal fee for the 5th year	EUR	
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16		Extension fee(s) for ⁸ _____	EUR	
17	122	Fee for further processing	EUR	240.00
18		_____	EUR	
19		_____	EUR	
20		_____	EUR	
21		_____	EUR	
22		Total	EUR	240.00

Signature **L.J. de Haas**

The Hague, 16 May 2012
Place, date

Notes 1 - 8 see overleaf.

EPO 1010 04.09

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Your ref. 08741668.1/1225
Our ref. LH/P81166EP20

The Hague,
16 May 2012

Re: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast
natuurwetenschappelijk onderzoek TNO

In reply to the communication dated 19/07.2011 applicant files a set of amended claims, to replace the claims on file. As an Auxiliary Request, Oral Proceedings are requested.

5

I herewith request further processing of the European patent application 08741668.1.

Please, debit the amount of the fee for further processing from our deposit account No. 2809.0002. A voucher for the amount of the fee for further processing is enclosed.

10

Claim amendments

Claim 1 has been amended first of all to make it more explicit that the claim is directed at a method of determining hyperparameters. The phrase defining the

15 hyperparameters has been relegated to a subordinate clause. This is based on claim 1 as filed. See also page 1 lines 15-16 of the application as filed. Secondly, claim 1 has

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been amended to elaborate the nature of the classifier, based on page 5 line 29 to page 6 line 5 of the application. Thirdly, a phrase has been added about the computation of "results" based on page 7 lines 14-16 of the application.

- 5 A new claim 10 has been added, involving computer implemented execution of hyperparameter determination in combination with classification. See claims 1 and 9 as well as page 5 line 29 to page 6 line 17 of the application.

- 10 Claim 12 has been amended to specify that the classifier is a classifier that is arranged to classify physical objects based on feature data from the objects, under control of the hyperparameters (see the basis of the amendments of claim 1).

Claim 13 has been amended in correspondence with claim 1.

15 Submissions in response to the communication

- Many of the objections appear to be due to the fact that the examiner is unsatisfied because the application gives no detailed examples of technical use of the invention. Applicant agrees that more detailed examples would have been convenient, but they are not strictly necessary. The application describes the application field of classification of physical objects based on feature data obtained from those objects. The application discloses a classifier that can be used in that field, the classifier being based upon thresholding of an aggregate value. This concerns a well known classification algorithm, also known as "linear classification" in the art (see Wikipedia).
- 20 This form of classification has been known for at least half a century and forms part of the basic knowledge in the art of pattern recognition, and certainly of the common general knowledge in that field. For this reason the application field is clearly disclosed, even though it is agreed that a more detailed description could have been more convenient.

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In this field it is conventional to distinguish parameters and hyperparameters.

Parameters are the parameters of the physical objects that are used as input for the classification and hyperparameters are control parameters, such as the thresholds,

5 that are used to control classification. The contribution to the art of the present invention is that it enables more accurate machine classification of physical objects based on feature data obtained from this object, by providing for an improved way to adapt hyperparameters (e.g. threshold values).

10 In order to express this more clearly the claims have been amended to indicate the field of classification of physical objects based on feature data obtained from these objects and it has been made explicit that the hyperparameters are control parameters of the classifier.

15 Point 1 of the communication first of all objects that claim 1 did not make clear whether protection is sought for a method, a classifier, a machine learning system or a combination thereof.

Claim 1 has been amended in an attempt to overcome the objection of point 1 by adding
20 an unambiguous statement that "the hyperparameters (HP) being hyperparameters (HP) of a classifier in a machine learning system". But it is noted that the objection is not fully understood: the claim clearly speaks of "a method of determining hyperparameters". It is true that this method claim mentions aspects of products, but that is not uncommon for method claims, since many methods concern handling,
25 control or testing of products without detracting from the method category. In the present case, it is not understood how the addition of "of a classifier" after hyperparameters could be said to suggest that a classifier is claimed, or that the addition of "in a machine learning system" could be said to suggest that a machine

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learning system is claimed. It is submitted that the words "of" and "in" clearly make the classifier and the machine learning system subordinated to the claimed method.

Next, point 1 of the communication objects that

- 5 (1) no claim defines any feature of the classifier or the machine learning system;
(2) it is not clear what hyperparameters refers to
(3) it is not clear what is "classified and/or learned" and how this is done

All these objections are accompanied by the mention of article 84 EPC.

- 10 (1) It is noted that "classifiers" and "machine learning" system are terms that have a definite meaning in the art, which is understandable without recourse to specific embodiments. For example, the definitions of the ECLA classes under G06K9 are replete with use of the words "classification" used for a definite step in recognition processes, without seeing a need for further definition. Therefore, the claims are not
15 unclear merely because it defines no features of the classifier or the machine learning system. The publications in these ECLA classes show that there is ample support for "classifiers".

- (2) The prefix "hyper" in hyper parameters distinguishes from parameters of an
20 underlying system under analysis. The term "hyperparameter", although less common than classification, is also known from the art. For example, at the day of writing, the term produced 183000 hits with Google, 86 published US patent application used the term. Wikipedia has a lemma for use of hyperparameters in Bayesian statistics. In the present case, a hyperparameter of a classifier is a parameter of a classifier that is not a
25 parameter of the pattern that is classified (see page 1 line 11-13 of the application). The classification process is controlled by hyperparameters which determine, for example, decision criteria such as threshold values.

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(3) The fact that the ECLA uses the term "classification" in ECLA classes for different recognition applications does not mean that the term cannot be used without limitation to such embodiments. On the contrary, the ECLA shows that it can. The invention concerns a way of selecting hyperparameters. The application mentions an example of use to make a distinction between ripe fruit from unripe fruit. But for the definition of this invention it is not essential what is classified (cd T1055/92). Therefore, the claims do not become unclear merely because this what and how is not mentioned.

Point 2 of the communication objects that claim 1 violates article 84 because it mentions "iteratively producing" without defining a termination criterion. This would make it unclear whether the iterations are meant to terminate. In response it is contested that the absence of a termination criterion makes the term "iteratively" unclear. The invention concerns the way in which individual iteration steps are performed, i.e. how new values are selected. The termination criterion is not needed to define this invention (cf Guidelines C III 4.5). As is well established in the case law of the boards (e.g. T1055/92), the fact that a feature like a termination criterion may be essential for a device that makes use of the invention does not yet make it an essential feature for defining the invention as required under article 84 EPC.

Point 3 of the communication raises a number of objections concerning

- (a) "a set of possible hyperparameter vectors"
- (b) "updating the estimate...using the random sample"
- (c) "selecting .. a hyperparameter vector producing the best result... "
- (d) "the best result in the present and any iterations"
- (e) "updating..."

(a) The objection to feature (a) is that it is not clear what "possible hyperparameter vectors" refer to or how a set thereof is obtained. In response it is noted that "possible" merely indicates "suitable for use". It is submitted that this term is clear, because

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Date 16 May 2012

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given a learning system, the skilled person will readily be able to determine whether it uses hyperparameters that can be used. For the definition of the invention it is not essential to define how the set is obtained.

5 (b) and (e) It appears that these objections arise from the use of the two part form. If the examiner is of the opinion that this form is not appropriate in this case, applicant is willing to recast the claim into one part form. With respect to the two part form it is submitted that it is well understood that later mention of a step in the characterizing part does not create uncertainty about the order (objection e) and that any step in the
10 pre-characterizing part should be read in combination with its elaboration in the characterizing part. As to the step of "updating the estimate of the target hyperparameter vector" it is noted that this term is used in the pre-characterizing part of claim 1 and that the updating is elaborated in the characterizing part. It is submitted that the characterizing part makes clear how the random sample is used for
15 the update.

(c) and (d) The definition of the "best result" has been clarified by adding a clause that specifies that the results are computed using a function. Ranking of function result values inherently defines a best result (cf. page 7 lines 17-18 of the application).

20 Point 4 of the communication picks up from the objection in point 1. It is submitted that this objection has been overcome due to the amendment of claim 1. In any case the objection is not fully understood: claim 9 is clearly a dependent claim and claims 10-11 (a computer program product, a classifier) have clearly different categories compared to
25 claim 1 (a method).

Mutatis mutandis the preceding response to points 1-3 also applies in response to point 5 of the communication.

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Points 6-8 of the communication raise an inventive step objection against claim 1 on the basis of D4. Point 7 acknowledges that claim 1 is distinguished from D4 at least because D4 does not teach the feature that the "selected hyperparameter vector" is also "producing the best result in ... [any] previous iterations".

5

Point 8 of the communication rejects inventive step with the argument that this feature cannot be seen to produce an unexpected special technical effect. The objection continues with an argument that the effect can impossibly be technical because it can only contribute to the solution of a non-technical problem because

- 10 (i) it is an implementation of an abstract method, and
(ii) combination with an arbitrary "classifier" and/or "machine learning system" can only contribute to a non-technical problem

The communication refers to the Guidelines C IV 11.5.2, second paragraph (solution of a non-technical problem, for instance a problem in a field excluded from patentability),
15 for a justification of these observations.

In response, it is noted that the present invention provides a solution to the problem of achieving improved classification accuracy by determining hyperparameters, even when the hyperparameters are not continuous and their effects are not transparent (cf.
20 page 2 lines 25-32) of the application. The solution of this problem has an effect on the classifier: it produces a more accurate classifier.

The Guidelines C IV 11.5.2, concerns contributions in a field excluded from patentability. However, it is submitted that a *classifier* as defined by amended claim 1
25 is not in a field excluded from patentability. The classifier produces effects that are not limited to the normal effects of a computer: it receives feature data obtained from physical objects and uses this data to classify the objects. A classifier is a pattern recognition device (usually a programmed computer) for classifying physical objects and/or their digital representations (cf. page 1 lines 6-7). Classifiers are in the field of

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automatic pattern recognition (recognition of data), a field for which there is an extensive ECLA class (G06K) in which many European patents have been granted.

Accordingly, the distinguishing feature that was identified in point 7 of the communication must be taken into account for assessing inventive step. The communication has not identified any reason why it would be obvious to the skilled person to use this feature in the method of D4.

In view of the inventive step of claim 1 there is no need to address point 9 of the communication, which concerns the identification of technical problems solved by the dependent claims.

Point 10 of the communication contains a review of the description, which ends in an observation "this might be a sign of lack of enabling disclosure (art 83 EPC)". As noted in point 10, the description gives an example wherein the hyperparameters are threshold values of a decision function used to classify input feature data. Point 10 faults the application for not giving a single enabling embodiment of a decision function or an aggregate value.

In response, it is noted first of all that the decision function and the aggregate value are aspects of the classifier used for pattern recognition. They are mentioned in the description because they constitute examples of hyperparameters. The use of decision functions (thresholding) and aggregate values has belonged to the basic skills in the field of pattern recognition and has been extremely well known for classifiers for pattern recognition for more than half a century. These concepts are explained for example in Wikipedia (Linear classifier), which speaks of a "linear combination" of characteristics and use of a "threshold".

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Your ref. 08741668.1/1225
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Page 6 line 13-17 mention the decision function and the aggregate value s an example of hyperparameter values. It is submitted that anyone with basic skills in the field of pattern recognition, let alone a skilled person, will immediately understand what is meant by this. Giving an embodiment would be adding the obvious, more or less like
5 requiring that "adding" should be enabled by giving embodiments with specific numbers. Given basic skills, the skilled person does not need such specific examples of adding, or in the present case of decision functions and aggregation, to be able to implement adding decision functions or aggregation, let alone that claims should be limited to such examples.

Points 11-17 contain observations about priority, culminating in an invitation to submit technical notes from applicant's organization (TNO) that have allegedly been available on the word wide web. In response it is submitted that these documents are not prior art. As recently decided in T1553/06, given enormous size of World Wide Web,
15 the fact alone that a document exists there does not go beyond mere theoretical accessibility. In order to conclude that the document is available to the public, it must further be established that direct and unambiguous access to it by known means and methods is possible.

The communication cites only the references to these documents in D1 and D2, which postdate the priority date recognized by the communication. Therefore, these publications do not make ref1 and ref 2 available to the public before the relevant priority date. There is no indication that the documents could have been retrieved via a search engine with relevant keywords, as required by T1553/06. This means that ref1
25 and ref2 are not part of the state of the art.

Points 11-17 also contain arguments about the validity of priority. the second priority is valid and the first priority is invalid. It is noted that the EPC does not provide for a decision on priority by the European patent office, other than as part of a decision to

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refuse the patent application, and that accordingly no review in appeal if applicant disagrees. If the issue of priority does not give rise to a reason for refusal, arguments about priority as no more than a personal opinion of the primary examiner. Because in the present case the arguments about priority do not give rise to a reason for refusal,
5 applicant declines to take a position on this opinion.

The professional representative,

L.J. de Haas

Enclosures: set of amended claims (clean version + track changes version)
voucher



Hatzmann, Martin
Vereenigde
Johan de Wittlaan 7
2517 JR Den Haag
PAYS-BAS

**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

07-03-2012

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1225 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor Toegepast -Natuurwetenschappelijk Onderzoek TNO	

Noting of loss of rights pursuant to Rule 112(1) EPC

The European patent application is deemed to be withdrawn under Article 94(4) EPC, because the invitation to file observations on the communication from the Examining Division dated 19.07.11 was not complied with.

Means of redress

Request for a decision (R. 112(2) EPC)

If the applicant considers that the finding of the European Patent Office is inaccurate, he may, within a (non-extendable) period of **two months** after notification of this communication, apply in writing for a decision on the matter. The application can only lead to the finding being reversed if this does not actually correspond to the factual or legal situation.

Further processing (Art. 121 EPC)

The legal consequence of the failure to observe the time limit shall be deemed not to have ensued if, within a (non-extendable) period of **two months** after notification of this communication, further processing is requested by payment of the fee prescribed under Article 2(12) of the Rules relating to Fees and the omitted act is completed (R. 135(1) EPC).

Important note to users of the automatic debiting procedure

The fee for further processing will be debited automatically on the day on which the above-mentioned omitted act is completed (see Arrangements for the automatic debiting procedure, Supplement to OJ EPO 3/2009).

For the Examining Division





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PAYS-BAS

**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

25.11.11

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1225 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor Toegepast -Natuurwetenschappelijk Onderzoek TNO	

Extension of time limit pursuant to Rule 132(2) EPC

Examination procedure

With reference to your request, the time limit for replying to the communication pursuant to Article 94(3) EPC dated 19.07.11 has been extended

by 2 months

to a total of 6 months

from the date of notification of the above-mentioned communication.

Please note: To the extent that your request exceeded the above extension, your request has been refused.

Note

The granting of extensions to time limits is governed by the Implementing Regulations to the EPC and the Guidelines for Examination in the EPO, part E-VIII, 1.6. A request for extension, which would result in the total period set exceeding six months, must be reasoned and supported by evidence.

If no reply to the communication is received in due time, the European patent application will be deemed to be withdrawn (Art. 94(4) EPC).

For the Examining Division





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The European Patent Office
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EPO - DG 2

18. 11. 2011

45

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Your ref. 08741668.1/1225
Our ref. P81166EP20

The Hague,
18 November 2011

Re.: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast-

I herewith request you to grant me a two months' extension of time for filing my observations to your Communication dated 19 July 2011.

The Professional Representative,



L.J. de Haas

P250EP

The Hague - Arnhem - 's-Hertogenbosch - Amsterdam - Eindhoven - Munich

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Your ref. 08741668.1/1225
Our ref. P81166EP20

The Hague.
18 November 2011

Re.: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast-

I herewith request you to grant me a two months' extension of time for filing my observations to your Communication dated 19 July 2011.

The Professional Representative,



L.J. de Haas

P2150EP

=== VOORBLAD ===

AAN: _____

VAN: VEREENIGDE

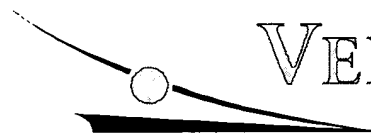
FAX: 31-704166799

TEL: 31-704166711

KOMMENT:

Duration: 18.11.2011 15:58:09 - 18.11.2011 15:58:16. This page 1 of 2 was completed at 18.11.2011 15:58:11

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EPO 08 2

05. 08. 2011

49

Your ref. 08741668.1/1225
Our ref. LH/P81166EP20

The Hague,
4 August 2011

Re: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk
onderzoek TNO
natuurwetenschappelijk onderzoek TNO

In reply to the invitation to file information on prior art pursuant to Article 124(1) and Rule 141(3) EPC, applicant informs the European Patent Office that no prior art has been taken into consideration in national or regional patent proceedings and
5 concerning an invention to which the European patent application relates.

The professional representative,



L.L. de Haas

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EPC - Munich
04. Aug. 2011

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Your ref. 08741668.1/1225
Our ref. LH/P81166EP20

The Hague,
4 August 2011

Re: European patent application No. 08741668.1
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk
onderzoek TNO
natuurwetenschappelijk onderzoek TNO

In reply to the invitation to file information on prior art pursuant to Article 124(1) and Rule 141(3) EPC, applicant informs the European Patent Office that no prior art has been taken into consideration in national or regional patent proceedings and
5 concerning an invention to which the European patent application relates.

The professional representative,



L. J. de Haas

~ .

=== VOORBLAD ===

AAN: _____

VAN: VEREENIGDE_____

FAX: 31-704166799

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KOMMENT:

Duration: 04.08.2011 17:12:30 - 04.08.2011 17:12:37. This page 1 of 2 was completed at 04.08.2011 17:12:32

The examination is being carried out on the **following application documents**

Description, Pages

1-10 as originally filed

Claims, Numbers

1-14 as originally filed

Drawings, Sheets

1 as originally filed

Reference is made to the following documents:

- **D1**: Raaijmakers; Proc. of ADKDD'07, 34-39; pub. in Aug. 2007; XP002495949;
- **D2**: AMIDA Project; Deliverable 5.2, 28-47; pub. in Dec. 2007; XP002496842;
- **D3**: de Boer et al; Annals of Op. Res, 134(1) 19-67; pub. in 2005; XP019390347;
- **D4**: Mannor et al; Proc. of ICML'05, 561-568; pub. in 2005; XP002449298.

The primary document **D4** refers explicitly to the document **D3** as providing more detailed information on the Cross Entropy method (abbrev. CE): see (**D4**: section 2) for "The reader is referred to [...] de-Boer et al. (2005) and references therein for context, extensions, and applications". Since **D3** was available to the public on the publication date of **D4**, the teachings of **D3** are to be regarded as incorporated into **D4** (Guidelines C-IV, 9.1).

Under **Art. 84 EPC** the claims shall define the matter for which protection is sought. The claims shall be clear and concise and supported by the description.

1. The independent claim 1 reads "A method of determining hyperparameters of a classifier in a machine learning system". It is not clear whether protection is sought for "A method", "a classifier", "a machine learning system" or a combination thereof yet to be clearly defined. (**Art. 84 EPC**) The claims 1-14 do not define any feature of the "classifier" nor of the "machine learning system". It is not clear what the term "hyperparameters" refers to. (**Art. 84 EPC**) It is not clear what is "classifie[d]" and/or "learn[ed]", nor how such a thing is "classifie[d]" and/or "learn[ed]". (**Art. 84 EPC**)

2. The claim 1 specifies that "determining hyperparameters" is achieved "by iteratively producing an estimate of a target hyperparameter", but the claims do not define any termination criterion. It is not clear if the "iteration[s]" are meant to terminate nor, if so, when they do terminate. (**Art. 84 EPC**) Particularly, it is not clear what "a target hyperparameter vector" refers to. (**Art. 84 EPC**)

3. The step of "drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors" is not defined. It is not clear what "possible hyperparameter vectors" refer to, nor how "a set there[of]" is obtained. (**Art. 84 EPC**) The step of "updating the estimate of the target hyperparameter vector by using the random sample" is not defined. It is not clear how "the random sample" is "us[ed]" in order to "updat[e] the estimate". (**Art. 84 EPC**). The step of "selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations" is not defined. It is not clear what a "result" refers to, nor how a "hyperparameter vector [is] producing" such a thing. (**Art. 84 EPC**) It is not clear how it is decided that a "result" is "the best" one. (**Art. 84 EPC**) Since "each iteration compris[es] the step[s] of: drawing a random sample", it is not clear how "the random sample" may contain "a hyperparameter vector [...] producing [a] [...] result in [...] any previous iterations". (**Art. 84 EPC**) Similarly, the statement "the step of updating [...] involves said selected hyperparameter vector" leaves the reader in doubt as to the order in which the claimed steps are performed. (**Art. 84 EPC**)

4. Following on from point 1, it is not clear whether the claims 9-11 are dependent claims or separate, independent claims. (**Art. 84 EPC**) In the former case, the claims 9-11 should be amended in such a way that they would meet the requirements of **Rule 43(4) EPC**. In the later case, the independent claims 1 & 9-11 lack conciseness. (**Art. 84 EPC**) They all relate to the same subject-matter and they fall within a same category (undefined combination of activity and physical entity) but not within anyone of the exceptional situations listed in **Rule 43(2)(a)-(c) EPC**. In any case, the objections raised in point 1 still apply and, particularly, it is not clear how to "us[e] hyperparameters as control parameters" (claim 11). (**Art. 84 EPC**)

5. The objections raised in points 1-3 apply mutatis mutandis to the subject-matter of the independent claim 12, which does not meet the requirements of **Art. 84 EPC**. It is also not clear how the scope of protection of dependent claim 14 may differ from the ones of claims 12 & 13. (**Art. 84 EPC**)

6. Independent claim 1: The above lack of clarity notwithstanding, **D4** discloses

1. "A method of determining hyperparameters of a classifier in a machine learning system". See (equation 1) in **D4**;
2. "by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of: drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and updating the estimate of the target hyperparameter vector by using the random sample". In **D4**, see (section 2) for "Once the associated stochastic optimization is defined, the CE method alternates the following two phases: 1. Generation of a random sample of random data (trajectories, vectors, etc.) according to a specified random mechanism. 2. Update of the parameters of the random mechanism, on the basis of the data, in order to produce a "better" sample in the next iteration";
3. "the method being characterised in that each iteration comprises the step of: selecting from the random sample a hyperparameter vector producing the best result in the present [...] iteration[s], and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector". In **D4**, see (equation 4) that does involve the " $Z^{(l)}$ " which produces the minimum cost " $S_{(1)}$ " (both defined in the item 1. above equation 4);

7. As far as it can be understood, the subject-matter aimed at being defined by the claim 1 would differ from **D4** in that "said selected hyperparameter vector" is also "producing the best result in [...] any previous iterations", not only "in the present" one as in **D4**.

