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Application Number: 18154727

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January 13, 2023

Attorney Docket No.: 22193-0137002 / M16-180P-US2-b

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Presented for filing is a new continuation patent application of:

Inventor(s): JAE-SUN SEO and MINKYU KIM

Title: CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

The requirement for a certified copy of the foreign priority document under 37 CFR 1.55 is satisfied in this application, as the certified copy is contained in the file of the related Application No. **16/335,775**, filed **March 22, 2019**.

Enclosed are the following papers, including those required to receive a filing date under 37 CFR 1.53(b):

	<u>Pages</u>
Specification	20
Claims	4
Abstract	1
Declaration	2
Drawing(s)	10

Enclosures:

- Application Data Sheet, 9 pages.
- Certification of Micro Entity Status, 2 pages.

The applicant certifies its micro entity status under 37 CFR 1.29.

Basic Filing Fee	\$64
Search Fee	\$140
Examination Fee	\$160
Total Claims 20 over 20 0 x \$20	\$0
Independent Claims 3 over 3 0 x \$96	\$0
Fee for Multiple Dependent claims	\$0
Application size fee for each 50 pages over 100	
Total Sheets: 35 x .75 - 100/50 = 0 x	\$0



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Page 2

Total Filing fee \$364

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I hereby authorize the USPTO to communicate in response to email communications from the undersigned and practitioners under Customer No. 20985 in accordance with 37 CFR 1.33 and 37 CFR 1.34 concerning any subject matter of this application via email. I understand that a copy of these communications will be made of record in the application file. (MPEP 502.03).

If this application is considered to be incomplete, or if a telephone conference would otherwise be helpful, call the undersigned at +1 (512) 226-8156.

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Respectfully submitted,

/Heather L. Flanagan/

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Enclosures

HZF/vzs
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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
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22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica Juarez

PATENT CENTER # 61438118

FILING DATE -

CUSTOMER # 20985

FIRST NAMED
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AUTHORIZED BY Heather Flanagan

Documents

TOTAL DOCUMENTS: 6

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
22193-0137002_PAP.PDF	2	Transmittal of New Application	114 KB
22193-0137002_ADS.pdf	9	Application Data Sheet	2174 KB
22193-0137002_MICRO.PDF	2	Certification of Micro Entity (Education Basis)	73 KB
22193-0137002_DECs.pdf	2	Oath or Declaration filed	1054 KB
22193-0137002- SPECIFICATION- APP.TEXT.docx	25	Application body structured text document	65 KB

Warning: The document line spacing appears to be incorrect. Please review and revise if

necessary. Bookmarks were found and have been removed.

22193-0137002__FIGs.pdf	10	Drawings-only black and white line drawings	1239 KB
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Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
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22193-0137002__FIGs.pdf	986A50EC911A43AF3C95DBBB3270C52B6F097FB1735479B48 EA3A4ABED5FDE422A3A5D3E7D8F58A867F37FF80DAB9625E FC4806A50D04953A096895C97B673F8

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New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d))

and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

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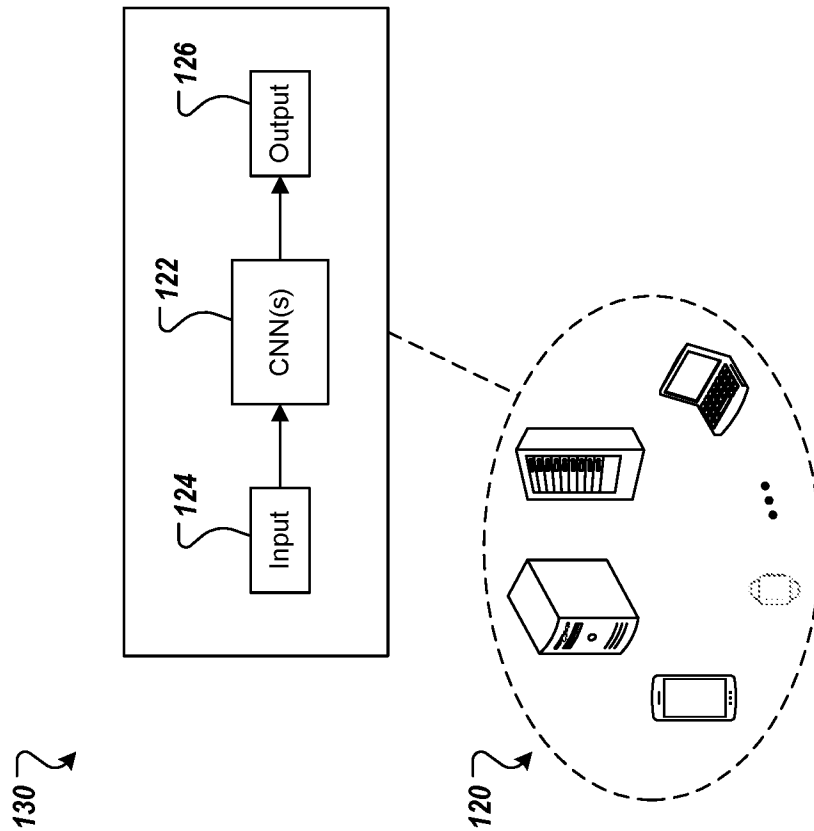


FIG. 1A