8. With due regard to the description and drawings, this distinguishing feature cannot be seen to produce an unexpected special technical effect and the subject-matter of claim 1 is not inventive within the meaning of **Art. 56 EPC**. Particularly, the claimed steps are those of an abstract method which does fall within the terms of the non-inventions listed in **Art. 52(2)(a)&(c) EPC**. Technical implementations of such an abstract method (e.g. in the form of a computer-implemented method) as well as its combinations with arbitrary "classifier" and/or "machine learning system" could only contribute to the solution of a non-technical problem and, thus, could not define an inventive step. (**Art. 56 EPC**; Guidelines C-IV, 2nd par. of 11.5.2; Official Journal EPO 11/2007, 594-600) Only the purposive use of such potential technical implementations and combinations, in the context of a solution to a technical problem, may contribute to the technical character of an invention.

9. The dependent claims do not disclose any clear feature that would have the potential to contribute to the solution of a technical problem. The claims 2-6 remain as vague and unclear as the claim 1 about the matter which the applicant wishes to

protect. (**Art. 84 EPC**) For example, the claims 4 & 5 both imply that a process "using the further selected hyperparameter vector" is performed before the step of "selecting [...] a hyperparameter vector producing the best result". (**Art. 84 EPC**) The combination of claims 7 & 8 discloses a mathematical "weighting function W" which does differ from the alternatives disclosed in **D4** (and **D3**) but, again, which can only contribute to the solution of a non-technical problem and cannot defined an inventive step. (**Art. 56 EPC**)

10. The description only discloses the following:

1. "Classifiers are used in machine learning systems to classify physical objects and/or their (typically digital) representations. Machine learning systems may, for example, be used to assist fruit picking robots. The classifier of the machine learning system is trained to distinguish ripe fruit (e.g. tomatoes) from unripe fruit. For each fruit item, the classifier determines a set of parameters which are compared with stored parameters in order to classify the items as "ripe" or "unripe". The classification process is, in turn, controlled by hyperparameters which determine, for example, decision criteria such as threshold values. Classifiers are typically trained using a training set prepared on the basis of human input: an operator indicates the correct classification for the items of the training set. On the basis of these training data, the correct hyperparameters of the classifier can be estimated" (page 1, lines 6-17);

2. "The classifier (C) 1 shown schematically in Fig. 1 receives feature data FD and hyperparameters HP, and produces classification data CD. The feature data FD may include image data produced by a CCD (Charge Coupled Device) array or other light-sensitive device. Additionally, the feature data FD may include sound data or data concerning database items, such as library data (book numbers and titles). [...]

The classifier 1 is capable of classifying the items represented by the input feature data FD. The feature data FD typically comprise parameters of the items, for example their size and/or colour in the case of fruit or machine parts. Under control of the hyperparameters HP the items are each assigned to a class, for example "ripe" in the case of fruit. At least two different classes are used, and typically an item is assigned to one class only.

The hyperparameters HP determine the decision function of the classifier that classifies items. For example, when this function is based upon thresholding, items producing an aggregate value (derived from the feature values) equal to or greater than the threshold are assigned to class A, while items producing a value smaller than the threshold are assigned to class B. It is noted that other classification techniques may be used as well.

Applications of the classifier 1 include picking fruit, sorting parts (e.g. machine parts), classifying books, selecting songs, recognising adult video material, detecting damage, etc.." (page 5, line 29 - page 6, line 20);

3. "The machine learning system 10 shown merely by way of non-limiting example in Fig. 3 comprises a classifier (C) 1 and a device (H) 2 for determining hyperparameters. The machine learning system 10 may further comprise at least one sensor (S) 3 and a display screen (D) 4. The sensor 3 serves to collect data while the display screen 4 serves to display classification result and other data" (page 9, lines 20-24);

From which it is understood that "a machine learning system" is learning "threshold values" of a "decision function" which is used in "classifying [...] items represented by [...] input feature data". However, the description does not disclose a single enabling embodiment of such a "decision function", or "aggregate value (derived from the feature values)", for at least one of the listed interpretations which could be given to the "feature values" & "classes" (see items **10.1-10.3**). This might be a sign of lack of disclosure. (**Art. 83 EPC**) If the applicant disagrees with this finding, he is requested to identify the relevant passages, in the application as originally filed, providing such an enabling disclosure.

11. The documents **D1** & **D2** were both published prior to the international filing date (25.04.2008) but later than the two priority claims:

- **prioA**: EP 1 986 139 A1; filed on 25.04.2007;
- **prioB**: European application number 07112037; filed on 09.07.2007.

The priority claim **prioB** is found valid, and **D1** & **D2** cannot be used to assess novelty and/or inventiveness of the subject-matter claimed by the present application.

12. However, as identified in the international search report, both **D1** & **D2** refer to the same two disclosures made by the inventor of the present application:

- **ref1**: "Raaijmakers. Hyperparameter estimation with an elitist cross-entropy method. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/multinomial-languagelearning-v2.pdf>";
- **ref2**: "Raaijmakers. Language learning with information diffusion kernels. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/ce-hyperparam.pdf>".

The hyperlinks imply that both **ref1** & **ref2** could be downloaded as "pdf" documents, i.e. were available to the public, in May 2007 (".../2007/05/...") that is prior to **prioB** but later than **prioA**.

13. Although **ref1** & **ref2** were not available anymore at the date of completion of the international search (24.09.2008) the present communication further considers, for the sake of completeness, the validity of **prioA**.

14. The present application seeks protection for "selecting [...] a vector producing the best result in [...] any previous iterations" (claims 1, 2, 4, 12 & 13) and "using the [...] selected [...] vector" (claims 1-3, 7 & 13). The claimed priority document **prioA** does not support such added subject-matters. They are not explicitly disclosed in **prioA**, and **prioA** does not contain any element from which the skilled person could derive them in a direct and unambiguous way. (**Art. 87(1) EPC**; Guidelines C-V, 2.2)

15. The embodiments disclosed by **prioA** select "a vector producing the best result in the present iteration" only (e.g. claim 1; page 7, line 11) and uses "the best sample of the previous iteration" (e.g. page 7, lines 9 & 26; page 8, lines 5-7). The recitation of "selecting [...] a vector producing the best result in [...] any previous iterations" and "using the [...] selected [...] vector" is a generalisation that is not derivable from **prioA**.

16. The same objection applies mutatis mutandis to the following passages of the present description: (page 2, lines 21-29), (page 3, lines 10-19 & 22-24), (page 5, lines 5-8), (page 7, lines 13-14), (page 8, lines 10-11 & 13), and (page 9, line 8).

17. Therefore, the priority claim **prioA** is valid insofar it is "the best result in the present iteration" only which is "select[ed]" and "use[d]". To assess novelty and/or inventiveness of "selecting [...] a vector producing the best result in [...] any previous iterations" and "using the [...] selected [...] vector" the relevant date is 09.07.2007 (**prioB**) for which **ref1** & **ref2** can be used. (Guidelines C-V, 1.5 & 2.3) Given that both disclosures were made by the inventor of the present application, the applicant is requested to provide their copies.

At least some of the objections raised above are such that there appears to be no possibility of overcoming them by amendment. Refusal of the application under **Art. 97(2) EPC** is therefore to be expected.

When attempting to overcome said objections by amendments, attention of the applicant is drawn to the fact that the application may not be amended in such a way that it contains subject-matter which extends beyond the content of the application as originally filed. (**Art. 123(2) EPC**)



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Substantive Examiner
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Tel: +31 70 340 - 4636

Application No. 08 741 668.1 - 1225	Ref. P81166EP20	Date 19.07.2011
Applicant Nederlandse Organisatie voor Toegepast -Natuurwetenschappelijk Onderzoek TNO		

Communication pursuant to Article 94(3) EPC

The examination of the above-identified application has revealed that it does not meet the requirements of the European Patent Convention for the reasons enclosed herewith. If the deficiencies indicated are not rectified the application may be refused pursuant to Article 97(2) EPC.

You are invited to file your observations and insofar as the deficiencies are such as to be rectifiable, to correct the indicated deficiencies within a period

of 4 months

from the notification of this communication, this period being computed in accordance with Rules 126(2) and 131(2) and (4) EPC. One set of amendments to the description, claims and drawings is to be filed within the said period on separate sheets (R. 50(1) EPC).

If filing amendments, you must identify them and indicate the basis for them in the application as filed. Failure to meet either requirement may lead to a communication from the Examining Division requesting that you correct this deficiency (R. 137(4) EPC).

Failure to comply with this invitation in due time will result in the application being deemed to be withdrawn (Art. 94(4) EPC).

The notification of this communication starts the 24-month period according to Rule 36(1)(a) EPC for filing a voluntary divisional application divided from this application or from any sequential application. For further information see Guidelines for Examination, A-IV, 1.1.1.2 and 1.1.1.4.



Douarche, Nicolas
Primary Examiner
For the Examining Division

Enclosure(s): 6 page/s reasons (Form 2906)



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Application No. 08 741 668.1 - 1225	Ref. P81166EP20	Date 19.07.2011
Applicant Nederlandse Organisatie voor Toegepast -Natuurwetenschappelijk Onderzoek TNO		

Invitation to file information on prior art pursuant to Article 124(1) and Rule 141(3) EPC

You are hereby requested to file, within a period of **two months** from notification of this invitation, the following information on prior art taken into consideration in national or regional patent proceedings and concerning an invention to which the European patent application relates:

reference data on cited prior art (i.e. a list of citations) other than any submitted under Rule 141(1) or Rule 70b(1) EPC.

If this information is not filed in due time the European patent application shall be deemed to be withdrawn (Article 124(2) EPC).



Douarche, Nicolas
Primary Examiner
for the Examining Division

08741668.1 - 1225 / 2156377

11.05.10

Client Database System (CDS) - clean up.

Application Nr.: 08741668.1

Following clean up action in CDS the entries concerning the **Applicant (01)** have been amended and are now as follows:

AT-BE-BG-CH-CY-CZ-DE-DK-EE-ES-FI-FR-GB-GR-HR-HU-IE-IS-IT-LI-LT-LU-LV-MC-MT-N
L-NO-PL-PT-RO-SE-SI-SK-TR
Nederlandse Organisatie voor
toegepast-natuurwetenschappelijk onderzoek TNO
Schoemakerstraat 97
2628 VK Delft/NL

Where appropriate, the Register of European Patents will be updated to show the amended details.

For questions please contact the Client Data Registration department of the European Patent Office in Munich, telephone +49 (0)89 2399 2780.



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**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

27.01.10

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1225 / 2156377
Applicant/Proprietor Nederlandse Organisatie voor Toegepast- Natuurwetenschappelijk Onderzoek TNO	

Communication of European publication number and information on the application of Article 67(3) EPC

The provisional protection under Article 67(1) and (2) EPC in the individual Contracting States becomes effective only when the conditions referred to in Article 67(3) EPC have been fulfilled (for further details, see information brochure of the European Patent Office "National Law relating to the EPC" and additional information in the Official Journal of the European Patent Office).

Pursuant to Article 153(3) EPC the publication under Article 21 PCT of an international application for which the European Patent Office is a designated or elected Office takes the place of the publication of a European patent application.

The bibliographic data of the above-mentioned Euro-PCT application will be published on 24.02.10 in Section I.1 of the European Patent Bulletin. The European publication number is 2156377.

In all future communications to the European Patent Office, please quote the application number plus Directorate number.

Receiving Section



PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P81166PC00		FOR FURTHER ACTION		See Form PCT/PEA/416
International application No. PCT/NL2008/050247		International filing date (day/month/year) 25.04.2008		Priority date (day/month/year) 25.04.2007
International Patent Classification (IPC) or national classification and IPC INV. G06N7/00				
Applicant Nederlandse Organisatie voor toegepast-				
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of <u>6</u> sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☐ sent to the applicant and to the International Bureau) a total of sheets, as follows: ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions). ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box. b. ☐ (sent to the International Bureau only) a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).				
4. This report contains indications relating to the following items: ☒ Box No. I Basis of the report ☒ Box No. II Priority ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability ☐ Box No. IV Lack of unity of invention ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement ☒ Box No. VI Certain documents cited ☐ Box No. VII Certain defects in the international application ☐ Box No. VIII Certain observations on the international application				
Date of submission of the demand 2009-02-06		Date of completion of this report 13.07.2009		
Name and mailing address of the international preliminary examining authority:  European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016		Authorized officer Douarche, Nicolas Telephone No. +31 70 340-4636		



**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/NL2008/050247

Box No. I Basis of the report

1. With regard to the **language**, this report is based on
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a))
2. With regard to the **elements*** of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

Description, Pages

1-10 as originally filed

Claims, Numbers

1-14 as originally filed

Drawings, Sheets

1 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing

3. ☐ The amendments have resulted in the cancellation of:

- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/figs
- ☐ the sequence listing (*specify*):
- ☐ any table(s) related to sequence listing (*specify*):

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

- ☐ the description, pages
- ☐ the claims, Nos.
- ☐ the drawings, sheets/figs
- ☐ the sequence listing (*specify*):
- ☐ any table(s) related to sequence listing (*specify*):

5. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 70.2 (e)).
6. ☐ Supplementary international search report(s) from Authority(ies) have been received and taken into account in drawing up this report (Rule 45bis.8(b) and (c)).

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/NL2008/050247

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
- ☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
 - ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:
- see separate sheet

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-14</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-14</u>
Industrial applicability (IA)	Yes: Claims	<u>1-14</u>
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

Reference is made to the following documents:

- D1** Raaijmakers; Proceedings of ADKDD'07, pp. 34-39; August 2007;
- D2** AMIDA Project; Deliverable 5.2, chapter 3; December 2007;
- D3** de Boer et al; Annals of Operations Research, vol. 134(1), pp. 19-67; February 2005;
- D4** Mannor et al; Proceedings of ICML'05, pp. 561-568; August 2005.

The primary document **D4** refers explicitly to the document **D3** (see "de-Boer et al. (2005)" in section 2) as providing more detailed information on certain features. Since **D3** was available to the public on the publication date of **D4**, the teachings of the document **D3** are to be regarded as incorporated into the primary document **D4** (see GL, 12.06).

Item V: Novelty, inventive step or industrial applicability

1.1 Independent claim 1: the document **D4 discloses**

- (a) "A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10)". See (equation 1) in **D4**;
- (b) "by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of: drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and updating the estimate of the target hyperparameter vector by using the random sample". In **D4**, see (section 2) for the items "1." & "2." that follow "Once the associated stochastic optimization is defined, the CE method alternates the following two phases:";
- (b) "the method being characterised in that each iteration comprises the step of: selecting from the random sample a hyperparameter vector producing the best result in the present [...] iteration[s], and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector". In **D4**, see (equation 4) that "involves" the " $Z^{(t)}$ " which produces the minimum cost " $S_{(t)}$ " (defined in item "1. Adaptive updating of γ_t ").

1.2 Claim 1 therefore differs from **D4 in that "said selected hyperparameter vector" is "producing the best result in [...] any previous iterations", not only "in the present" one as in **D4**. However, *no unexpected special technical effect* can be associated with such a distinguishing feature. *The independent claim 1 is therefore not***

inventive (Art. 33(3) PCT).

The arguments given in points 1.1 & 1.2 for the independent claim 1 apply *mutatis mutandis* to *the corresponding independent claims 10-12 which are therefore not inventive (Art. 33(3) PCT).*

- 1.3 *The dependent claims 2-9, 13 & 14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step (Art. 33(3) PCT).*

In particular, the examiner fails to find any feature in the application as filed that would have the potential to contribute to the solution of a technical problem, thereby defining an inventive step in the sense of Art. 33(3) PCT.

For example, although "the weighting function W" recited in claim 8 (or page 4 of the description) differs from the alternatives which **D4** discloses, such a distinguishing feature does not solve a technical problem.

Items II & VI: Priority & Certain documents cited

- 2.1 The documents **D1** & **D2** were both published prior to the international filing date (25.04.2008) but later than the two priority claims:
- prioA** Application number 07106963; filing date: 25.04.2007; publication date: 29.10.2008;
- prioB** Application number 07112037; filing date: 09.07.2007.
- The priority claim **prioB** is valid, and **D1** & **D2** cannot be used to assess novelty and/or inventiveness of the subject-matter claimed by the present application.*
- 2.2 However, as identified in the international search report, both **D1** & **D2** refer to the same two disclosures made by the inventor of the present application:
- ref1** "Raaijmakers. Hyperparameter estimation with an elitist cross-entropy method. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/multinomial-language-learning-v2.pdf>";
- ref2** "Raaijmakers. Language learning with information diffusion kernels. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/ce-hyperparam.pdf>".
- The hyperlinks imply that both **ref1** & **ref2** could be downloaded as "pdf"

documents, i.e. were available to the public, in May 2007 (".../2007/05/...") that is prior to **prioB** but later than **prioA**.

- 2.3 Although **ref1** & **ref2** were not available anymore at the date of completion of the international search the present communication further considers, for the sake of completeness, the validity of **prioA**.
- 3.1 The present application seeks protection for "selecting [...] a vector producing the best result in [...] any previous iterations" (claims 1, 2, 4, 12 & 13) and "using the [...] selected [...] vector" (claims 1-3, 7 & 13).
- 3.2 The claimed priority document **prioA** does not support such added subject-matters. They are not explicitly disclosed in **prioA**, and **prioA** does not contain any elements from which the skilled person could derive them in a direct and unambiguous way.
- 3.3 The embodiments disclosed by **prioA** select "a vector producing the best result in the present iteration" only (e.g. claim 1; page 7, line 11) and uses "the best sample of the previous iteration" (e.g. page 7, lines 9 & 26; page 8, lines 5-7), not "any previous iterations" as presently claimed.
- 3.4 The same objection applies mutatis mutandis to the following passages of the present description: (page 2, lines 21-29), (page 3, lines 10-19 & 22-24), (page 5, lines 5-8), (page 7, lines 13-14), (page 8, lines 10-11 & 13), and (page 9, line 8).
- 3.5 *As a result, the priority claim **prioA** is invalid (Art. 8(2)(a) PCT & GL 6.10). To assess novelty and/or inventiveness of the claimed subject-matter, the priority claim **prioB** (09.07.2007) is the relevant date (Rules 43bis.1 & 64.1(b)(ii) PCT).*



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Tel.: +31 (0)70 340 45 00

Date
21-01-2010

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1225 PCT/NL2008050247
Applicant/Proprietor Nederlandse Organisatie voor Toegepast- Natuurwetenschappelijk Onderzoek TNO	

Communication pursuant to Rules 161 and 162 EPC

(1) Amendment of application documents, especially the claims (R. 161 EPC)

The above mentioned international (Euro-PCT) application has entered the European phase.

Under Articles 28, 41 PCT, Rules 52, 78 PCT and Rule 137(2) to (4) EPC, the applicant may amend the application documents after receiving the international search report.

Whether or not he has already done so, he now has a further opportunity to file amended claims or other application documents within a non-extendable period of ONE MONTH after notification of the present communication (R. 161 EPC).

The claims applicable on expiry of the above time limit, i.e. those filed on entry into the European phase or in response to the present communication, will form the basis for the calculation of any claims fee to be paid (see page 2) and for any supplementary search to be carried out under Article 153(7) EPC (R. 161 EPC).

(2) Claims fees under Rule 162 EPC

If the application documents on which the European grant procedure is to be based comprise more than fifteen claims, a claims fee shall be payable for the sixteenth and each subsequent claim within the period provided for in Rule 159(1) EPC.

- ☒ Based on the application documents currently on file, all necessary claims fees have already been paid (or the documents do not comprise more than 15 claims).
- ☐ All necessary fees will be/have been debited automatically according to the automatic debit order.
- ☐ The claims fees due for the claims to were not paid within the above-mentioned period.

Any non-paid claims fee, either based on the current set of claims or on any amended claims to be filed pursuant to Rule 161 EPC (see page 1), may still be validly paid within a non-extendable period of **one month** after notification of this communication (R. 162(2) EPC).

If a payment is made for only some of the claims, it must be indicated for which claims it is intended. If a claims fee is not paid in due time, the claim concerned is deemed to be abandoned (R. 162(4) EPC).

If claims fees have already been paid, but on expiry of the above-mentioned period there is a new set of claims containing fewer fee-incurring claims than previously, the claims fees in excess of those due under Rule 162(2), 2nd sentence EPC will be refunded (R. 162(3) EPC).

You are reminded that any supplementary search under Article 153(7) EPC will relate only to the last set of claims applicable on expiry of the above period AND will be confined to those fee-incurring claims for which fees have been paid in due time.

The present amount of the claims fee is

EUR 200 for the 16th and each subsequent claim up to the limit of 50
EUR 500 for the 51st and each subsequent claim

Note to users of the automatic debiting procedure

Unless the EPO receives prior instructions to the contrary, the fees for all claims incurring fees will be debited on the last day of the period for payment. For further details see the Arrangements for the automatic debiting procedure, Supplement to OJ EPO 3/2009.

Receiving Section



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Date

02-12-2009

Reference P81166EP20	Application No./Patent No. 08741668.1 - 1225 PCT/NL2008050247
Applicant/Proprietor Nederlandse Organisatie voor Toegepast- Natuurwetenschappelijk Onderzoek TNO	

Communication pursuant to Rules 161 and 162 EPC

(1) Amendment of application documents, especially the claims (R. 161 EPC)

The above mentioned international (Euro-PCT) application has entered the European phase.

Under Articles 28, 41 PCT, Rules 52, 78 PCT and Rule 137(2) to (4) EPC, the applicant may amend the application documents after receiving the international search report.

Whether or not he has already done so, he now has a further opportunity to file amended claims or other application documents within a non-extendable period of ONE MONTH after notification of the present communication (R. 161 EPC).

The claims applicable on expiry of the above time limit, i.e. those filed on entry into the European phase or in response to the present communication, will form the basis for the calculation of any claims fee to be paid (see page 2) and for any supplementary search to be carried out under Article 153(7) EPC (R. 161 EPC).

(2) Claims fees under Rule 162 EPC

If the application documents on which the European grant procedure is to be based comprise more than fifteen claims, a claims fee shall be payable for the sixteenth and each subsequent claim within the period provided for in Rule 159(1) EPC.

- ☒ Based on the application documents currently on file, all necessary claims fees have already been paid (or the documents do not comprise more than 15 claims).
- ☐ All necessary fees will be/have been debited automatically according to the automatic debit order.
- ☐ The claims fees due for the claims to were not paid within the above-mentioned period.

Any non-paid claims fee, either based on the current set of claims or on any amended claims to be filed pursuant to Rule 161 EPC (see page 1), may still be validly paid within a non-extendable period of **one month** after notification of this communication (R. 162(2) EPC).

If a payment is made for only some of the claims, it must be indicated for which claims it is intended. If a claims fee is not paid in due time, the claim concerned is deemed to be abandoned (R. 162(4) EPC).

If claims fees have already been paid, but on expiry of the above-mentioned period there is a new set of claims containing fewer fee-incurring claims than previously, the claims fees in excess of those due under Rule 162(2), 2nd sentence EPC will be refunded (R. 162(3) EPC).

You are reminded that any supplementary search under Article 153(7) EPC will relate only to the last set of claims applicable on expiry of the above period AND will be confined to those fee-incurring claims for which fees have been paid in due time.

The present amount of the claims fee is

EUR 200 for the 16th and each subsequent claim up to the limit of 50
EUR 500 for the 51st and each subsequent claim

Note to users of the automatic debiting procedure

Unless the EPO receives prior instructions to the contrary, the fees for all claims incurring fees will be debited on the last day of the period for payment. For further details see the Arrangements for the automatic debiting procedure, Supplement to OJ EPO 3/2009.

Receiving Section

Acknowledgement of receipt

We hereby acknowledge receipt of the form for entry into the European phase (EPO as designated or elected Office) as follows:

Submission number	685227	
PCT application number	PCT/NL2008/050247	
EP application number	08741668.1	
Date of receipt	04 November 2009	
Receiving Office	European Patent Office, The Hague	
Your reference	P81166EP20	
Applicant		
Country		
Documents submitted	package-data.xml application-body.xml OTHER-1.pdf/Additional represent- atives.pdf (1 p.)	ep-euro-pct.xml epf1200.pdf (3 p.)
Submitted by	CN=A. Dalmulder 14413,O=Vereenigde,C=NL	
Method of submission	Online	
Date and time receipt generated	04 November 2009, 11:48 (CET)	
Message Digest	E7:CE:49:17:DD:9D:28:6F:C0:CD:61:D6:36:32:F5:CB:7A:BD:2C:3F	

Correction by the EPO of errors in debit instructions filed by eOLF

Errors in debit instructions filed by eOLF that are caused by the editing of Form 1038E entries or the continued use of outdated software (all forms) may be corrected automatically by the EPO, leaving the payment date unchanged (see decision T 152/82, OJ EPO 1984, 301 and point 6.3 ff ADA, Supplement to OJ EPO 10/2007).

/European Patent Office/

Entry into the European phase (EPO as designated or elected Office)

To the European Patent Office

European application number	EP08741668.1
PCT application number	PCT/NL2008/050247
PCT publication number	WO2008133509
Applicant's or representative's reference	P81166EP20
International Filing Date	25.04.2008
International Search Authority (ISA)	EP
International Preliminary Examination Authority (IPEA)	not applicable
1. Applicant Indications concerning the applicant(s) are contained in the international publication or were recorded by the International Bureau after the international publication. Changes which have not yet been recorded by the International Bureau are set out here:	☒ ☐
2. Representative This is the representative who will be listed in the Register of European Patents and to whom notifications will be made Representative 1	Name: HATZMANN, Drs. M.J. Registration No.: 100977615 Company: VEREENIGDE Address of place of business: Johan de Wittlaan 7 2517 JR Den Haag, Netherlands Telephone: +31 70 4166711 Fax: +31 70 4166799 e-mail: patent@vereenigde.com
3. Authorisation An individual authorisation is attached. A general authorisation has been registered under No: A general authorisation has been filed, but not yet registered. The authorisation filed with the EPO as PCT receiving Office expressly includes the European phase.	☐ ☐ ☐ ☐
4. Request for examination Examination of the application under Art. 94 EPC is hereby requested. The examination fee is being (has been, will be) paid. Request for examination in an admissible non-EPO language: The applicant waives his right to be asked under Rule 70(2) EPC whether he wishes to proceed further with the application.	☒ ☒ Verzocht wordt om onderzoek van de aanvraag als bedoeld in Art. 94. ☐
5. Copies Additional copies of the documents cited in the supplementary European search report are requested. Number of additional sets of copies	☐
6. Documents intended for proceedings before the EPO 6.1 Proceedings before the EPO as designated Office (PCT I) are to be based on the following documents: the application documents published by the International Bureau (with all claims, description and drawings), where applicable with amended claims under Art. 19	☒

unless replaced by the amendments attached.

6.2 Proceedings before the EPO as elected Office (PCT II) are to be based on the following documents:

unless replaced by the amendments attached.

If the EPO as International Preliminary Examining Authority has been supplied with test reports, these may be used as the basis of proceedings before the EPO.

Translations in one of the official languages of the EPO (English, French, German) are attached as crossed below:

Translation of the international application (description, claims, any text in the drawings) as originally filed, of the abstract as published and of any indication under Rule 13bis.3 and 13bis.4 PCT regarding biological material

It is hereby declared that the international application as originally filed is a complete translation of the previous application (Rule 53(3) EPC)

Translation of amended claims and any statement under Art. 19 PCT, if the claims as amended are to form the basis for the proceedings before the EPO (see Section 6).

Translation of annexes to the international preliminary examination report

The particulars referred to in Rule 31(1)(c) EPC (if not yet known, the depositary institution and the identification reference(s)) [number, symbols, etc.] of the depositor) are given in the international publication or in the translation submitted in Section 7 on:

will be filed later.

The sequence listing data in computer-readable form in accordance with WIPO Standard 25 is identical to the sequence listing in PDF format.

AT BE BG CH&LI CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LT LU LV
MC MT NL NO PL PT RO SE SI SK TR

10.1 It is currently intended to pay fewer than seven designation fees, for the following contracting states:

☐

10.2 If contracting states are indicated in Section 10.1, it is agreed that for the contracting states not thus indicated no communication under Rule 112(1) EPC be issued and further processing be excluded.

☐

11. Extension of the European patent

This application is deemed to be a request to extend the European patent application and the European patent granted in respect of it to all the non-contracting states to the EPC designated in the international application and with which extension agreements are in force on the date on which the international application is filed. However, the extension only takes effect if the prescribed extension fee is paid.

☐

It is currently intended to pay the extension fee for the following states:

Note: Under the automatic debiting procedure, extension fees will only be debited for states indicated here, unless the EPO is instructed otherwise before expiry of the period for payment.

12. List of enclosed documents

	Description of document	Original file name	Assigned file name
1	Additional representatives	Additional representatives.pdf	OTHER-1.pdf

13. Mode of payment: Debit from deposit account

Currency

☒

EUR

The European Patent Office is hereby authorised, to debit from the deposit account with the EPO any fees and costs indicated on the fees page.

Deposit account number

28090002

Account holder

VEREENIGDE

14. Any refunds should be made to the following EPO deposit account:

Number and account holder

☒

VEREENIGDE, 28090002

15. Fees

		Factor/reducti on applied	Fee schedule	Amount to be paid
15-1	002 Fee for (supplementary) European search for applications filed on/after 01.07.2005	0	1 050.00	0.00
15-2	005 Designation fee Designated states: AT, BE, BG, CH&LI, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR	0	85.00	0.00
15-3	005e Designation fee for all Contracting States designated	1	500.00	500.00
15-4	006e Examination fee (Euro-PCT without supplementary European search report)	0.4	1 565.00	626.00
15-5	015 Claims fee for 16th up to 50th claim	0	200.00	0.00
15-6	020 Filing fee - entry EP phase (Rule 159(1)(c) EPC)	1	100.00	100.00
15-7	520 Additional fee for the 36th and each subsequent page - Euro-PCT application -	0	12.00	0.00
Total:			EUR	1 226.00

16. Annotations

17. Signature(s) of applicant(s) or representative

Place: Den Haag
Date: 04 November 2009
Signed by: /M.J.Hatzmann/
Capacity: (Representative)

SUPPLEMENTARY SHEET

Weiterer Vertreter – Additional representatives – Autres mandataires

Ir C.M. Jansen
Ir A.H.K. Tan
Drs H.A.M. Marsman
Ir H.A. Witmans
Ir L.J.J. Jessen
Drs K.M.L. Bijvank
Ir B.Ch. Ledeboer
Dr L.J. de Haas
Mr Drs L.A.C.M. van Wezenbeek
Dr Ir O.L. Oudshoorn
Dr M.P.W. Einerhand
Mr Drs J.C.C. van Melle
Ir M. van Rooij
Drs H. Kraak
Ir M.C. Molling
Dr R. Lelkes
Ir F.J. Smit
Ir D.J. de Jong
Ing D.A. Ploeg
Drs S.T. van Doorn
Dr F. Schut
Dr Ir K.F.I. Haak
Dr A.D. Tepper
Ir T.B. Sazonova
Dr Ir K.F.I de Jong
Dr Ir H.P.A. Maas
Ir C. Box
Ir A.P.M. Duijker
Dr J. Ebner von Eschenbach
Dr B.C. Hermann
M. Blood, MSc
Drs Ir A. Jaeken
Dr G.A.M. Michiels



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NL-2517 JR Den Haag
PAYS-BAS

**For any questions about
this communication:**

Tel.: +31 (0)70 340 45 00

Date

11.09.09

Reference	Application No./Patent No. 08741668.1 - 1225 PCT/NL2008050247
Applicant/Proprietor Nederlandse Centrale Organisatie Voor Toegepast	

Entry into the European phase before the European Patent Office

The following information describes the procedural steps required for entry into the European phase before the European Patent Office (EPO). You are advised to read it carefully because failure to take the necessary action in due time can lead to a loss of rights.

1. The above mentioned international patent application has been given the **European application No. 08741668.1**.
2. Applicants **without a residence or their principal place of business** in an EPC Contracting State may themselves initiate European processing of their international applications, provided they do so before expiry of the 31st month from the priority date.

During the European phase before the EPO as designated or elected Office, however, such applicants **must** be represented by a professional representative (Art. 133(2) and Art. 134(1) and (8) EPC).

Where, at the expiry of the time period laid down in Rule 163(5) EPC, the requirements of Article 133(2) EPC have not been complied with, the European patent application will be **refused**, pursuant to Rule 163(6) EPC.

Please note that a professional representative authorised to act before the EPO and who acted for the applicant during the international phase does not automatically become the representative for the European phase. Applicants are therefore strongly advised to appoint in good time any representative they wish to initiate the European phase for them; otherwise the EPO has to send all communications directly to the applicant.

3. Applicants **with a residence or their principal place of business** in an EPC Contracting State are not obliged to appoint for the European phase a professional representative authorised to act before the EPO. However, in view of the complexity of the procedure it is recommended that they do so.
4. Applicants and professional representatives are also strongly advised to initiate the European phase using **EPO Form 1200**. It is available free of charge from the EPO or via the EPO website at <http://www.epo.org>. Similarly, it can be generated with the epoline® Online Filing Software, obtainable free of charge from the EPO (<http://www.epoline.org>) The use of the form is not compulsory.

-
5. Where the EPO acts as designated or elected Office (Art. 22(1) and (3) and 39(1) PCT), to enter the European phase before the EPO, the **following acts** must be performed by the applicant within **31 months** from the date of filing of the international application or (where applicable) the earliest priority date:
- a) Supply a translation of the international application into an EPO official language, if the International Bureau did not publish the application in such language (Art. 22(1) PCT and R. 159(1)(a) EPC);
 - b) Specify the application documents, as originally filed or as amended, on which the European grant procedure is to be based (R. 159(1)(c) EPC);
 - c) Pay the filing fee and, where applicable, the additional fee for a European patent application comprising more than 35 pages (R. 159(1)(c) EPC, Art. 2, items 1, 1a Rules relating to Fees);
 - d) Pay the search fee where a supplementary European search report has to be drawn up (R. 159(1)(e) EPC);
 - e) Pay the designation fee if the time limit laid down in Rule 39(1) EPC (i.e. six months after publication of the international search report) has expired before the 31-month period pursuant to Rule 159(1) EPC (R. 159(1)(d) EPC);
 - f) File the written request for examination and pay the examination fee if the time limit laid down in Rule 70(1) EPC has expired before the 31-month period pursuant to Rule 159(1) EPC (R. 159(1)(f) EPC);
 - g) Pay the renewal fee in respect of the third year, if the fee has fallen due (see Rule 51(1) EPC) before expiry of the 31-month period pursuant to Rule 159(1) EPC (R. 159(1)(g) EPC);
 - h) File, where applicable, the certificate of exhibition referred to in Article 55(2) and Rule 25 EPC (R. 159(1)(h) EPC);
 - i) Pay the claims fees for the sixteenth and each subsequent claim when the application documents on which the European grant procedure is to be based comprise more than fifteen claims (R. 162(1) EPC). For applications entering the European phase on or after 1 April 2009, a higher amount is payable for the 51st and each subsequent claim (Decision of the Administrative Council of 14 December 2007 amending the Rules relating to Fees, OJ EPO 2008, 10).

If either the translation of the international application or the request for examination is not filed in time, or if the filing fee, the additional fee, the search fee, the designation fee or the examination fee is not paid in due time, the application shall be deemed to be withdrawn (R. 160(1) EPC).

6. Payment of fees

The amounts of fees are set out in the Schedule of fees and expenses, which is published from time to time as a supplement to the Official Journal of the EPO. Applicants should always check the fee amounts applying at the time of payment.

Payments can be validly made by any person. Permissible methods of payment are laid down in Article 5 RFees. Please note that payment cannot be made by cheque sent to the EPO.

For information on the calculation of the additional fee for applications comprising more than 35 pages, see Notice from the European Patent Office dated 26 January 2009 concerning the 2009 fee structure, OJ EPO 2/2009, 118, and Guidelines for Examination in the EPO, April 2009, A-III, 13.2. For an overview of search and examination fees, see Notice from the European Patent Office of 11 February 2008 (OJ EPO 2008, 130).

The above and further fee-related information is available on the EPO website (<http://www.epo.org>).

-
7. If the applicant had appointed a representative during the application's international phase, the present Form will be sent to the representative, asking him to inform the applicant accordingly.

All subsequent communications will be sent to the applicant, or - if the EPO is informed of his appointment in time - to the applicant's European representative.

8. For more details about time limits and procedural acts before the EPO as designated or elected Office, see the EPO brochure "How to get a European patent", Guide for applicants - Part 2, PCT procedure before the EPO - "Euro-PCT".

This brochure, the list of professional representatives before the EPO as well as Form 1200 are available on the Internet under <http://www.epo.org>.

Receiving Section



PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P81166PC00	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/NL2008/050247	International filing date (day/month/year) 25.04.2008	Priority date (day/month/year) 25.04.2007	
International Patent Classification (IPC) or national classification and IPC INV. G06N7/00			
Applicant Nederlandse Organisatie voor toegepast-			
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of <u>6</u> sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☐ <i>sent to the applicant and to the International Bureau</i> a total of sheets, as follows: ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions). ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box. b. ☐ <i>(sent to the International Bureau only)</i> a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).			
4. This report contains indications relating to the following items: ☒ Box No. I Basis of the report ☒ Box No. II Priority ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability ☐ Box No. IV Lack of unity of invention ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement ☒ Box No. VI Certain documents cited ☐ Box No. VII Certain defects in the international application ☐ Box No. VIII Certain observations on the international application			
Date of submission of the demand 2009-02-06		Date of completion of this report 13.07.2009	
Name and mailing address of the international preliminary examining authority:  European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016		Authorized officer Douarche, Nicolas Telephone No. +31 70 340-4636 	

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P81166PC00	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/NL2008/050247	International filing date (<i>day/month/year</i>) 25.04.2008	Priority date (<i>day/month/year</i>) 25.04.2007	
International Patent Classification (IPC) or national classification and IPC INV. G06N7/00			
Applicant Nederlandse Organisatie voor toegepast-			
1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36. 2. This REPORT consists of a total of <u>6</u> sheets, including this cover sheet. 3. This report is also accompanied by ANNEXES, comprising: a. ☐ <i>sent to the applicant and to the International Bureau</i> a total of sheets, as follows: ☐ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions). ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box. b. ☐ <i>(sent to the International Bureau only)</i> a total of (indicate type and number of electronic carrier(s)) , containing a sequence listing and/or tables related thereto, in electronic form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).			
4. This report contains indications relating to the following items: ☒ Box No. I Basis of the report ☒ Box No. II Priority ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability ☐ Box No. IV Lack of unity of invention ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement ☒ Box No. VI Certain documents cited ☐ Box No. VII Certain defects in the international application ☐ Box No. VIII Certain observations on the international application			
Date of submission of the demand 2009-02-06		Date of completion of this report 13.07.2009	
Name and mailing address of the international preliminary examining authority:  European Patent Office P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Fax: +31 70 340 - 3016		Authorized officer Douarche, Nicolas Telephone No. +31 70 340-4636 	

Reference is made to the following documents:

- D1** Raaijmakers; Proceedings of ADKDD'07, pp. 34-39; August 2007;
- D2** AMIDA Project; Deliverable 5.2, chapter 3; December 2007;
- D3** de Boer et al; Annals of Operations Research, vol. 134(1), pp. 19-67; February 2005;
- D4** Mannor et al; Proceedings of ICML'05, pp. 561-568; August 2005.

The primary document **D4** refers explicitly to the document **D3** (see "de-Boer et al. (2005)" in section 2) as providing more detailed information on certain features. Since **D3** was available to the public on the publication date of **D4**, the teachings of the document **D3** are to be regarded as incorporated into the primary document **D4** (see GL, 12.06).

Item V: Novelty, inventive step or industrial applicability

- 1.1 Independent claim 1: the document **D4** discloses
 - (a) "A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10)". See (equation 1) in **D4**;
 - (b) "by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of: drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and updating the estimate of the target hyperparameter vector by using the random sample". In **D4**, see (section 2) for the items "1." & "2." that follow "Once the associated stochastic optimization is defined, the CE method alternates the following two phases:";
 - (b) "the method being characterised in that each iteration comprises the step of: selecting from the random sample a hyperparameter vector producing the best result in the present [...] iteration[s], and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector". In **D4**, see (equation 4) that "involves" the " $Z^{(i)}$ " which produces the minimum cost " $S_{(1)}$ " (defined in item "1. Adaptive updating of γ_t ").
- 1.2 Claim 1 therefore differs from **D4** in that "said selected hyperparameter vector" is "producing the best result in [...] any previous iterations", not only "in the present" one as in **D4**. However, *no unexpected special technical effect* can be associated with such a distinguishing feature. *The independent claim 1 is therefore not*

inventive (Art. 33(3) PCT).

The arguments given in points 1.1 & 1.2 for the independent claim 1 apply *mutatis mutandis* to *the corresponding independent claims 10-12 which are therefore not inventive (Art. 33(3) PCT).*

- 1.3 *The dependent claims 2-9, 13 & 14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step (Art. 33(3) PCT).*

In particular, the examiner fails to find any feature in the application as filed that would have the potential to contribute to the solution of a technical problem, thereby defining an inventive step in the sense of Art. 33(3) PCT.

For example, although "the weighting function W" recited in claim 8 (or page 4 of the description) differs from the alternatives which **D4** discloses, such a distinguishing feature does not solve a technical problem.

Items II & VI: Priority & Certain documents cited

- 2.1 The documents **D1** & **D2** were both published prior to the international filing date (25.04.2008) but later than the two priority claims:
- prioA** Application number 07106963; filing date: 25.04.2007; publication date: 29.10.2008;
- prioB** Application number 07112037; filing date: 09.07.2007.
- The priority claim **prioB** is valid, and **D1** & **D2** cannot be used to assess novelty and/or inventiveness of the subject-matter claimed by the present application.*
- 2.2 However, as identified in the international search report, both **D1** & **D2** refer to the same two disclosures made by the inventor of the present application:
- ref1** "Raaijmakers. Hyperparameter estimation with an elitist cross-entropy method. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/multinomial-language-learning-v2.pdf>";
- ref2** "Raaijmakers. Language learning with information diffusion kernels. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/ce-hyperparam.pdf>".
- The hyperlinks imply that both **ref1** & **ref2** could be downloaded as "pdf"

- documents, i.e. were available to the public, in May 2007 (".../2007/05/...") that is prior to **prioB** but later than **prioA**.
- 2.3 Although **ref1** & **ref2** were not available anymore at the date of completion of the international search the present communication further considers, for the sake of completeness, the validity of **prioA**.
- 3.1 The present application seeks protection for "selecting [...] a vector producing the best result in [...] any previous iterations" (claims 1, 2, 4, 12 & 13) and "using the [...] selected [...] vector" (claims 1-3, 7 & 13).
- 3.2 The claimed priority document **prioA** does not support such added subject-matters. They are not explicitly disclosed in **prioA**, and **prioA** does not contain any elements from which the skilled person could derive them in a direct and unambiguous way.
- 3.3 The embodiments disclosed by **prioA** select "a vector producing the best result in the present iteration" only (e.g. claim 1; page 7, line 11) and uses "the best sample of the previous iteration" (e.g. page 7, lines 9 & 26; page 8, lines 5-7), not "any previous iterations" as presently claimed.
- 3.4 The same objection applies mutatis mutandis to the following passages of the present description: (page 2, lines 21-29), (page 3, lines 10-19 & 22-24), (page 5, lines 5-8), (page 7, lines 13-14), (page 8, lines 10-11 & 13), and (page 9, line 8).
- 3.5 *As a result, the priority claim **prioA** is invalid (Art. 8(2)(a) PCT & GL 6.10). To assess novelty and/or inventiveness of the claimed subject-matter, the priority claim **prioB** (09.07.2007) is the relevant date (Rules 43bis.1 & 64.1(b)(ii) PCT).*

Reference is made to the following documents:

- D1** Raaijmakers; Proceedings of ADKDD'07, pp. 34-39; August 2007;
- D2** AMIDA Project; Deliverable 5.2, chapter 3; December 2007;
- D3** de Boer et al; Annals of Operations Research, vol. 134(1), pp. 19-67; February 2005;
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The primary document **D4** refers explicitly to the document **D3** (see "de-Boer et al. (2005)" in section 2) as providing more detailed information on certain features. Since **D3** was available to the public on the publication date of **D4**, the teachings of the document **D3** are to be regarded as incorporated into the primary document **D4** (see GL, 12.06).

Item V: Novelty, inventive step or industrial applicability

- 1.1 Independent claim 1: the document **D4** discloses
 - (a) "A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10)". See (equation 1) in **D4**;
 - (b) "by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of: drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and updating the estimate of the target hyperparameter vector by using the random sample". In **D4**, see (section 2) for the items "1." & "2." that follow "Once the associated stochastic optimization is defined, the CE method alternates the following two phases:";
 - (b) "the method being characterised in that each iteration comprises the step of: selecting from the random sample a hyperparameter vector producing the best result in the present [...] iteration[s], and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector". In **D4**, see (equation 4) that "involves" the " $Z^{(i)}$ " which produces the minimum cost " $S_{(1)}$ " (defined in item "1. Adaptive updating of γ_t ").
- 1.2 Claim 1 therefore differs from **D4** in that "said selected hyperparameter vector" is "producing the best result in [...] any previous iterations", not only "in the present" one as in **D4**. However, *no unexpected special technical effect* can be associated with such a distinguishing feature. *The independent claim 1 is therefore not*

inventive (Art. 33(3) PCT).

The arguments given in points 1.1 & 1.2 for the independent claim 1 apply *mutatis mutandis* to *the corresponding independent claims 10-12 which are therefore not inventive (Art. 33(3) PCT).*

- 1.3 *The dependent claims 2-9, 13 & 14 do not contain any features which, in combination with the features of any claim to which they refer, meet the requirements of the PCT in respect of inventive step (Art. 33(3) PCT).*

In particular, the examiner fails to find any feature in the application as filed that would have the potential to contribute to the solution of a technical problem, thereby defining an inventive step in the sense of Art. 33(3) PCT.

For example, although "the weighting function W" recited in claim 8 (or page 4 of the description) differs from the alternatives which **D4** discloses, such a distinguishing feature does not solve a technical problem.

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- prioA** Application number 07106963; filing date: 25.04.2007; publication date: 29.10.2008;
- prioB** Application number 07112037; filing date: 09.07.2007.
- The priority claim **prioB** is valid, and **D1** & **D2** cannot be used to assess novelty and/or inventiveness of the subject-matter claimed by the present application.*
- 2.2 However, as identified in the international search report, both **D1** & **D2** refer to the same two disclosures made by the inventor of the present application:
- ref1** "Raaijmakers. Hyperparameter estimation with an elitist cross-entropy method. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/multinomial-language-learning-v2.pdf>";
- ref2** "Raaijmakers. Language learning with information diffusion kernels. 2007. Technical report, TNO ICT, 2007. Available from <http://stephanraaijmakers.files.wordpress.com/2007/05/ce-hyperparam.pdf>".
- The hyperlinks imply that both **ref1** & **ref2** could be downloaded as "pdf"

- documents, i.e. were available to the public, in May 2007 (".../2007/05/...") that is prior to **prioB** but later than **prioA**.
- 2.3 Although **ref1** & **ref2** were not available anymore at the date of completion of the international search the present communication further considers, for the sake of completeness, the validity of **prioA**.
- 3.1 The present application seeks protection for "selecting [...] a vector producing the best result in [...] any previous iterations" (claims 1, 2, 4, 12 & 13) and "using the [...] selected [...] vector" (claims 1-3, 7 & 13).
- 3.2 The claimed priority document **prioA** does not support such added subject-matters. They are not explicitly disclosed in **prioA**, and **prioA** does not contain any elements from which the skilled person could derive them in a direct and unambiguous way.
- 3.3 The embodiments disclosed by **prioA** select "a vector producing the best result in the present iteration" only (e.g. claim 1; page 7, line 11) and uses "the best sample of the previous iteration" (e.g. page 7, lines 9 & 26; page 8, lines 5-7), not "any previous iterations" as presently claimed.
- 3.4 The same objection applies mutatis mutandis to the following passages of the present description: (page 2, lines 21-29), (page 3, lines 10-19 & 22-24), (page 5, lines 5-8), (page 7, lines 13-14), (page 8, lines 10-11 & 13), and (page 9, line 8).
- 3.5 *As a result, the priority claim **prioA** is invalid (Art. 8(2)(a) PCT & GL 6.10). To assess novelty and/or inventiveness of the claimed subject-matter, the priority claim **prioB** (09.07.2007) is the relevant date (Rules 43bis.1 & 64.1(b)(ii) PCT).*

Box No. I Basis of the report

1. With regard to the **language**, this report is based on
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a))
2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report)*:

Description, Pages

1-10 as originally filed

Claims, Numbers

1-14 as originally filed

Drawings, Sheets

1 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
5. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 70.2 (e)).
6. ☐ Supplementary international search report(s) from Authority(ies) have been received and taken into account in drawing up this report (Rule 45bis.8(b) and (c)).

**INTERNATIONAL PRELIMINARY REPORT
ON PATENTABILITY**

International application No.
PCT/NL2008/050247

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
- ☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
 - ☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:
- see separate sheet**

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-14</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-14</u>
Industrial applicability (IA)	Yes: Claims	<u>1-14</u>
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

Box No. I Basis of the report

1. With regard to the **language**, this report is based on
- ☒ the international application in the language in which it was filed
 - ☐ a translation of the international application into , which is the language of a translation furnished for the purposes of:
 - ☐ international search (under Rules 12.3(a) and 23.1(b))
 - ☐ publication of the international application (under Rule 12.4(a))
 - ☐ international preliminary examination (under Rules 55.2(a) and/or 55.3(a))
2. With regard to the **elements*** of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

Description, Pages

1-10 as originally filed

Claims, Numbers

1-14 as originally filed

Drawings, Sheets

1 as originally filed

- ☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing
3. ☐ The amendments have resulted in the cancellation of:
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).
- ☐ the description, pages
 - ☐ the claims, Nos.
 - ☐ the drawings, sheets/figs
 - ☐ the sequence listing (*specify*):
 - ☐ any table(s) related to sequence listing (*specify*):
5. ☐ This opinion has been established taking into account the **rectification of an obvious mistake** authorized by or notified to this Authority under Rule 91 (Rule 70.2 (e)).
6. ☐ Supplementary international search report(s) from Authority(ies) have been received and taken into account in drawing up this report (Rule 45bis.8(b) and (c)).

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/NL2008/050247

Box No. II Priority

1. ☐ This report has been established as if no priority had been claimed due to the failure to furnish within the prescribed time limit the requested:
☐ copy of the earlier application whose priority has been claimed (Rule 66.7(a)).
☐ translation of the earlier application whose priority has been claimed (Rule 66.7(b)).
2. ☐ This report has been established as if no priority had been claimed due to the fact that the priority claim has been found invalid (Rule 64.1). Thus for the purposes of this report, the international filing date indicated above is considered to be the relevant date.
3. Additional observations, if necessary:
see separate sheet

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes: Claims	<u>1-14</u>
	No: Claims	
Inventive step (IS)	Yes: Claims	
	No: Claims	<u>1-14</u>
Industrial applicability (IA)	Yes: Claims	<u>1-14</u>
	No: Claims	

2. Citations and explanations (Rule 70.7):

see separate sheet

Box No. VI Certain documents cited

1. Certain published documents (Rule 70.10)

and / or

2. Non-written disclosures (Rule 70.9)

see separate sheet

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

The International Bureau of WIPO
34, chemin des Colombettes
CH - 1211 Geneva 20
Switzerland

PCT

NOTIFICATION CONCERNING
DOCUMENTS TRANSMITTED

Date of mailing
(day/month/year)

13.07.2009

International application No: PCT/NL2008/050247

This International Preliminary Examining Authority transmits herewith the following documents:

1. ☐ demand (Rule 61.1(a)).
2. ☒ copy of the international preliminary examination report and its annexes (Rule 71.1).
3. ☐ _____ other documents (*specify*):

Name and mailing address of the international
preliminary examining authority:



European Patent Office P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040
Fax: +31 70 340 - 3016

Authorized Officer

Bota-Madsen, Zorka

Tel. +31 70 340-2393



PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY (PCT Rule 71.1)

To:

VEREENIGDE
Johan de Wittlaan 7
2517 JR Den Haag
PAYS-BAS

Date of mailing
(day/month/year)

13.07.2009

Applicant's or agent's file reference
P81166PC00

IMPORTANT NOTIFICATION

International application No.
PCT/NL2008/050247

International filing date (day/month/year)
25.04.2008

Priority date (day/month/year)
25.04.2007

Applicant
Nederlandse Organisatie voor toegepast-

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary report on patentability and its annexes, if any, established on the international application.
2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.
3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. REMINDER

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary report on patentability. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

The applicant's attention is drawn to Article 33(5), which provides that the criteria of novelty, inventive step and industrial applicability described in Article 33(2) to (4) merely serve the purposes of international preliminary examination and that "any Contracting State may apply additional or different criteria for the purposes of deciding whether, in that State, the claimed inventions is patentable or not" (see also Article 27(5)). Such additional criteria may relate, for example, to exemptions from patentability, requirements for enabling disclosure, clarity and support for the claims.

Name and mailing address of the international
preliminary examining authority:



European Patent Office P.B. 5818 Patentlaan 2
NL-2280 HV Rijswijk - Pays Bas
Tel. +31 70 340 - 2040
Fax: +31 70 340 - 3016

Authorized Officer

Bota-Madsen, Zorka

Tel. +31 70 340-2393



From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Article 31(7) and Rule 61.2)

To:

European Patent Office
Postbus 5818
Patentlaan 2
NL-2280 HV RIJSWIJK
PAYS-BAS

in its capacity as elected Office

Date of mailing (*day/month/year*)

19 March 2009 (19.03.2009)

International application No.

PCT/NL2008/050247

Applicant's or agent's file reference

P81166PC00

International filing date (*day/month/year*)

25 April 2008 (25.04.2008)

Priority date (*day/month/year*)

25 April 2007 (25.04.2007)

Applicant

NEDERLANDSE ORGANISATIE VOOR TOEGEPAST-NATUURWETENSCHAPPELIJK ONDERZOEK TNO et al

1. The designated Office is hereby notified of its election made in the demand filed with the International Preliminary Examining Authority on:

06 February 2009 (06.02.2009)

2. The election

☐

was

☒

was not

made before the expiration of 19 months from the priority date (PCT Article 39(1)(a)).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No. +41 22 338 82 70

Authorized officer

Nora Lindner

e-mail: pt11.pct@wipo.int

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

The International Bureau of WIPO
34, Chemin des Colombettes
1211 Geneva 20
SUISSE

NOTIFICATION CONCERNING
DOCUMENTS TRANSMITTED

Date of mailing
(day/month/year)

17-02-2009

International application No: **PCT/NL2008/050247**

This International Preliminary Examination Authority transmits herewith the following documents:

1. ☒ demand (Rule 61.1(a)).
2. ☐ copy of the international preliminary examination report and its annexes (Rule 71.1).
3. ☒ — other documents (*specify*):

Copy of form PCT/IPEA/402

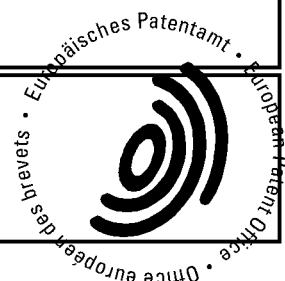
Name and mailing address of the IPEA/



European Patent Office
D-80298 Munich
Tel. (+49-89) 2399-0
Fax: (+49-89) 2399-4465

Authorized officer

Verwer, Marlies
Tel: (+31-70)340-3644



PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

PCT

To:

HATZMANN, M.J.
VEREENIGDE
Johan de Wittlaan 7
2517 JR Den Haag
PAYS-BAS

NOTIFICATION OF RECEIPT OF DEMAND BY COMPETENT INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

(PCT Rules 59.3(e) and 61.1(b), first sentence
and Administrative Instructions, Section 601(a))

Date of mailing
(day/month/year)

17-02-2009

Applicant's or agent's file reference
P81166PC00

IMPORTANT NOTIFICATION

International application No.

PCT/NL2008/050247

International filing date (day/month/year)

25 April 2008 (25-04-2008)

Priority date (day/month/year)

25 April 2007 (25-04-2007)

Applicant

NEDERLANDSE ORGANISATIE VOOR TOEGEPAST NATUURWETEN

1. The applicant is hereby **notified** that this International Preliminary Examining Authority considers the following date as the date of receipt of the demand for international preliminary examination of the international application:

6 February 2009 (06-02-2009)

2. This date of receipt is:



the actual date of receipt of the demand by this Authority (Rule 61.1(b)).



the actual date of receipt of the demand on behalf of this Authority (Rule 59.3(e)).



the date on which this Authority has, in response to the invitation to correct defects in the demand (Form PCT/IPEA/404), received the required corrections.

3. ☒ **ATTENTION:** That date of receipt is **after** the expiration of 19 months from the priority date. Consequently, in respect of some Offices, the demand does not have the effect of postponing the entry into the national phase until 30 months from the priority date (or later in some Offices) (Article 39(1)) and the acts for entry into the national phase must therefore be performed within 20 months from the priority date (or later in some Offices). **However**, in respect of some other Offices, the time limit of 30 months (or later) may nevertheless apply. See the Annex to Form PCT/IB/301 and, for details about the applicable time limits, Office by Office, see the *PCT Applicant's Guide*, Volume II, National Chapters and the WIPO Internet site.



(If applicable) This notification confirms the information given by telephone, facsimile transmission or in person on:

4. Only where paragraph 3 applies, a copy of this notification has been sent to the International Bureau.

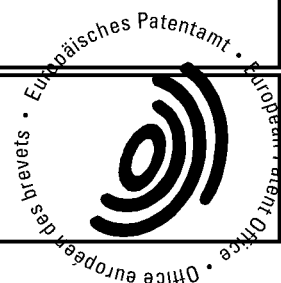
Name and mailing address of the IPEA/



European Patent Office
D-80298 Munich
Tel. (+49-89) 2399-0
Fax: (+49-89) 2399-4465

Authorized officer

Verwer, Marlies
Tel: (+31-70)340-3644



The demand must be filed directly with the competent International Preliminary Examining Authority or, if two or more Authorities are competent, with the one chosen by the applicant. The full name or two-letter code of that Authority may be indicated by the applicant on the line below:

IPEA/ EP

PCT

CHAPTER II

DEMAND

EP-DG 1

06-02-2009

under Article 31 of the Patent Cooperation Treaty:

The undersigned requests that the international application specified below be the subject of international preliminary examination according to the Patent Cooperation Treaty and hereby elects all eligible States (except where otherwise indicated).

103

For International Preliminary Examining Authority use only

Identification of IPEA		Date of receipt of DEMAND	
EP		06-02-2009	
Box No. I IDENTIFICATION OF THE INTERNATIONAL APPLICATION			Applicant's or agent's file reference
			P81166PC00
International application No.	International filing date (day/month/year)	(Earliest) Priority date (day/month/year)	
PCT/NL2008/050247	25 April 2008	25 April 2007	
Title of invention MACHINE LEARNING HYPERPARAMETER ESTIMATION			
Box No. II APPLICANT(S)			
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)		Telephone No.	
Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek TNO		Facsimile No.	
Schoemakerstraat 97		Teleprinter No.	
2628 VK Delft		Applicant's registration No. with the Office	
The Netherlands			
State (that is, country) of nationality: NL		State (that is, country) of residence: NL	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)			
Raaijmakers, Stephan Alexander Borgerstraat 222-II 1053 RE Amsterdam The Netherlands			
State (that is, country) of nationality: NL		State (that is, country) of residence: NL	
Name and address: (Family name followed by given name; for a legal entity, full official designation. The address must include postal code and name of country.)			
ZUR KASSE Ew. 1,804.-			
State (that is, country) of nationality:		State (that is, country) of residence:	
☐ Further applicants are indicated on a continuation sheet.			

Box No. III AGENT OR COMMON REPRESENTATIVE; OR ADDRESS FOR CORRESPONDENCE

The following person is ☒ agent ☐ common representative
 and ☒ has been appointed earlier and represents the applicant(s) also for international preliminary examination.
☐ is hereby appointed and any earlier appointment of (an) agent(s)/common representative is hereby revoked.
☐ is hereby appointed, specifically for the procedure before the International Preliminary Examining Authority, in addition to the agent(s)/common representative appointed earlier.

Name and address: (Family name followed by given name; for a legal entity, full official designation.
 The address must include postal code and name of country.)

Hatzmann, M.J.
 c/o VEREENIGDE
 Johan de Wittlaan 7
 2517 JR The Hague
 The Netherlands

Telephone No.

070-4166711

Facsimile No.

070-4166799

Teleprinter No.

Agent's registration No. with the Office

☐ **Address for correspondence:** Mark this check-box where no agent or common representative is/has been appointed and the space above is used instead to indicate a special address to which correspondence should be sent.

Box No. IV BASIS FOR INTERNATIONAL PRELIMINARY EXAMINATION**Statement concerning amendments:***

1. The applicant wishes the international preliminary examination to start on the basis of:

☐ the international application as originally filed

the description

☐

as originally filed

☐

as amended under Article 34

the claims

☐

as originally filed

☐

as amended under Article 19 (together with any accompanying statement)

☐

as amended under Article 34

the drawings

☐

as originally filed

☐

as amended under Article 34

2. ☐ The applicant wishes any amendment to the claims under Article 19 to be considered as reversed.

3. ☐ The applicant wishes the start of the international preliminary examination to be postponed until the expiration of 20 months from the priority date unless the International Preliminary Examining Authority receives a copy of any amendments made under Article 19 or a notice from the applicant that he does not wish to make such amendments (Rule 69.1(d)). (This check-box may be marked only where the time limit under Article 19 has not yet expired.)

* Where no check-box is marked, international preliminary examination will start on the basis of the international application as originally filed or, where a copy of amendments to the claims under Article 19 and/or amendments of the international application under Article 34 are received by the International Preliminary Examining Authority before it has begun to draw up a written opinion or the international preliminary examination report, as so amended.

Language for the purposes of international preliminary examination: English

☒

which is the language in which the international application was filed.

☐

which is the language of a translation furnished for the purposes of international search.

☐

which is the language of publication of the international application.

☐

which is the language of the translation (to be) furnished for the purposes of international preliminary examination.

Box No. V ELECTION OF STATES

The applicant hereby elects all eligible States (that is, all States which have been designated and which are bound by Chapter II of the PCT)

excluding the following States which the applicant wishes not to elect:

Box No. VI CHECK LIST

The demand is accompanied by the following elements, in the language referred to in Box No. IV, for the purposes of international preliminary examination:

- | | | |
|--|---|----------|
| 1. translation of international application | : | sheets |
| 2. amendments under Article 34 | : | sheets |
| 3. copy (or, where required, translation) of amendments under Article 19 | : | sheets |
| 4. copy (or, where required, translation) of statement under Article 19 | : | sheets |
| 5. letter | : | 2 sheets |
| 6. other (<i>specify</i>) | : | sheets |

For International Preliminary
Examining Authority use only

received not received

☐	☐
☐	☐
☐	☐
☐	☐
☐	☐
☐	☐

The demand is also accompanied by the item(s) marked below:

- | | |
|---|--|
| 1. ☒ fee calculation sheet | 5. ☐ statement explaining lack of signature |
| 2. ☐ original separate power of attorney | 6. ☐ sequence listing in computer readable form |
| 3. ☐ original general power of attorney | 7. ☐ other (<i>specify</i>): |
| 4. ☐ copy of general power of attorney;
reference number, if any: | |

Box No. VII SIGNATURE OF APPLICANT, AGENT OR COMMON REPRESENTATIVE

Next to each signature, indicate the name of the person signing and the capacity in which the person signs (if such capacity is not obvious from reading the demand).



L.J. de Haas

For International Preliminary Examining Authority use only

1. Date of actual receipt of DEMAND: 06-02-2009

2. Adjusted date of receipt of demand due to CORRECTIONS under Rule 60.1(b):

3. ☒ The date of receipt of the demand is AFTER the expiration of 19 months from the priority date and item 4 or 5, below, does not apply.

☒ The applicant has been informed accordingly.

4. ☐ The date of receipt of the demand is WITHIN the period of 19 months from the priority date as extended by virtue of Rule 80.5.

5. ☐ Although the date of receipt of the demand is after the expiration of 19 months from the priority date, the delay in arrival is EXCUSED pursuant to Rule 82.

For International Bureau use only

Demand received from IPEA on:



European Patent Office
P.B. 5818
2280 HV Rijswijk

EPO-DG 1

06-02-2009

103

Vereenigde Octrooibureaux N.V.
Johan de Wittlaan 7

P.O. Box 87930
2508 DH Den Haag
The Netherlands

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Telefax + 31 70 416 67 99

patent@vereenigde.nl
trademark@vereenigde.nl
legal@vereenigde.nl
www.vereenigde.com

Your ref. PCT/NL2008/050247
Our ref. LH/P81166PC00

The Hague,
February 6, 2009

Re: International Patent Application No. PCT/NL2008/050247
Nederlandse Organisatie voor toegepast-
natuurwetenschappelijk onderzoek TNO

Arguments submitted in response to the written opinion

Priority

- 5 The written opinion mailed 09/10/2008 appears to have overlooked one of applicants' priority claims.

10 The application as filed on April 25, 2008 claims the priority of a first priority document EP07106963.7 (25.04.2007) and a second priority document EP07112037.2 (09.07.2007). The claims of the present PCT application are a one to one copy of the claims of the second priority document.

15 The points Re Item II of the written opinion discuss only the first priority document, concluding that the priority claim to this document is invalid. From this a conclusion is drawn that novelty and inventiveness should be assessed relative to an alleged international filing date of May 9, 2008. With that priority the inventors' own publication (D1) dated August 12, 2007 was found to be damaging.

20 The written opinion made no finding with respect to the second priority document. In view of the one to one relation of the claims of this second priority document and the claims of the present PCT application, it would have been inescapable that either the claimed priority from the first document is valid or the PCT application would have



valid priority from the second priority document. Thus both priority documents predate the allegedly damaging publication of August 12, 2007.

Even apart from the obvious error in the PCT filing date in point 1.5 (should be April 25, 2008 rather than May 9, 2008), the assigned priority date is therefore obviously wrong and the finding of lack of novelty of inventive step is unfounded.

A withdrawal of the finding of an earliest priority on May 9, 2008 is requested. As a consequence it is also requested to withdraw the finding of lack and novelty and inventive step based on documents published after the second priority date.

As no documents have been found with a publication date between the first and second priority date, there is no reason for discussing the question whether the present PCT application has a right to priority of the first priority date (and of course no decision can be reached about this at the PCT stage). Therefore applicant files no arguments about this, without prejudice to the right to raise such arguments later, if needed.

The documents cited in the search report but not in the written opinion

It is noted that the search report identifies three other documents as “X” for all claims, although the written opinion relies only on D1 as a basis for the novelty objection.

The first of the other “X” documents (D2=XP002496842) is identified in the search report as “P”. Its publication date is not clear, but the document bears a “due date” of 30/11/2007 and a “submission date” of 07/12/2007. Therefore, there is no suggestion that the document was published before the second priority date.

The third and fourth “X” document (D3=de Boer et al, D4 Mannor et al) are mentioned as prior art in the present application and the reason why they are different from the present application is explained (page 1 lines 22 page 2 line 9).

It will be recalled that the present application concerns the determination of hyperparameters of a classifier, i.e. parameters, such as threshold values, that determine the decision function of the classifier.

As claimed, this involves computing updated estimations of a target hyperparameter vector in successive iterations. In each iteration, the update involves drawing a random sample of hyperparameter vectors X. In an embodiment, the target hyperparameter vector is used to restrict the range from which the random sample is selected in the next iteration. The samples are used to update the estimated target hyperparameter vector.



This involves an application of a modified version of a known cross-entropy technique to determination of hyperparameters of a classifier. Conventionally, cross-entropy techniques are used to determine statistics of events in the case that the statistics depend heavily on “rare” events. Cross-entropy techniques are also used in search problems that can be reformulated into such statistical problems. The cross-entropy technique involves generating a random sample of events random with probabilities according to an adaptable probability density, in which relevant rare events are made more probable.

Cross-entropy involves a weight function $W()$ that accounts for the difference between the real probability density and the adapted probability density that was used to obtain the random sample of events. This makes it possible to get fair estimates also for quantities that depend heavily on “rare” events, i.e. events that would occur only rarely if a standard probability distribution was used. The cross entropy technique expresses this probability density in terms of a parameter vector that is computed by formula that bears some resemblance to formula (2) of the present application, used for determining the successively updated estimations of the target hyperparameter vector. This formula has an indicator function $I()$ to select best ranking events and a weight function $W()$, to weigh the contributions of these events. In cross-entropy techniques, the weight function $W()$ accounts for the difference between the real probability density and the adapted probability density that was used to obtain the random sample of events. Much of the effort of cross-entropy techniques is involved in deriving the weight function from the real probability density, which requires use of continuous probability density functions.

In the claimed method of the present application hyperparameter vectors E are selected that produce best results in the iterations. The selected “best” hyperparameter vector E is used to update the estimated target hyperparameter vector for the next iteration. In an embodiment, the “best” hyperparameter vector is used to compute weights to be assigned to different hyperparameter vectors when they are combined to form the updated version of the target hyperparameter vector. The use of the “best” hyperparameter vectors solves the problem of guiding the selection of the estimated target hyperparameter without using the classical parameterized probability density functions used in known cross-entropy techniques. In the embodiment of the present invention with iterations wherein weights are used, a weight function $W()$ is determined from the “best” hyperparameter vectors found for the iterations.

Document D3 discloses the conventional cross-entropy method, but not the application to selection of hyperparameter vectors for a classifier, or the modification of using the “best” hyperparameter vectors of the iterations to select the updated target hyperparameter vectors.

D3 illustrates applications of cross-entropy to optimization problems like the travelling salesman problem. This involves a search for an event that minimizes a cost function.



The search is implemented in a series of iterations. In each iteration, a sample of random events is selected, according to the adapted probability density for that iteration. A best performing fraction of events is extracted from the sample and that fraction is used to form an adapted probability density for the next iteration. D3 determines this probability by combining contributions from samples with a formula that bears some resemblance to the formula used by the present application for determining the successively updated estimations of the target hyperparameter vector (formula (2) of the application). This formula has an indicator function $I()$ to select best ranking events and a weight function $W()$, to weigh the contributions of these events. The weight function $W()$ of D3 accounts for the difference between the difference between the adapted probability distribution that was used to obtain the random sample of events.

It should carefully be noted that D3 does not disclose specifically selecting a best vector in the iterations, and in particular not that this best vector is used to determine the updates in the next iteration, let alone using it to compute the weights. Moreover, D3 only describes the application of the technique to optimization (the travelling salesman problem).

D4 discloses an application of cross-entropy techniques to pattern classification. D4 uses a conventional cross-entropy technique to estimate a classification parameter vector "alpha". Like that of D3, the technique of D4 uses iterations with successively adapted probability densities for the selection of samples. The update formula is similar to that of D4, but without weight function. In the case of D4 as well, it should carefully be noted that D4 does not involve specific selection of a best vector in the iterations, or using these best vectors to determine updates, let alone using them to compute any weights.

Summarizing, although D3 and D4 disclose use of a cross-entropy method for estimating parameters, neither discloses specifically selecting a best vector in the iterations, or using selected best vectors to determine updates. Therefore claim 1 is novel over D3 and D4.

Claim 1 also has inventive step. The crucial aspect for the application of cross-entropy D3 and D4 is the ability to parameterize the probability distribution. In the case of selection of hyperparameters this raises a problem, because it is not always clear how the probability distribution of hyperparameters can be parameterized. The present invention solves this problem by using the selected best vectors to determine the updates. As a result, the parameterization of the probability density is merely an optional feature. The present invention provides for an alternative solution that is capable of handling hyperparameters even if they are not continuous parameters and

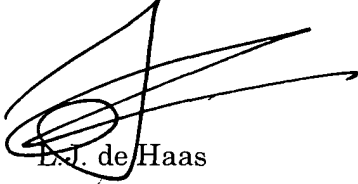
Page 5
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Our ref. LH/P81166PC00
Date February 6, 2009

Patents • Trademarks • Designs



their effects are not transparent.

The agent,



L.J. de Haas

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Bescheinigung

Certificate

Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr.

Patent application No.

Demande de brevet n°

07112037.2 / EP07112037

The organization code and number of your priority application, to be used for filing abroad under the Paris Convention, is EP07112037

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R.C. van Dijk



Anmeldung Nr.:
Application no.: 07112037.2
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2628 VK The Hague/NL

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se référer à la description.)

Machine learning hyperparameter estimation

In anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen / State/Date/File no. / Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation / International Patent Classification / Classification internationale de brevets:

G06F17/30

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AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC MT NL PL PT RO SE SI SK TR

Machine Learning Hyperparameter Estimation

The present invention relates to hyperparameter estimation. More in particular, the present invention relates to a method and device for determining hyperparameters of classifiers in machine learning systems and applications.

Classifiers are used in machine learning systems to classify physical objects and/or their (typically digital) representations. Machine learning systems may, for example, be used to assist fruit picking robots. The classifier of the machine learning system is trained to distinguish ripe fruit (e.g. tomatoes) from unripe fruit. For each fruit item, the classifier determines a set of parameters which are compared with stored parameters in order to classify the items as "ripe" or "unripe". The classification process is, in turn, controlled by hyperparameters which determine, for example, decision criteria such as threshold values.

Classifiers are typically trained using a training set prepared on the basis of human input: an operator indicates the correct classification for the items of the training set. On the basis of these training data, the correct hyperparameters of the classifier can be estimated.

Hyperparameters may be determined using various methods, for example heuristic or statistical optimisation methods. However, many heuristic methods are ad hoc methods, while not all statistical optimisation methods are suitable for determining hyperparameters.

A particularly efficient yet relatively simple method for estimating parameters in general is the cross-entropy (CE) method. This iterative method comprises the repeated steps of drawing, in a parameterised way, a random sample of candidate solutions, and updating the parameters on the basis of the random sample. At the time of writing, the paper "A Tutorial on the Cross-Entropy Method" by P.T. de Boer et al. could be found at <http://iew3.technion.ac.il/CE/tutor.php>, said paper is herewith incorporated in this document in its entirety.

Unfortunately, the cross-entropy method as described in the above-mentioned paper is not suitable for determining hyperparameters. Determining optimal sets of hyperparameter values is a difficult problem due to the extremely large size of the search space: the optimal solution typically is a rare event. While the cross-entropy

method is geared towards sampling rare event spaces, it is not *a priori* clear how the process of drawing hyperparameter values can be parameterised, as the hyperparameter samples are not classical parameterised probability density functions.

5 It is an object of the present invention to overcome these and other problems of the Prior Art and to provide a method and device for determining hyperparameters which allow efficient methods similar to the cross-entropy method to be utilized.

Accordingly, the present invention provides a method of determining hyperparameters of a classifier in a machine learning system by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- 10
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - updating the estimate of the target hyperparameter vector by using the random sample,

the method being characterised in that each iteration comprises the step of:

- 15
- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

By selecting from the random sample a or the hyperparameter vector
 20 producing the best result in the present and any previous iterations, and using said selected hyperparameter vector to update the estimate of the target hyperparameter vector, the properties of the best performing hyperparameters are used to guide the next iteration. In this way, a method similar to the cross-entropy method can be used effectively for determining hyperparameters, even when the hyperparameters are not
 25 continuous and their effects are not transparent.

In the method of the present invention, hyperparameter vectors obtained through randomly sampling a set of hyperparameter vectors are used to estimate a desired (that is, target) hyperparameter vector to be used in the classifier. Each hyperparameter vector preferably comprises two or more elements, that is
 30 hyperparameters, but it is also possible for a hyperparameter vector to contain only a single hyperparameter. Although the samples are preferably completely random, pseudo-random samples may be used instead.

In a preferred embodiment, the method according to the present invention further comprises the steps of:

- selecting from the random sample a further hyperparameter vector producing the best result in any previous iterations, and
- 5 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

The step of restricting the random sample preferably involves the use of an interval surrounding the further selected hyperparameter vector which produces the best result in any previous iteration.

- 10 It is preferred that the step of restricting the random sample is carried out prior to the step of determining the hyperparameter vector producing the best result in the present and any previous iterations. However, in alternative embodiments, the step of restricting the random sample is carried out during the step of updating the estimate of the target hyperparameter vector.

- 15 In a preferred embodiment, E^t is the hyperparameter vector X_i^t at iteration t producing the best result $S(X_i^t)$ in the present iteration t and all previous iterations (if any). The random sample X_i^t has elements X_{ij}^t , while the step of updating the hyperparameters comprises the step of determining the (target) hyperparameter v_j^t , where

$$20 \quad v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value, W is a weighting function and $I\{S(X_i^t) \geq \gamma^t\}$ is an indicator function which is equal to 1 if $S(X_i^t)$ greater than or equal to the threshold value γ^t , and else is equal to 0. The weighting function W is preferably given by

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}}.$$

- 25 Accordingly, the step of updating the hyperparameters may involve a weighting function based upon a distance function, preferably a Euclidean distance function. It

is noted that when the Euclidean distance between E^t and X_{ij}^t is zero, the weighting function W is equal to one.

5 The method according to the present invention is typically carried out by computer apparatus, for example a general purpose computer system comprising a processor and an associated memory, one part of the memory storing a software program for instructing the processor to carry out the method steps of the present invention, and another part of the memory storing data, said data comprising the hyperparameter values referred to above.

10 The present invention also provides a computer program product for carrying out the method as defined above. A computer program product may comprise a set of computer executable instructions stored on a data carrier, such as a CD or a DVD. The set of computer executable instructions, which allows a programmable computer to carry out the method as defined above, may also be available for downloading from a remote server, for example via the Internet.

15 The present invention additionally provides a classifier for use in a machine learning system, the classifier being arranged for using hyperparameters as control parameters, wherein the hyperparameters have been determined by the method according to any of the preceding claims. The classifier is preferably embodied in software, but may also be embodied in hardware, or in a combination of hardware and software.

The present invention still further provides a device for determining hyperparameters of a classifier in a machine learning system, the device comprising a processor arranged for iteratively producing estimates of a target hyperparameter vector, each iteration comprising the steps of:

- 25
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - updating the estimate of the target hyperparameter vector by using the random sample,

the device being characterised in that the processor is arranged such that each iteration comprises the step of:

- 30
- selecting from the random sample a hyperparameter vector producing the best result in the present iteration and any previous iterations, and

in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

The processor may be arranged for carrying out the steps mentioned above by providing a suitable software program in the memory associated with the processor.

5 Alternatively, or additionally, the processor may be designed specifically to carry out the steps mentioned above.

A machine learning system comprising a device as defined above and/or arranged for carrying out the method as defined above is also provided by the present invention. The machine learning system may comprise hardware and/or software
10 components.

The present invention will further be explained below with reference to exemplary embodiments illustrated in the accompanying drawings, in which:

15 Fig. 1 schematically shows a classifier having hyperparameters as input control variables.

Fig. 2 schematically shows a device for determining hyperparameters according to the present invention.

20 Fig. 3 schematically shows a machine learning system according to the present invention.

The classifier (C) 1 shown schematically in Fig. 1 receives feature data FD and hyperparameters HP, and produces classification data CD. The feature data FD
25 may include image data produced by a CCD (Charge Coupled Device) array or other light-sensitive device. Additionally, the feature data FD may include sound data or data concerning database items, such as library data (book numbers and titles). The classifier may be constituted by an apparatus (hardware embodiment), but is preferably constituted by a software program running on a computer apparatus, for
30 example a general purpose computer ("personal computer"), a dedicated computer, or other suitable apparatus.

The classifier 1 is capable of classifying the items represented by the input feature data FD. The feature data FD typically comprise parameters of the items, for example their size and/or colour in the case of fruit or machine parts. Under control of the hyperparameters HP the items are each assigned to a class, for example "ripe" in the case of fruit. At least two different classes are used, and typically an item is assigned to one class only.

The hyperparameters HP determine the decision function of the classifier that classifies items. For example, when this function is based upon thresholding, items producing an aggregate value (derived from the feature values) equal to or greater than the threshold are assigned to class A, while items producing a value smaller than the threshold are assigned to class B. It is noted that other classification techniques may be used as well.

Applications of the classifier 1 include picking fruit, sorting parts (e.g. machine parts), classifying books, selecting songs, recognising adult video material, detecting damage, etc..

The present invention allows a method similar to the cross-entropy (CE) method to be used for estimating and determining hyperparameters. To this end, the present invention proposes to include a memory facility into the algorithm by preserving samples which produce a good result (the result being defined by a suitable function, such as a loss function). Additionally, or alternatively, the sampling of candidate hyperparameter settings is made dependent on the (hyper)parameter vector updated by the algorithm, and/or a suitably weighting function (also known as "change of measure" or "likelihood ratio" in the CE algorithm) guiding the search process should be provided.

The method of the present invention uses parameters N , ρ and μ which are typically predetermined. It is noted that these parameters may be thought of as hyperparameters of the method but are distinct from the hyperparameters to be determined by the method. The parameter N represents the number of random draws; the parameter N may for example be equal to 10, 100 or 1000.

In the iterations a parameter n is used which represents the size of each data vector, that is, the number of elements X_{ij} of each hyperparameter vector X_i of the set of possible hyperparameter vectors. The parameter n may for example be equal to 5,

10 or 100, although other numbers are also possible. The parameter ρ represents a fraction and may have a value ranging from 0.2 to 0.01, although other values may also be used. The width parameter μ , which will be explained in more detail below, indicates a preferred sampling interval.

5 The initial set of target hyperparameters, the hyperparameter vector u , can typically be chosen arbitrarily. Each estimated (target) hyperparameter vector v^t at point in time (or iteration number) t consists of hyperparameters v_j^t .

In the present invention, the "best" hyperparameter vector v of iterations $1 \dots t$ is kept for use in the next iteration and is denoted E^t . This "best" (or "elitist")
 10 hyperparameter vector is found using a function $S(X^t)$ which may be a loss function or any other suitable function producing a result value based upon X^t . The value of $S(X^t)$ may also be viewed as an importance measure. The value of X^t corresponding with the maximum value of $S(X^t)$ is denoted $\text{argmax } S(X^t)$. In addition, the values of $S(X^t)$ are ranked and are used to determine a threshold γ^t , involving ρ and N to
 15 determine the $((1-\rho)N)^{\text{th}}$ value of the ranked values of $S(X^t)$. It is noted that the number $((1-\rho)N)$ is not necessarily an integer and is therefore rounded up, expressed mathematically as $\lceil ((1-\rho)N) \rceil$.

Subsequently, the (target) hyperparameters are determined using an expression involving indicator functions $I\{S(X_i^t) \geq \gamma^t\}$ and weighting functions
 20 $W(X_i^t; E^t)$. The indication functions are equal to 1 when $S(X_i^t) \geq \gamma^t$ and equal to 0 when $S(X_i^t) < \gamma^t$. The weighting functions $W(X_i^t; E^t)$, also known as "change of measure" functions, have the data vector elements X_i (actually X_i^t) and E^t as input variables. This implies that the best data vector E^t of the present iteration is used to determine the (target) hyperparameters.

25 The weighting function $W(X_i^t; E^t)$ is preferably defined as:

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}} \quad (1)$$

This function produces a value of 1 when the Euclidean distance between a sample and the "best" sample is 0.

Accordingly, a preferred embodiment of the method according to the present invention comprises the following steps:

1. Choose initial parameters N , ρ and μ and generate an initial (target) hyperparameter vector u .
- 5 2. Let $v^0 = E^0 = u$ and set iteration number $t = 1$.
3. Generate a random sample $X'_1, \dots, X'_n$ of hyperparameters drawn from a (given) set of possible hyperparameters. The random sample preferably is restricted by v^{t-1} . Compute the performance $S(X'_i)$ for every value of i and rank the results: $S_{(1)} \leq \dots \leq S_{(n)}$. Compute $\gamma^t = S_{\text{percentile}}$ and compute $E^t =$
- 10 $\arg\max_{v_i=1 \dots t} \gamma^t$.
4. For every (target) hyperparameter v'_j let

$$v'_j = \frac{\sum_{i=1}^n I\{S(X'_i) \geq \gamma^t\} W(X'_i; E^t) X'_i}{\sum_{i=1}^n I\{S(X'_i) \geq \gamma^t\} W(X'_i; E^t)} \quad (2)$$

5. Let $t := t+1$, repeat from step 3 until the stopping condition is met.
- The final set v of j (target) hyperparameters v_j is the desired optimal set.
- 15 By using the best sample E^t in hyperparameter estimation / update formula (2), the better results are reinforced, leading to a more efficient convergence of the method. In addition, discontinuity problems associated with hyperparameters are overcome by the method of the present invention.

The stopping criterion (or condition) is preferably a non-changing value of the parameter γ^t during a number of iterations, but could also be a threshold value. The value $S_{\text{percentile}}$ is determined using the $((1-\rho)N)^{\text{th}}$ value of S in the ranking $S_{(1)} \leq \dots \leq S_{(n)}$, where rounding up may be used if this value is not an integer. The weighting function $W(X'_i; E^t)$ used in formula (2) is preferably defined by formula (1) above.

- 25 The method of the present invention may be summarized as deriving a target hyperparameter vector from a random sample of hyperparameter vectors while taking the performance of the hyperparameters of the random sample into account.

The restriction which may be applied when generating a random sample at time t in step 3 may be defined by the interval:

$$[v'_j * (1 - \mu), v'_j * (1 + \mu)] \quad (3)$$

where μ is a width parameter and "*" denoted multiplication. If the sample X'_i lies within this interval, its distance relative to the best sample E'_j of the previous iteration is limited to the value of μ . It is noted that the use of this interval is

5 preferred but not essential as the method of the present invention could be carried out without using this interval.

The device 2 for determining hyperparameters comprises a processor (μ P) 21 and an associated memory (M) 22. The memory stores both instructions for the processor and data. The device 2 receives parameters P (more in general: feature
10 data), such as the parameters ρ and μ mentioned above, and outputs hyperparameters HP. The stored instructions allow the processor to carry out the method according to the present invention.

The machine learning system 10 shown merely by way of non-limiting example in Fig. 3 comprises a classifier (C) 1 and a device (H) 2 for determining
15 hyperparameters. The machine learning system 10 may further comprise at least one sensor (S) 3 and a display screen (D) 4. The sensor 3 serves to collect data while the display screen 4 serves to display classification result and other data.

The present invention is based upon the insight that methods similar to the cross-entropy method can be adapted for hyperparameter estimation by adding a best
20 performance preservation feature. The present invention benefits from the additional insight that the best performance in a particular iteration may be preserved by restricting the sample using the best performance of the previous iterations.

It is noted that any terms used in this document should not be construed so as to limit the scope of the present invention. In particular, the words "comprise(s)" and
25 "comprising" are not meant to exclude any elements not specifically stated. Single (circuit) elements may be substituted with multiple (circuit) elements or with their equivalents.

It will be understood by those skilled in the art that the present invention is not limited to the embodiments illustrated above and that many modifications and
30 additions may be made without departing from the scope of the invention as defined in the appending claims.

Claims

1. A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) by iteratively producing an estimate of a target

5 hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the target hyperparameter vector by using the random sample,

10 the method being characterised in that each iteration comprises the step of:

- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

15

2. The method according to claim 1, further comprising the steps of:

- selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample of hyperparameter vectors by using the further

20

3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.

25

4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

30

5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

5 6. The method according to any of the preceding claims, wherein the step of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E' is the selected hyperparameter vector X'_i at iteration i producing the best result $S(X'_i)$, the
10 selected hyperparameter vector X'_i having elements X'_{ij} , wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v'_j , where

$$v'_j = \frac{\sum_{i=1}^n I\{S(X'_i) \geq \gamma'\} W(X'_i; E') X'_{ij}}{\sum_{i=1}^n I\{S(X'_i) \geq \gamma'\} W(X'_i; E')},$$

wherein γ' is a threshold value and W is a weighting function.

15

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X'_i; E') = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E'_j)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E'_j)^2}}$$

20 9. The method according to any of the preceding claims, carried out by computer apparatus.

10. A computer program product for carrying out the method according to any of the preceding claims.

25

11. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein the

hyperparameters (HP) have been determined by the method according to any of claims 1-9.

12. A device (2) for determining hyperparameters of a classifier (1) in a machine learning system (10), the device comprising a processor (21) arranged for iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the hyperparameter vector by using the random sample,

the device being characterised in that the processor is arranged such that each iteration comprises the step of:

- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

13. The device according to claim 12, wherein the processor (21) is further arranged for:

- selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.

14. A machine learning system (10), comprising a device (2) according to claim 12 or 13.

Abstract

A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) iteratively produces an estimate of a target

5 hyperparameter vector. The method comprises the steps of selecting from the random sample the hyperparameter vector producing the best result in the present and any previous iterations, and updating the estimate of the target hyperparameter vector by using said selected hyperparameter vector. The random sample may be restricted by using the hyperparameter vector producing the best result in the present and any
10 previous iterations.

[Fig. 3]

1 / 1

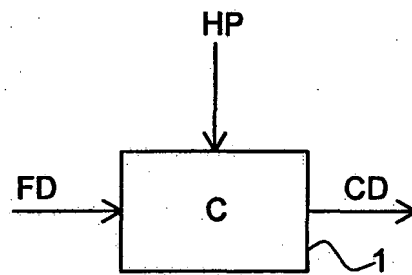


FIG. 1

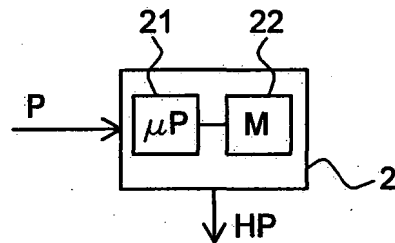


FIG. 2

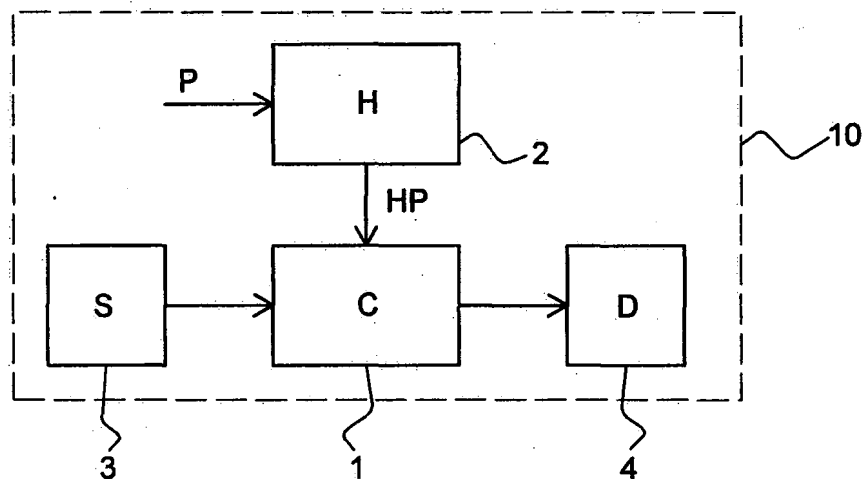


FIG. 3

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Bescheinigung

Certificate

Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr.

Patent application No.

Demande de brevet n°

07106963.7 / EP07106963

The organization code and number of your priority application, to be used for filing abroad under the Paris Convention, is EP07106963

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R.C. van Dijk



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Application no.: 07106963.7
Demande no:

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se référer à la description.)

Machine learning hyperparameter estimation

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G06F19/00

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Machine Learning Hyperparameter Estimation

The present invention relates to hyperparameter estimation. More in particular, the present invention relates to a method and device for determining hyperparameters of classifiers in machine learning systems and applications.

Classifiers are used in machine learning systems to classify physical objects and/or their (typically digital) representations. Machine learning systems may, for example, be used to assist fruit picking robots. The classifier of the machine learning system is trained to distinguish ripe fruit (e.g. tomatoes) from unripe fruit. For each fruit item, the classifier determines a set of parameters which are compared with stored parameters in order to classify the items as "ripe" or "unripe". The classification process is, in turn, controlled by hyperparameters which determine, for example, decision criteria such as threshold values.

Classifiers are typically trained using a training set prepared on the basis of human input: an operator indicates the correct classification for the items of the training set. On the basis of these training data, the correct hyperparameters of the classifier can be estimated.

Hyperparameters may be determined using various methods, for example heuristic or statistical optimisation methods. However, many heuristic methods are ad hoc methods, while not all statistical optimisation methods are suitable for determining hyperparameters.

A particularly efficient yet relatively simple method for estimating parameters in general is the cross-entropy (CE) method. This iterative method comprises the repeated steps of drawing, in a parameterised way, a random sample of candidate solutions, and updating the parameters on the basis of the random sample. At the time of writing, the paper "A Tutorial on the Cross-Entropy Method" by P.T. de Boer et al. could be found at <http://iew3.technion.ac.il/CE/tutor.php>, said paper is herewith incorporated in this document in its entirety.

Unfortunately, the cross-entropy method as described in the above-mentioned paper is not suitable for determining hyperparameters. Determining optimal sets of hyperparameter values is a difficult problem due to the extremely large size of the search space: the optimal solution typically is a rare event. While the cross-entropy

method is geared towards sampling rare event spaces, it is not *a priori* clear how the process of drawing hyperparameter values can be parameterised, as the hyperparameter samples are not classical parameterised probability density functions.

5 It is an object of the present invention to overcome these and other problems of the Prior Art and to provide a method and device for determining hyperparameters which allow efficient cross-entropy methods to be utilized.

Accordingly, the present invention provides a method of determining hyperparameters of a classifier in a machine learning system, the method involving a cross-entropy algorithm to iteratively produce estimates of the hyperparameters, each
10 iteration comprising the steps of:

- drawing a random sample comprising a plurality of data vectors, and
- updating the hyperparameters on the basis of the random sample,

the method being characterised in that each iteration comprises the steps of:

- determining the data vector producing the best result in the present iteration,
15 and
- updating the hyperparameters using said data vector producing the best result in the present iteration.

By determining the data vector producing the best result in the present iteration and using said data vector to update the hyperparameters, the properties of the best
20 performing hyperparameters are used to guide the next iteration. In this way, the cross-entropy method can be used effectively for determining hyperparameters, even when the hyperparameters are not continuous and their effects are not transparent.

In a preferred embodiment, the method according to the present invention further comprises the step of restricting the sample on the basis of the data vector
25 producing the best result in the previous iteration. The step of restricting the sample preferably involves the use of an interval surrounding the data vector producing the best result in the present iteration.

It is preferred that the step of restricting the sample is carried out prior to the step of determining the data vector producing the best result in the present iteration.
30 However, in alternative embodiments, the step of restricting the sample is carried out during the step of updating the hyperparameters, preferably by using indicator functions. Said indicator function may have a value equal to one when the result of

the sample exceeds a threshold value, and have a value equal to zero when the result of the sample is below the threshold value.

In a preferred embodiment, E^t is the random sample X_i^t at iteration t producing the best result $S(X_i^t)$, the random sample X_i^t having elements X_{ij}^t , wherein the step of updating the hyperparameters comprises the step of determining the hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function. The weighting function W is preferably given by

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}}.$$

Accordingly, the step of updating the hyperparameters may involve a weighting function based upon a distance function, preferably a Euclidean distance function. It is noted that when Euclidean distance between E^t and X_{ij}^t is zero, the weighting function W is equal to one.

The method according to the present invention is typically carried out by computer apparatus, for example a general purpose computer system comprising a processor and an associated memory, one part of the memory storing a software program for instructing the processor to carry out the method steps of the present invention, and another part of the memory storing data, said data comprising the hyperparameter values referred to above.

The present invention also provides a computer program product for carrying out the method as defined above. A computer program product may comprise a set of computer executable instructions stored on a data carrier, such as a CD or a DVD. The set of computer executable instructions, which allows a programmable computer to carry out the method as defined above, may also be available for downloading from a remote server, for example via the Internet.

The present invention additionally provides a classifier for use in a machine learning system, the classifier being arranged for using hyperparameters as control parameters, wherein the hyperparameters have been determined by the method according to any of the preceding claims. The classifier is preferably embodied in software, but may also be embodied in hardware, or in a combination of hardware and software.

The present invention still further provides a device for determining hyperparameters of a classifier in a machine learning system, the device comprising a processor arranged for carrying out a cross-entropy algorithm to iteratively produce estimates of the hyperparameters, each iteration comprising the steps of:

- drawing a random sample comprising a plurality of data vectors, and
- updating the hyperparameters on the basis of the random sample,

the device being characterised in that the processor is arranged such that each iteration comprises the steps of:

- determining the data vector producing the best result in the present iteration, and
- updating the hyperparameters using said data vector producing the best result in the present iteration.

A machine learning system comprising a device as defined above and/or arranged for carrying out the method as defined above is also provided by the present invention. The machine learning system may comprise hardware and/or software components.

The present invention will further be explained below with reference to exemplary embodiments illustrated in the accompanying drawings, in which:

Fig. 1 schematically shows a classifier having hyperparameters as input control variables.

Fig. 2 schematically shows a device for determining hyperparameters according to the present invention.

Fig. 3 schematically shows a machine learning system according to the present invention.

The classifier 1 shown schematically in Fig. 1 receives feature data FD and hyperparameters HP, and produces classification data CD. The feature data FD may include image data produced by a CCD (Charge Coupled Device) array or other light-sensitive device. Additionally, the feature data FD may include sound data or data concerning database items, such as library data (book numbers and titles). The classifier may be constituted by an apparatus (hardware embodiment), but is preferably constituted by a software program running on a computer apparatus, for example a general purpose computer ("personal computer"), a dedicated computer, or other suitable apparatus.

The classifier 1 is capable of classifying the items represented by the input feature data FD. The feature data FD typically comprise parameters of the items, for example their size and/or colour in the case of fruit or machine parts. Under control of the hyperparameters HP the items are each assigned to a class, for example "ripe" in the case of fruit. At least two different classes are used, and typically an item is assigned to one class only.

The hyperparameters HP determine the a decision function of the classifier: items that classifies items. For example, when this function is based upon thresholding, items producing an aggregate value (derived from the feature values) equal to or greater than the threshold are assigned to class A, while items producing a value smaller than the threshold are assigned to class B. It is noted that other classification techniques may be used as well.

Applications of the classifier 1 include picking fruit, sorting parts (e.g. machine parts), classifying books, selecting songs, recognising adult video material, detecting damage, etc..

The present invention allows the cross-entropy (CE) method to be used for estimating and determining hyperparameters. To this end, the present invention proposes to include a memory facility into the CE algorithm by preserving samples which produce a good result (the result being defined by a suitable function, such as a loss function). Additionally, or alternatively, the sampling of candidate hyperparameter settings is made dependent on the (hyper)parameter vector updated by the CE algorithm, and/or a suitably weighting function (also known as "change of

measure” or “likelihood-ratio” in the CE algorithm) guiding the search process should be provided.

The method of the present invention uses parameters N , ρ and μ which are typically predetermined. It is noted that these parameters may be thought of as hyperparameters of the method but are distinct from the hyperparameters to be determined by the method. The parameter N represents the number of random draws; the parameter N may for example be equal to 10, 100 or 1000. In the iterations a parameter n is used which represents the size of each data vector, that is, the number of elements X_{ij} of each data vector X_i . The parameter n may for example be equal to 5, 10 or 100, although other numbers are also possible. The parameter ρ represents a fraction and may have a value ranging from 0.2 to 0.01, although other values may also be used. The width parameter μ , which will be explained in more detail below, indicates a preferred sampling interval.

The initial set of hyperparameters, the hyperparameter vector u , can typically be chosen arbitrarily. Each estimated hyperparameter vector v^t at point in time (or iteration number) t consists of hyperparameters v_j^t .

In the present invention, the “best” data vector (or datum) X^t of iteration t is kept for use in the next iteration and is denoted E^t . This best data vector is found using a function $S(X^t)$ which may be a loss function or any other suitable function producing a result value based upon X^t , the value of X^t corresponding with the maximum value of $S(X^t)$ is denoted $\text{argmax } S(X^t)$. In addition, the values of $S(X^t)$ are ranked and are used to determine a threshold γ^t , involving ρ and N to determine the $((1-\rho)N)^{\text{th}}$ value of S .

Then the hyperparameters are determined using an expression involving indicator functions $I\{S(X_i^t) \geq \gamma^t\}$ and weighting functions $W(X_i; E^t)$. The indication functions are equal to 1 when $S(X_i^t) \geq \gamma^t$ and equal to 0 when $S(X_i^t) < \gamma^t$. The weighting functions $W(X_i; E^t)$, also known as “change of measure” functions, have the data vector elements X_i (actually X_i^t) and E^t as input variables. This implies that the best data vector E^t of the present iteration is used to determine the hyperparameters.

The weighting function $W(X_i^t; E^t)$ is preferably defined as:

$$W(X'_i; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}} \quad (1)$$

This function produces a value of 1 when the Euclidean distance between a sample and the “best” sample is 0.

Accordingly, a preferred embodiment of the method according to the present invention comprises the following steps:

1. Choose initial parameters N , ρ and μ and generate an initial hyperparameter vector u .

2. Let $v^0 = E^0 = u$ and set iteration number $t = 1$.

3. Generate a random sample $X'_1, \dots, X'_n$ restricted by E^{t-1} . Compute the performance $S(X'_i)$ for every value of i and rank the results: $S_{(1)} \leq \dots \leq S_{(n)}$. Compute $\gamma^t = S_{\text{percentile}}$ and compute $E^t = \arg\max S(X^t)$.

4. For every hyperparameter v_j^t let

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X'_i) \geq \gamma^t\} W(X'_i; E^t) X'_{ij}}{\sum_{i=1}^n I\{S(X'_i) \geq \gamma^t\} W(X'_i; E^t)} \quad (2)$$

5. Let $t := t + 1$, repeat from step 3 until the stop condition is met.

15 The final set v of j hyperparameters v_j is the desired optimal set.

By using the best sample E_j^t in hyperparameter estimation / update formula (2), the better results are reinforced, leading to a more efficient convergence of the method. In addition, any discontinuity problems associated with hyperparameters are overcome by the method of the present invention.

20 The stop criterion is preferably a non-changing value of the parameter γ^t during a number of iterations, but could also be a threshold value. The value $S_{\text{percentile}}$ is determined using the $((1-\rho)N)^{\text{th}}$ value of S in the ranking $S_{(1)} \leq \dots \leq S_{(n)}$, where rounding up may be used if this value is not an integer.

25 The restriction which is applied when generating a random sample at time t in step 3 may be defined by the interval:

$$[E_j^{t-1} * (1 - \mu), E_j^{t-1} * (1 + \mu)] \quad (3)$$

where μ is a width parameter and "*" denoted multiplication. If the sample X'_i lies within this interval, its distance relative to the best sample E'_j of the previous iteration is limited to the value of μ . It is noted that the use of this interval is advantageous but not essential.

- 5 Alternatively, the restriction could be applied by using indicator functions $I\{X'_{ij} \sim_{\mu} E'_{ij}\}$ which are equal to 1 when X'_{ij} deviates less than μ from E'_{ij} and equal to 0 when this is not the case. Formula (2) may then be rewritten as:

$$v'_j = \frac{\sum_{i=1}^n I\{S(X'_i) \geq \gamma'\} \cdot I\{X'_{ij} \sim_{\mu} E'_{ij}\} \cdot W(X'_i; E', E'^{-1}) X'_{ij}}{\sum_{i=1}^n I\{S(X'_i) \geq \gamma'\} \cdot I\{X'_{ij} \sim_{\mu} E'_{ij}\} \cdot W(X'_i; E', E'^{-1})} \quad (2a)$$

where

$$10 \quad W(X'_i; E', E'^{-1}) = \exp\left(-\sum_{j=1}^N X'_{ij} \left(\frac{1}{E'_j} - \frac{1}{E'^{-1}_j}\right)\right) \cdot \prod_{j=1}^N \frac{E'^{-1}_j}{E'_j} \quad (1a).$$

- The device 2 for determining hyperparameters comprises a processor 21 and an associated memory 22. The memory stores both instructions for the processor and data. The device 2 receives parameters P, such as the parameters ρ and μ mentioned above, and outputs hyperparameters HP. The stored instructions allow the processor
15 to carry out the method according to the present invention.

- The machine learning system 10 shown merely by way of non-limiting example in Fig. 3 comprises a classifier 1 and a device 2 for determining hyperparameters. The machine learning system 10 may further comprise at least one sensor 3 and a display screen 4. The sensor 3 serves to collect data while the display
20 screen 4 serves to display classification result and other data.

- The present invention is based upon the insight that the cross-entropy method can be adapted for hyperparameter estimation by adding a best performance preservation feature. The present invention benefits from the additional insight that the best performance in a particular iteration may be preserved by restricting the
25 sample using the best performance of the previous iteration.

It is noted that any terms used in this document should not be construed so as to limit the scope of the present invention. In particular, the words "comprise(s)" and "comprising" are not meant to exclude any elements not specifically stated. Single

(circuit) elements may be substituted with multiple (circuit) elements or with their equivalents.

It will be understood by those skilled in the art that the present invention is not limited to the embodiments illustrated above and that many modifications and
5 additions may be made without departing from the scope of the invention as defined in the appending claims.

Claims

1. A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10), the method involving a cross-entropy algorithm to iteratively produce estimates of the hyperparameters, each iteration comprising the steps of:
 - drawing a random sample comprising a plurality of data vectors, and
 - updating the hyperparameters on the basis of the random sample,
 the method being **characterised** in that each iteration comprises the steps of:
 - determining the data vector producing the best result in the present iteration, and
 - updating the hyperparameters using said data vector producing the best result in the present iteration.
2. The method according to claim 1, further comprising the step of restricting the sample on the basis of the data vector producing the best result in the previous iteration.
3. The method according to claim 2, wherein the step of restricting the sample involves using an interval surrounding the data vector producing the best result in the present iteration.
4. The method according to claim 2 or 3, wherein the step of restricting the sample is carried out prior to the step of determining the data vector producing the best result in the present iteration.
5. The method according to claim 2 or 3, wherein the step of restricting the sample is carried out during the step of updating the hyperparameters, preferably by using indicator functions.
6. The method according to any of the preceding claims, wherein the step of updating the hyperparameters involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the random sample X^t_i at iteration t producing the best result $S(X^t_i)$, the random sample X^t_i having elements X^t_{ij} , wherein the step of updating the hyperparameters comprises the step of determining the hyperparameter v^t_j , where

$$v^t_j = \frac{\sum_{i=1}^n I\{S(X^t_i) \geq \gamma^t\} W(X^t_i; E^t) X^t_{ij}}{\sum_{i=1}^n I\{S(X^t_i) \geq \gamma^t\} W(X^t_i; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X^t_i; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X^t_{ij} - E^t_j)^2}}{\sqrt{\sum_{j=1}^m (X^t_{ij})^2} \sqrt{\sum_{j=1}^m (E^t_j)^2}}$$

9. The method according to any of the preceding claims, carried out by computer apparatus.
10. A computer program product for carrying out the method according to any of the preceding claims.
11. A classifier for use in a machine learning system, the classifier being arranged for using hyperparameters as control parameters, wherein the hyperparameters have been determined by the method according to any of the preceding claims.
12. A device (2) for determining hyperparameters of a classifier in a machine learning system (10), the device comprising a processor (21) arranged for carrying out a cross-entropy algorithm to iteratively produce estimates of the hyperparameters, each iteration comprising the steps of:

- drawing a random sample comprising a plurality of data vectors, and
- updating the hyperparameters on the basis of the random sample,

the device being **characterised** in that the processor is arranged such that each iteration comprises the steps of:

- 5
 - determining the data vector producing the best result in the present iteration, and
 - updating the hyperparameters using said data vector producing the best result in the present iteration.

10 13. The device according to claim 11, wherein the processor (21) is further arranged for restricting the sample on the basis of the data vector producing the best result in the previous iteration.

14. A machine learning system (10), comprising a device (2) according to claim
15 12 or 13.

Abstract

A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) uses a cross-entropy method to iteratively produce estimates of the hyperparameters. The method comprises the steps of determining the data vector producing the best result in the present iteration, and updating the hyperparameters (HP) using said data vector producing the best result in the present iteration. The sample may be restricted on the basis of the data vector producing the best result in the previous iteration.

10 [Fig. 3]

1 / 1

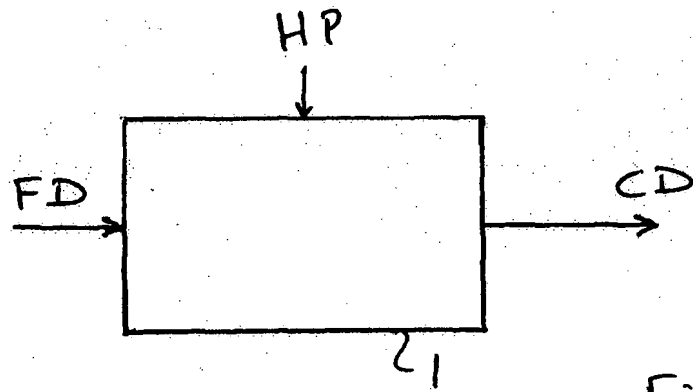


Fig. 1

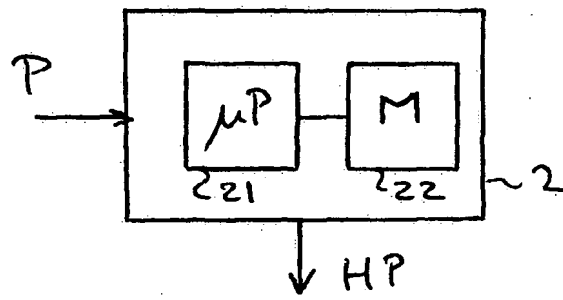


Fig. 2

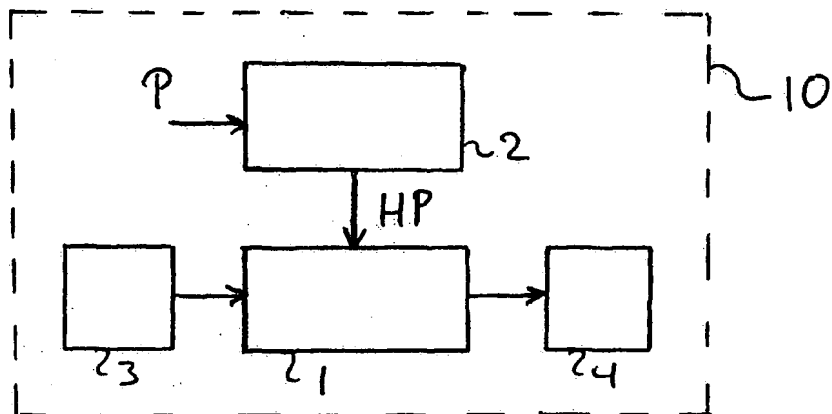


Fig. 3

INTERNATIONAL SEARCH REPORT

International application No
PCT/NL2008/050247

A. CLASSIFICATION OF SUBJECT MATTER

INV. G06N7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06N G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	S. RAAIJMAKERS: "Sentiment classification with interpolated information diffusion kernels" PROCEEDINGS OF THE 1ST INTERNATIONAL WORKSHOP ON DATA MINING AND AUDIENCE INTELLIGENCE FOR ADVERTISING (ADKDD'07), 12 August 2007 (2007-08-12), pages 34-39, XP002495949 Retrieved from the Internet: URL: http://dx.doi.org/10.1145/1348599.1348605 section 4.1 references 5 & 14 ----- -/--	1-14

☒ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

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T later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

X document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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G document member of the same patent family

Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

International application No

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P, X	AMIDA PROJECT: "Chapter 3: subjectivity recognition" DELIVRABLE 5.2: MULTIMODAL CONTENT ABSTRACTION, 2007, pages 28-47, XP002496842 Retrieved from the Internet: URL: http://www.amiproject.org/ami-scientific-portal/documentation/annual-reports/pdf/AMIDA_D5_2_Report-on-multimodal-content.pdf pages 35-36: "Hyperparameter Estimation" reference "Raaijmakers (...) 2007c"	1-14
X	P.-T. DE BOER, D. P. KROESE, S. MANNOR, R. Y. RUBINSTEIN: "A Tutorial on the Cross-Entropy Method" ANNALS OF OPERATIONS RESEARCH, vol. 134, no. 1, February 2005 (2005-02), pages 19-67, XP019390347 Retrieved from the Internet: URL: http://dx.doi.org/10.1007/s10479-005-5724-z cited in the application the whole document	1-14
X	S. MANNOR, D. PELEG, R. RUBINSTEIN: "The cross entropy method for classification" PROCEEDINGS OF THE 22ND INTERNATIONAL CONFERENCE ON MACHINE LEARNING (ICML'05), 9 August 2005 (2005-08-09), XP002449298 Retrieved from the Internet: URL: http://dx.doi.org/10.1145/1102351.1102422 cited in the application the whole document	1-14

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(54) Title: MACHINE LEARNING HYPERPARAMETER ESTIMATION

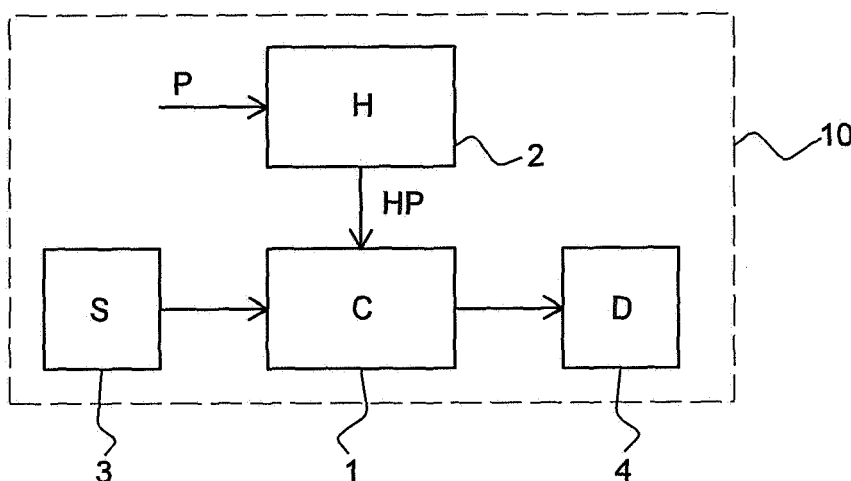


FIG. 3

(57) Abstract: A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) iteratively produces an estimate of a target hyperparameter vector. The method comprises the steps of selecting from the random sample the hyperparameter vector producing the best result in the present and any previous iterations, and updating the estimate of the target hyperparameter vector by using said selected hyperparameter vector. The random sample may be restricted by using the hyperparameter vector producing the best result in the present and any previous iterations.

Machine Learning Hyperparameter Estimation

The present invention relates to hyperparameter estimation. More in particular, the present invention relates to a method and device for determining
5 hyperparameters of classifiers in machine learning systems and applications.

Classifiers are used in machine learning systems to classify physical objects and/or their (typically digital) representations. Machine learning systems may, for example, be used to assist fruit picking robots. The classifier of the machine learning system is trained to distinguish ripe fruit (e.g. tomatoes) from unripe fruit. For each
10 fruit item, the classifier determines a set of parameters which are compared with stored parameters in order to classify the items as "ripe" or "unripe". The classification process is, in turn, controlled by hyperparameters which determine, for example, decision criteria such as threshold values.

Classifiers are typically trained using a training set prepared on the basis of
15 human input: an operator indicates the correct classification for the items of the training set. On the basis of these training data, the correct hyperparameters of the classifier can be estimated.

Hyperparameters may be determined using various methods, for example heuristic or statistical optimisation methods. However, many heuristic methods are
20 ad hoc methods, while not all statistical optimisation methods are suitable for determining hyperparameters.

A particularly efficient yet relatively simple method for estimating parameters in general is the cross-entropy (CE) method. This iterative method comprises the repeated steps of drawing, in a parameterised way, a random sample of
25 candidate solutions, and updating the parameters on the basis of the random sample. At the time of writing, the paper "A Tutorial on the Cross-Entropy Method" by P.T. de Boer et al. could be found at <http://iew3.technion.ac.il/CE/tutor.php>, said paper is herewith incorporated in this document in its entirety.

The paper "The cross-entropy method for classification" by S. Mannor, D.
30 Peleg and R. Rubinstein, Proceedings of the 22nd International Conference on Machine Learning, 2005, discloses an application of the CE algorithm for searching

the space of support vectors. Hyperparameter values are determined by using a simple grid search, not by using the CE algorithm, for the reasons discussed below.

The cross-entropy method as described in the above-mentioned papers is unfortunately not suitable for determining hyperparameters. Determining optimal
5 sets of hyperparameter values is a difficult problem due to the extremely large size of the search space: the optimal solution typically is a rare event. While the cross-entropy method is geared towards sampling rare event spaces, it is not *a priori* clear how the process of drawing hyperparameter values can be parameterised, as the hyperparameter samples are not classical parameterised probability density functions.

10 It is an object of the present invention to overcome these and other problems of the Prior Art and to provide a method and device for determining hyperparameters which allow efficient methods similar to the cross-entropy method to be utilized.

Accordingly, the present invention provides a method of determining hyperparameters of a classifier in a machine learning system by iteratively producing
15 an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the target hyperparameter vector by using the random sample,

20 the method being characterised in that each iteration comprises the step of:

- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

25 By selecting from the random sample a or the hyperparameter vector producing the best result in the present and any previous iterations, and using said selected hyperparameter vector to update the estimate of the target hyperparameter vector, the properties of the best performing hyperparameters are used to guide the next iteration. In this way, a method similar to the cross-entropy method can be used
30 effectively for determining hyperparameters, even when the hyperparameters are not continuous and their effects are not transparent. By using the method according to the present invention, an improved classification accuracy is achieved.

In the method of the present invention, hyperparameter vectors obtained through randomly sampling a set of hyperparameter vectors are used to estimate a desired (that is, target) hyperparameter vector to be used in the classifier. Each hyperparameter vector preferably comprises two or more elements, that is
 5 hyperparameters, but it is also possible for a hyperparameter vector to contain only a single hyperparameter. Although the samples are preferably completely random, pseudo-random samples may be used instead.

In a preferred embodiment, the method according to the present invention further comprises the steps of:

- 10 - selecting from the random sample a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

The step of restricting the random sample preferably involves the use of an interval
 15 surrounding the further selected hyperparameter vector which produces the best result in any previous iteration.

It is preferred that the step of restricting the random sample is carried out prior to the step of determining the hyperparameter vector producing the best result in the present and any previous iterations. However, in alternative embodiments, the
 20 step of restricting the random sample is carried out during the step of updating the estimate of the target hyperparameter vector.

In a preferred embodiment, E^t is the hyperparameter vector X_i^t at iteration t producing the best result $S(X_i^t)$ in the present iteration t and all previous iterations (if any). The random sample X_i^t has elements X_{ij}^t , while the step of updating the
 25 hyperparameters comprises the step of determining the (target) hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value, W is a weighting function and $I\{S(X_i^t) \geq \gamma^t\}$ is an indicator function which is equal to 1 if $S(X_i^t)$ greater than or equal to the threshold
 30 value γ^t , and else is equal to 0. The weighting function W is preferably given by

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}} .$$

Accordingly, the step of updating the hyperparameters may involve a weighting function based upon a distance function, preferably a Euclidean distance function. It is noted that when the Euclidean distance between E^t and X_{ij}^t is zero, the weighting function W is equal to one.

The method according to the present invention is typically carried out by computer apparatus, for example a general purpose computer system comprising a processor and an associated memory, one part of the memory storing a software program for instructing the processor to carry out the method steps of the present invention, and another part of the memory storing data, said data comprising the hyperparameter values referred to above.

The present invention also provides a computer program product for carrying out the method as defined above. A computer program product may comprise a set of computer executable instructions stored on a data carrier, such as a CD or a DVD.

The set of computer executable instructions, which allows a programmable computer to carry out the method as defined above, may also be available for downloading from a remote server, for example via the Internet.

The present invention additionally provides a classifier for use in a machine learning system, the classifier being arranged for using hyperparameters as control parameters, wherein the hyperparameters have been determined by the method according to any of the preceding claims. The classifier is preferably embodied in software, but may also be embodied in hardware, or in a combination of hardware and software.

The present invention still further provides a device for determining hyperparameters of a classifier in a machine learning system, the device comprising a processor arranged for iteratively producing estimates of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and

- updating the estimate of the target hyperparameter vector by using the random sample,

the device being characterised in that the processor is arranged such that each iteration comprises the step of:

- 5 - selecting from the random sample a hyperparameter vector producing the best result in the present iteration and any previous iterations, and
- in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

The processor may be arranged for carrying out the steps mentioned above by
10 providing a suitable software program in the memory associated with the processor. Alternatively, or additionally, the processor may be designed specifically to carry out the steps mentioned above.

A machine learning system comprising a device as defined above and/or
arranged for carrying out the method as defined above is also provided by the present
15 invention. The machine learning system may comprise hardware and/or software components.

The present invention will further be explained below with reference to
20 exemplary embodiments illustrated in the accompanying drawings, in which:

Fig. 1 schematically shows a classifier having hyperparameters as input control variables.

Fig. 2 schematically shows a device for determining hyperparameters according to the present invention.

25 Fig. 3 schematically shows a machine learning system according to the present invention.

The classifier (C) 1 shown schematically in Fig. 1 receives feature data FD
30 and hyperparameters HP, and produces classification data CD. The feature data FD may include image data produced by a CCD (Charge Coupled Device) array or other light-sensitive device. Additionally, the feature data FD may include sound data or

data concerning database items, such as library data (book numbers and titles). The classifier may be constituted by an apparatus (hardware embodiment), but is preferably constituted by a software program running on a computer apparatus, for example a general purpose computer ("personal computer"), a dedicated computer, or other suitable apparatus.

The classifier 1 is capable of classifying the items represented by the input feature data FD. The feature data FD typically comprise parameters of the items, for example their size and/or colour in the case of fruit or machine parts. Under control of the hyperparameters HP the items are each assigned to a class, for example "ripe" in the case of fruit. At least two different classes are used, and typically an item is assigned to one class only.

The hyperparameters HP determine the decision function of the classifier that classifies items. For example, when this function is based upon thresholding, items producing an aggregate value (derived from the feature values) equal to or greater than the threshold are assigned to class A, while items producing a value smaller than the threshold are assigned to class B. It is noted that other classification techniques may be used as well.

Applications of the classifier 1 include picking fruit, sorting parts (e.g. machine parts), classifying books, selecting songs, recognising adult video material, detecting damage, etc..

The present invention allows a method similar to the cross-entropy (CE) method to be used for estimating and determining hyperparameters. To this end, the present invention proposes to include a memory facility into the algorithm by preserving samples which produce a good result (the result being defined by a suitable function, such as a loss function). Additionally, or alternatively, the sampling of candidate hyperparameter settings is made dependent on the (hyper)parameter vector updated by the algorithm, and/or a suitably weighting function (also known as "change of measure" or "likelihood ratio" in the CE algorithm) guiding the search process should be provided.

The method of the present invention uses parameters N , ρ and μ which are typically predetermined. It is noted that these parameters may be thought of as hyperparameters of the method but are distinct from the hyperparameters to be

determined by the method. The parameter N represents the number of random draws; the parameter N may for example be equal to 10, 100 or 1000.

In the iterations a parameter n is used which represents the size of each data vector, that is, the number of elements X_{ij} of each hyperparameter vector X_i of the set of possible hyperparameter vectors. The parameter n may for example be equal to 5,
 10 or 100, although other numbers are also possible. The parameter ρ represents a fraction and may have a value ranging from 0.2 to 0.01, although other values may also be used. The width parameter μ , which will be explained in more detail below, indicates a preferred sampling interval.

10 The initial set of target hyperparameters, the hyperparameter vector u , can typically be chosen arbitrarily. Each estimated (target) hyperparameter vector v^t at point in time (or iteration number) t consists of hyperparameters v_j^t .

In the present invention, the “best” hyperparameter vector v of iterations $1 \dots t$ is kept for use in the next iteration and is denoted E^t . This “best” (or “elitist”) hyperparameter vector is found using a function $S(X^t)$ which may be a loss function
 15 or any other suitable function producing a result value based upon X^t . The value of $S(X^t)$ may also be viewed as an importance measure. The value of X^t corresponding with the maximum value of $S(X^t)$ is denoted $\arg\max S(X^t)$. In addition, the values of $S(X^t)$ are ranked and are used to determine a threshold γ^t , involving ρ and N to
 20 determine the $((1-\rho)N)^{\text{th}}$ value of the ranked values of $S(X^t)$. It is noted that the number $((1-\rho)N)$ is not necessarily an integer and is therefore rounded up, expressed mathematically as $\lceil ((1-\rho)N) \rceil$.

Subsequently, the (target) hyperparameters are determined using an expression involving indicator functions $I\{S(X_i^t) \geq \gamma^t\}$ and weighting functions
 25 $W(X_i; E^t)$. The indication functions are equal to 1 when $S(X_i^t) \geq \gamma^t$ and equal to 0 when $S(X_i^t) < \gamma^t$. The weighting functions $W(X_i; E^t)$, also known as “change of measure” functions, have the data vector elements X_i (actually X_i^t) and E^t as input variables. This implies that the best data vector E^t of the present iteration is used to determine the (target) hyperparameters.

30 The weighting function $W(X_i^t; E^t)$ is preferably defined as:

$$W(X'_i; E') = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E'_j)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E'_j)^2}} \quad (1)$$

This function produces a value of 1 when the Euclidean distance between a sample and the “best” sample is 0.

Accordingly, a preferred embodiment of the method according to the present invention comprises the following steps:

1. Choose initial parameters N , ρ and μ and generate an initial (target) hyperparameter vector u .
2. Let $v^0 = E^0 = u$ and set iteration number $t = 1$.
3. Generate a random sample $X'_1, \dots, X'_n$ of hyperparameters drawn from a (given) set of possible hyperparameters. The random sample preferably is restricted by v^{t-1} . Compute the performance $S(X'_i)$ for every value of i and rank the results: $S_{(1)} \leq \dots \leq S_{(n)}$. Compute $\gamma^t = S_{\text{percentile}}$ and compute $E^t = \arg\max_{i=1 \dots t} \gamma^t$.
4. For every (target) hyperparameter v'_j let

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X'_i) \geq \gamma^t\} W(X'_i; E^t) X'_{ij}}{\sum_{i=1}^n I\{S(X'_i) \geq \gamma^t\} W(X'_i; E^t)} \quad (2)$$

5. Let $t := t+1$, repeat from step 3 until the stopping condition is met.

The final set v of j (target) hyperparameters v_j is the desired optimal set.

By using the best sample E_j^t in hyperparameter estimation / update formula (2), the better results are reinforced, leading to a more efficient convergence of the method. In addition, discontinuity problems associated with hyperparameters are overcome by the method of the present invention.

The stopping criterion (or condition) is preferably a non-changing value of the parameter γ^t during a number of iterations, but could also be a threshold value. The value $S_{\text{percentile}}$ is determined using the $((1-\rho)N)^{\text{th}}$ value of S in the ranking $S_{(1)} \leq \dots \leq S_{(n)}$, where rounding up may be used if this value is not an integer. The

weighting function $W(X_i^t; E^t)$ used in formula (2) is preferably defined by formula (1) above.

The method of the present invention may be summarized as deriving a target hyperparameter vector from a random sample of hyperparameter vectors while

5 taking the performance of the hyperparameters of the random sample into account.

The restriction which may be applied when generating a random sample at time t in step 3 may be defined by the interval:

$$[v_j^t * (1 - \mu), v_j^t * (1 + \mu)] \quad (3)$$

where μ is a width parameter and “*” denoted multiplication. If the sample X_i^t lies
10 within this interval, its distance relative to the best sample E_j^t of the previous iteration is limited to the value of μ . It is noted that the use of this interval is preferred but not essential as the method of the present invention could be carried out without using this interval.

The device 2 for determining hyperparameters comprises a processor (μP) 21
15 and an associated memory (M) 22. The memory stores both instructions for the processor and data. The device 2 receives parameters P (more in general: feature data), such as the parameters ρ and μ mentioned above, and outputs hyperparameters HP. The stored instructions allow the processor to carry out the method according to the present invention.

20 The machine learning system 10 shown merely by way of non-limiting example in Fig. 3 comprises a classifier (C) 1 and a device (H) 2 for determining hyperparameters. The machine learning system 10 may further comprise at least one sensor (S) 3 and a display screen (D) 4. The sensor 3 serves to collect data while the display screen 4 serves to display classification result and other data.

25 The present invention is based upon the insight that methods similar to the cross-entropy method can be adapted for hyperparameter estimation by adding a best performance preservation feature. The present invention benefits from the additional insight that the best performance in a particular iteration may be preserved by restricting the sample using the best performance of the previous iterations.

30 It is noted that any terms used in this document should not be construed so as to limit the scope of the present invention. In particular, the words “comprise(s)” and “comprising” are not meant to exclude any elements not specifically stated. Single

(circuit) elements may be substituted with multiple (circuit) elements or with their equivalents.

It will be understood by those skilled in the art that the present invention is not limited to the embodiments illustrated above and that many modifications and
5 additions may be made without departing from the scope of the invention as defined in the appending claims.

Claims

1. A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - updating the estimate of the target hyperparameter vector by using the random sample,
- the method being **characterised** in that each iteration comprises the step of:
- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.
2. The method according to claim 1, further comprising the steps of:
- selecting a further hyperparameter vector producing the best result in any previous iterations, and
 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.
3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.
4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

5 6. The method according to any of the preceding claims, wherein the step of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the selected hyperparameter vector X_i^t at iteration t producing the best result $S(X_i^t)$, the
10 selected hyperparameter vector X_i^t having elements X_{ij}^t , wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

15

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}}$$

20 9. The method according to any of the preceding claims, carried out by computer apparatus.

10. A computer program product for carrying out the method according to any of the preceding claims.

25

11. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein the

hyperparameters (HP) have been determined by the method according to any of claims 1-9.

12. A device (2) for determining hyperparameters of a classifier (1) in a machine learning system (10), the device comprising a processor (21) arranged for iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- 10 - updating the estimate of the hyperparameter vector by using the random sample,

the device being **characterised** in that the processor is arranged such that each iteration comprises the step of:

- selecting from the random sample a hyperparameter vector producing the best
- 15 result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

13. The device according to claim 12, wherein the processor (21) is further arranged for:

- selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.

25

14. A machine learning system (10), comprising a device (2) according to claim 12 or 13.

1 / 1

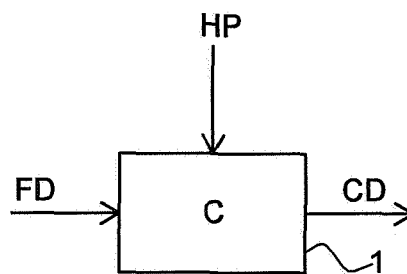


FIG. 1

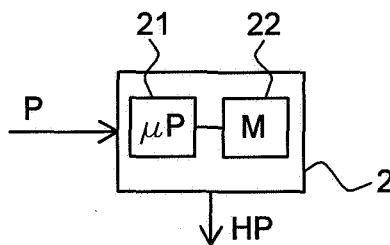


FIG. 2

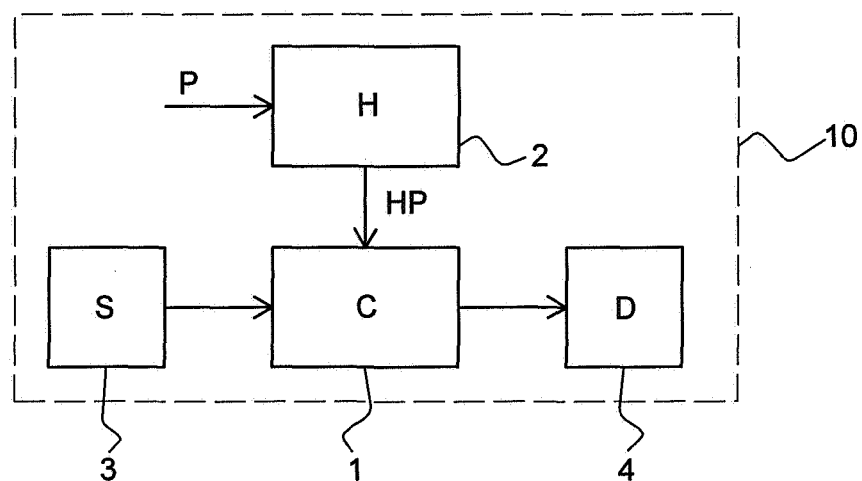


FIG. 3

Abstract

A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) iteratively produces an estimate of a target
5 hyperparameter vector. The method comprises the steps of selecting from the random sample the hyperparameter vector producing the best result in the present and any previous iterations, and updating the estimate of the target hyperparameter vector by using said selected hyperparameter vector. The random sample may be restricted by
10 using the hyperparameter vector producing the best result in the present and any previous iterations.

[Fig. 3]

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0	For receiving Office use only	
0-1	International Application No.	
0-2	International Filing Date	
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0-4	Form PCT/RO/101 PCT Request	
0-4-1	Prepared Using	PCT Online Filing Version 3.5.000.193 MT/FOP 20020701/0.20.5.9
0-5	Petition The undersigned requests that the present international application be processed according to the Patent Cooperation Treaty	
0-6	Receiving Office (specified by the applicant)	Netherlands Patent Office (RO/NL)
0-7	Applicant's or agent's file reference	P81166PC00
I	Title of Invention	MACHINE LEARNING HYPERPARAMETER ESTIMATION
II	Applicant	
II-1	This person is	applicant only
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III-1-7	State of residence	NL

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IV-1	Agent or common representative; or address for correspondence The person identified below is hereby/ has been appointed to act on behalf of the applicant(s) before the competent International Authorities as:	agent
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V-1	The filing of this request constitutes under Rule 4.9(a), the designation of all Contracting States bound by the PCT on the international filing date, for the grant of every kind of protection available and, where applicable, for the grant of both regional and national patents.	
VI-1	Priority claim of earlier regional application	
VI-1-1	Filing date	25 April 2007 (25.04.2007)
VI-1-2	Number	07106963.7
VI-1-3	Regional Office	EP
VI-2	Priority claim of earlier regional application	
VI-2-1	Filing date	09 July 2007 (09.07.2007)
VI-2-2	Number	07112037.2
VI-2-3	Regional Office	EP
VI-3	Incorporation by reference : where an element of the international application referred to in Article 11(1)(iii)(d) or (e) or a part of the description, claims or drawings referred to in Rule 20.5(a) is not otherwise contained in this international application but is completely contained in an earlier application whose priority is claimed on the date on which one or more elements referred to in Article 11(1)(iii) were first received by the receiving Office, that element or part is, subject to confirmation under Rule 20.6, incorporated by reference in this international application for the purposes of Rule 20.6.	

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VII-1	International Searching Authority Chosen	European Patent Office (EPO) (ISA/EP)	
VII-2	Request to use results of earlier search; reference to that search		
VII-2-1	Date	04 September 2007 (04.09.2007)	
VII-2-2	Number	07106963.7	
VII-2-3	Country (or regional Office)	EP	
VIII	Declarations	Number of declarations	
VIII-1	Declaration as to the identity of the inventor	—	
VIII-2	Declaration as to the applicant's entitlement, as at the international filing date, to apply for and be granted a patent	—	
VIII-3	Declaration as to the applicant's entitlement, as at the international filing date, to claim the priority of the earlier application	—	
VIII-4	Declaration of inventorship (only for the purposes of the designation of the United States of America)	—	
VIII-5	Declaration as to non-prejudicial disclosures or exceptions to lack of novelty	—	
IX	Check list	number of sheets	electronic file(s) attached
IX-1	Request (including declaration sheets)	4	✓
IX-2	Description	10	✓
IX-3	Claims	3	✓
IX-4	Abstract	1	✓
IX-5	Drawings	1	✓
IX-7	TOTAL	19	
	Accompanying Items	paper document(s) attached	electronic file(s) attached
IX-8	Fee calculation sheet	—	✓
IX-17	PCT-SAFE physical media	—	—
IX-19	Figure of the drawings which should accompany the abstract	3	
IX-20	Language of filing of the international application	English	
X-1	Signature of applicant, agent or common representative		
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X-1-3	Capacity		

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Claims

1. A method of determining hyperparameters (HP) of a classifier (1) in a machine learning system (10) by iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:
- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
 - updating the estimate of the target hyperparameter vector by using the random sample,
- the method being **characterised** in that each iteration comprises the step of:
- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,
- and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.
2. The method according to claim 1, further comprising the steps of:
- selecting a further hyperparameter vector producing the best result in any previous iterations, and
 - restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.
3. The method according to claim 2, wherein the step of restricting the random sample of hyperparameter vectors involves using an interval surrounding the further selected hyperparameter vector.
4. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out prior to the step of selecting the hyperparameter vector producing the best result in the present and any previous iterations.

5. The method according to claim 2 or 3, wherein the step of restricting the random sample of hyperparameter vectors is carried out during the step of updating the estimate of the target hyperparameter vector.

5 6. The method according to any of the preceding claims, wherein the step of updating the estimate of the hyperparameter vector involves a weighting function.

7. The method according to any of the preceding claims, wherein E^t is the selected hyperparameter vector X_i^t at iteration t producing the best result $S(X_i^t)$, the
10 selected hyperparameter vector X_i^t having elements X_{ij}^t , wherein the step of updating the estimate of the target hyperparameter vector comprises the step of determining the hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value and W is a weighting function.

15

8. The method according to claim 7, wherein the weighting function W is given by

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}}$$

20 9. The method according to any of the preceding claims, carried out by computer apparatus.

10. A computer program product for carrying out the method according to any of the preceding claims.

25

11. A classifier (1) for use in a machine learning system (1), the classifier being arranged for using hyperparameters (HP) as control parameters, wherein the

hyperparameters (HP) have been determined by the method according to any of claims 1-9.

12. A device (2) for determining hyperparameters of a classifier (1) in a machine learning system (10), the device comprising a processor (21) arranged for iteratively producing an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the hyperparameter vector by using the random sample,

the device being **characterised** in that the processor is arranged such that each iteration comprises the step of:

- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

13. The device according to claim 12, wherein the processor (21) is further arranged for:

- selecting a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample by using the hyperparameter vector producing the best result in any previous iteration.

14. A machine learning system (10), comprising a device (2) according to claim 12 or 13.

Machine Learning Hyperparameter Estimation

The present invention relates to hyperparameter estimation. More in particular, the present invention relates to a method and device for determining
5 hyperparameters of classifiers in machine learning systems and applications.

Classifiers are used in machine learning systems to classify physical objects and/or their (typically digital) representations. Machine learning systems may, for example, be used to assist fruit picking robots. The classifier of the machine learning system is trained to distinguish ripe fruit (e.g. tomatoes) from unripe fruit. For each
10 fruit item, the classifier determines a set of parameters which are compared with stored parameters in order to classify the items as “ripe” or “unripe”. The classification process is, in turn, controlled by hyperparameters which determine, for example, decision criteria such as threshold values.

Classifiers are typically trained using a training set prepared on the basis of
15 human input: an operator indicates the correct classification for the items of the training set. On the basis of these training data, the correct hyperparameters of the classifier can be estimated.

Hyperparameters may be determined using various methods, for example heuristic or statistical optimisation methods. However, many heuristic methods are
20 ad hoc methods, while not all statistical optimisation methods are suitable for determining hyperparameters.

A particularly efficient yet relatively simple method for estimating parameters in general is the cross-entropy (CE) method. This iterative method comprises the repeated steps of drawing, in a parameterised way, a random sample of
25 candidate solutions, and updating the parameters on the basis of the random sample. At the time of writing, the paper “A Tutorial on the Cross-Entropy Method” by P.T. de Boer et al. could be found at <http://iew3.technion.ac.il/CE/tutor.php> , said paper is herewith incorporated in this document in its entirety.

The paper “The cross-entropy method for classification” by S. Mannor, D.
30 Peleg and R. Rubinstein, Proceedings of the 22nd International Conference on Machine Learning, 2005, discloses an application of the CE algorithm for searching

the space of support vectors. Hyperparameter values are determined by using a simple grid search, not by using the CE algorithm, for the reasons discussed below.

The cross-entropy method as described in the above-mentioned papers is unfortunately not suitable for determining hyperparameters. Determining optimal
5 sets of hyperparameter values is a difficult problem due to the extremely large size of the search space: the optimal solution typically is a rare event. While the cross-entropy method is geared towards sampling rare event spaces, it is not *a priori* clear how the process of drawing hyperparameter values can be parameterised, as the hyperparameter samples are not classical parameterised probability density functions.

10 It is an object of the present invention to overcome these and other problems of the Prior Art and to provide a method and device for determining hyperparameters which allow efficient methods similar to the cross-entropy method to be utilized.

Accordingly, the present invention provides a method of determining hyperparameters of a classifier in a machine learning system by iteratively producing
15 an estimate of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and
- updating the estimate of the target hyperparameter vector by using the random sample,

20 the method being characterised in that each iteration comprises the step of:

- selecting from the random sample a hyperparameter vector producing the best result in the present and any previous iterations,

and in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

25 By selecting from the random sample a or the hyperparameter vector producing the best result in the present and any previous iterations, and using said selected hyperparameter vector to update the estimate of the target hyperparameter vector, the properties of the best performing hyperparameters are used to guide the next iteration. In this way, a method similar to the cross-entropy method can be used
30 effectively for determining hyperparameters, even when the hyperparameters are not continuous and their effects are not transparent. By using the method according to the present invention, an improved classification accuracy is achieved.

In the method of the present invention, hyperparameter vectors obtained through randomly sampling a set of hyperparameter vectors are used to estimate a desired (that is, target) hyperparameter vector to be used in the classifier. Each hyperparameter vector preferably comprises two or more elements, that is
 5 hyperparameters, but it is also possible for a hyperparameter vector to contain only a single hyperparameter. Although the samples are preferably completely random, pseudo-random samples may be used instead.

In a preferred embodiment, the method according to the present invention further comprises the steps of:

- 10 - selecting from the random sample a further hyperparameter vector producing the best result in any previous iterations, and
- restricting the random sample of hyperparameter vectors by using the further selected hyperparameter vector.

The step of restricting the random sample preferably involves the use of an interval
 15 surrounding the further selected hyperparameter vector which produces the best result in any previous iteration.

It is preferred that the step of restricting the random sample is carried out prior to the step of determining the hyperparameter vector producing the best result in the present and any previous iterations. However, in alternative embodiments, the
 20 step of restricting the random sample is carried out during the step of updating the estimate of the target hyperparameter vector.

In a preferred embodiment, E^t is the hyperparameter vector X_i^t at iteration t producing the best result $S(X_i^t)$ in the present iteration t and all previous iterations (if any). The random sample X_i^t has elements X_{ij}^t , while the step of updating the
 25 hyperparameters comprises the step of determining the (target) hyperparameter v_j^t , where

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)},$$

wherein γ^t is a threshold value, W is a weighting function and $I\{S(X_i^t) \geq \gamma^t\}$ is an indicator function which is equal to 1 if $S(X_i^t)$ greater than or equal to the threshold
 30 value γ^t , and else is equal to 0. The weighting function W is preferably given by

$$W(X'_i; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X'_{ij} - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X'_{ij})^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}} .$$

Accordingly, the step of updating the hyperparameters may involve a weighting function based upon a distance function, preferably a Euclidean distance function. It is noted that when the Euclidean distance between E^t and X'_{ij} is zero, the weighting function W is equal to one.

The method according to the present invention is typically carried out by computer apparatus, for example a general purpose computer system comprising a processor and an associated memory, one part of the memory storing a software program for instructing the processor to carry out the method steps of the present invention, and another part of the memory storing data, said data comprising the hyperparameter values referred to above.

The present invention also provides a computer program product for carrying out the method as defined above. A computer program product may comprise a set of computer executable instructions stored on a data carrier, such as a CD or a DVD.

The set of computer executable instructions, which allows a programmable computer to carry out the method as defined above, may also be available for downloading from a remote server, for example via the Internet.

The present invention additionally provides a classifier for use in a machine learning system, the classifier being arranged for using hyperparameters as control parameters, wherein the hyperparameters have been determined by the method according to any of the preceding claims. The classifier is preferably embodied in software, but may also be embodied in hardware, or in a combination of hardware and software.

The present invention still further provides a device for determining hyperparameters of a classifier in a machine learning system, the device comprising a processor arranged for iteratively producing estimates of a target hyperparameter vector, each iteration comprising the steps of:

- drawing a random sample of hyperparameter vectors from a set of possible hyperparameter vectors, and

- updating the estimate of the target hyperparameter vector by using the random sample,

the device being characterised in that the processor is arranged such that each iteration comprises the step of:

- 5 - selecting from the random sample a hyperparameter vector producing the best result in the present iteration and any previous iterations, and
- in that the step of updating the estimate of the target hyperparameter vector involves said selected hyperparameter vector.

10 The processor may be arranged for carrying out the steps mentioned above by providing a suitable software program in the memory associated with the processor. Alternatively, or additionally, the processor may be designed specifically to carry out the steps mentioned above.

15 A machine learning system comprising a device as defined above and/or arranged for carrying out the method as defined above is also provided by the present invention. The machine learning system may comprise hardware and/or software components.

20 The present invention will further be explained below with reference to exemplary embodiments illustrated in the accompanying drawings, in which:

Fig. 1 schematically shows a classifier having hyperparameters as input control variables.

Fig. 2 schematically shows a device for determining hyperparameters according to the present invention.

25 Fig. 3 schematically shows a machine learning system according to the present invention.

30 The classifier (C) 1 shown schematically in Fig. 1 receives feature data FD and hyperparameters HP, and produces classification data CD. The feature data FD may include image data produced by a CCD (Charge Coupled Device) array or other light-sensitive device. Additionally, the feature data FD may include sound data or

data concerning database items, such as library data (book numbers and titles). The classifier may be constituted by an apparatus (hardware embodiment), but is preferably constituted by a software program running on a computer apparatus, for example a general purpose computer ("personal computer"), a dedicated computer, or other suitable apparatus.

The classifier 1 is capable of classifying the items represented by the input feature data FD. The feature data FD typically comprise parameters of the items, for example their size and/or colour in the case of fruit or machine parts. Under control of the hyperparameters HP the items are each assigned to a class, for example "ripe" in the case of fruit. At least two different classes are used, and typically an item is assigned to one class only.

The hyperparameters HP determine the decision function of the classifier that classifies items. For example, when this function is based upon thresholding, items producing an aggregate value (derived from the feature values) equal to or greater than the threshold are assigned to class A, while items producing a value smaller than the threshold are assigned to class B. It is noted that other classification techniques may be used as well.

Applications of the classifier 1 include picking fruit, sorting parts (e.g. machine parts), classifying books, selecting songs, recognising adult video material, detecting damage, etc..

The present invention allows a method similar to the cross-entropy (CE) method to be used for estimating and determining hyperparameters. To this end, the present invention proposes to include a memory facility into the algorithm by preserving samples which produce a good result (the result being defined by a suitable function, such as a loss function). Additionally, or alternatively, the sampling of candidate hyperparameter settings is made dependent on the (hyper)parameter vector updated by the algorithm, and/or a suitably weighting function (also known as "change of measure" or "likelihood ratio" in the CE algorithm) guiding the search process should be provided.

The method of the present invention uses parameters N , ρ and μ which are typically predetermined. It is noted that these parameters may be thought of as hyperparameters of the method but are distinct from the hyperparameters to be

determined by the method. The parameter N represents the number of random draws; the parameter N may for example be equal to 10, 100 or 1000.

In the iterations a parameter n is used which represents the size of each data vector, that is, the number of elements X_{ij} of each hyperparameter vector X_i of the set of possible hyperparameter vectors. The parameter n may for example be equal to 5,
 10 or 100, although other numbers are also possible. The parameter ρ represents a fraction and may have a value ranging from 0.2 to 0.01, although other values may also be used. The width parameter μ , which will be explained in more detail below, indicates a preferred sampling interval.

10 The initial set of target hyperparameters, the hyperparameter vector u , can typically be chosen arbitrarily. Each estimated (target) hyperparameter vector v^t at point in time (or iteration number) t consists of hyperparameters v_j^t .

In the present invention, the “best” hyperparameter vector v of iterations $1 \dots t$ is kept for use in the next iteration and is denoted E^t . This “best” (or “elitist”) hyperparameter vector is found using a function $S(X^t)$ which may be a loss function or any other suitable function producing a result value based upon X^t . The value of $S(X^t)$ may also be viewed as an importance measure. The value of X^t corresponding with the maximum value of $S(X^t)$ is denoted $\text{argmax } S(X^t)$. In addition, the values of $S(X^t)$ are ranked and are used to determine a threshold γ^t , involving ρ and N to
 15 determine the $((1-\rho)N)^{\text{th}}$ value of the ranked values of $S(X^t)$. It is noted that the number $((1-\rho)N)$ is not necessarily an integer and is therefore rounded up, expressed mathematically as $\lceil ((1-\rho)N) \rceil$.

Subsequently, the (target) hyperparameters are determined using an expression involving indicator functions $I\{S(X_i^t) \geq \gamma^t\}$ and weighting functions
 25 $W(X_i; E^t)$. The indication functions are equal to 1 when $S(X_i^t) \geq \gamma^t$ and equal to 0 when $S(X_i^t) < \gamma^t$. The weighting functions $W(X_i; E^t)$, also known as “change of measure” functions, have the data vector elements X_i (actually X_i^t) and E^t as input variables. This implies that the best data vector E^t of the present iteration is used to determine the (target) hyperparameters.

30 The weighting function $W(X_i^t; E^t)$ is preferably defined as:

$$W(X_i^t; E^t) = 1 - \frac{\sqrt{\sum_{j=1}^m (X_{ij}^t - E_j^t)^2}}{\sqrt{\sum_{j=1}^m (X_{ij}^t)^2} \sqrt{\sum_{j=1}^m (E_j^t)^2}} \quad (1)$$

This function produces a value of 1 when the Euclidean distance between a sample and the “best” sample is 0.

Accordingly, a preferred embodiment of the method according to the present invention comprises the following steps:

1. Choose initial parameters N , ρ and μ and generate an initial (target) hyperparameter vector u .
2. Let $v^0 = E^0 = u$ and set iteration number $t = 1$.
3. Generate a random sample $X_1^t, \dots, X_n^t$ of hyperparameters drawn from a (given) set of possible hyperparameters. The random sample preferably is restricted by v^{t-1} . Compute the performance $S(X_i^t)$ for every value of i and rank the results: $S_{(1)} \leq \dots \leq S_{(n)}$. Compute $\gamma^t = S_{\text{percentile}}$ and compute $E^t = \arg\max_{v_{i=1 \dots t} \gamma^t}$.
4. For every (target) hyperparameter v_j^t let

$$v_j^t = \frac{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t) X_{ij}^t}{\sum_{i=1}^n I\{S(X_i^t) \geq \gamma^t\} W(X_i^t; E^t)} \quad (2)$$

5. Let $t := t+1$, repeat from step 3 until the stopping condition is met.

The final set v of j (target) hyperparameters v_j is the desired optimal set.

By using the best sample E_j^t in hyperparameter estimation / update formula (2), the better results are reinforced, leading to a more efficient convergence of the method. In addition, discontinuity problems associated with hyperparameters are overcome by the method of the present invention.

The stopping criterion (or condition) is preferably a non-changing value of the parameter γ^t during a number of iterations, but could also be a threshold value. The value $S_{\text{percentile}}$ is determined using the $((1-\rho)N)^{\text{th}}$ value of S in the ranking $S_{(1)} \leq \dots \leq S_{(n)}$, where rounding up may be used if this value is not an integer. The

weighting function $W(X_i^t; E^t)$ used in formula (2) is preferably defined by formula (1) above.

The method of the present invention may be summarized as deriving a target hyperparameter vector from a random sample of hyperparameter vectors while

5 taking the performance of the hyperparameters of the random sample into account.

The restriction which may be applied when generating a random sample at time t in step 3 may be defined by the interval:

$$[v_j^t * (1 - \mu), v_j^t * (1 + \mu)] \quad (3)$$

where μ is a width parameter and “*” denoted multiplication. If the sample X_i^t lies
10 within this interval, its distance relative to the best sample E_j^t of the previous iteration is limited to the value of μ . It is noted that the use of this interval is preferred but not essential as the method of the present invention could be carried out without using this interval.

The device 2 for determining hyperparameters comprises a processor (μ P) 21
15 and an associated memory (M) 22. The memory stores both instructions for the processor and data. The device 2 receives parameters P (more in general: feature data), such as the parameters ρ and μ mentioned above, and outputs hyperparameters HP. The stored instructions allow the processor to carry out the method according to the present invention.

20 The machine learning system 10 shown merely by way of non-limiting example in Fig. 3 comprises a classifier (C) 1 and a device (H) 2 for determining hyperparameters. The machine learning system 10 may further comprise at least one sensor (S) 3 and a display screen (D) 4. The sensor 3 serves to collect data while the display screen 4 serves to display classification result and other data.

25 The present invention is based upon the insight that methods similar to the cross-entropy method can be adapted for hyperparameter estimation by adding a best performance preservation feature. The present invention benefits from the additional insight that the best performance in a particular iteration may be preserved by restricting the sample using the best performance of the previous iterations.

30 It is noted that any terms used in this document should not be construed so as to limit the scope of the present invention. In particular, the words “comprise(s)” and “comprising” are not meant to exclude any elements not specifically stated. Single

(circuit) elements may be substituted with multiple (circuit) elements or with their equivalents.

It will be understood by those skilled in the art that the present invention is not limited to the embodiments illustrated above and that many modifications and
5 additions may be made without departing from the scope of the invention as defined in the appending claims.

1 / 1

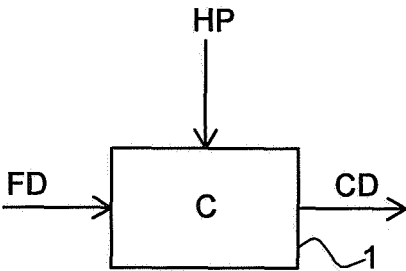


FIG. 1

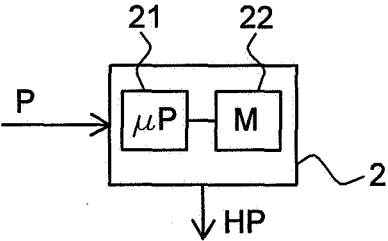


FIG. 2

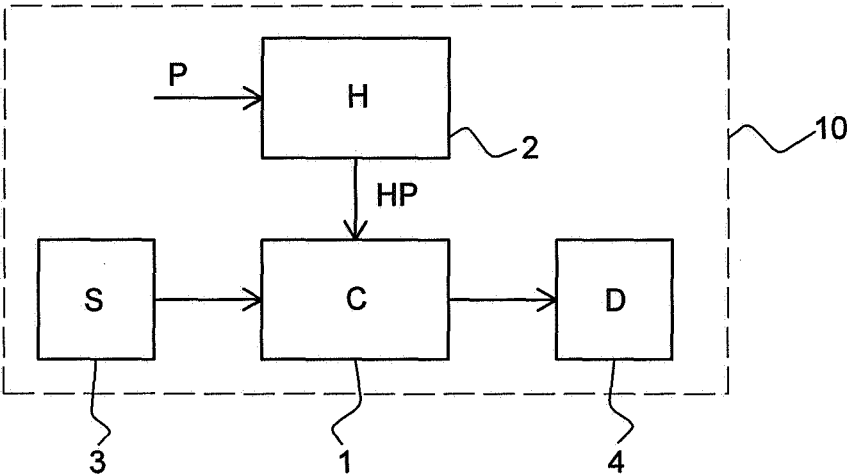


FIG. 3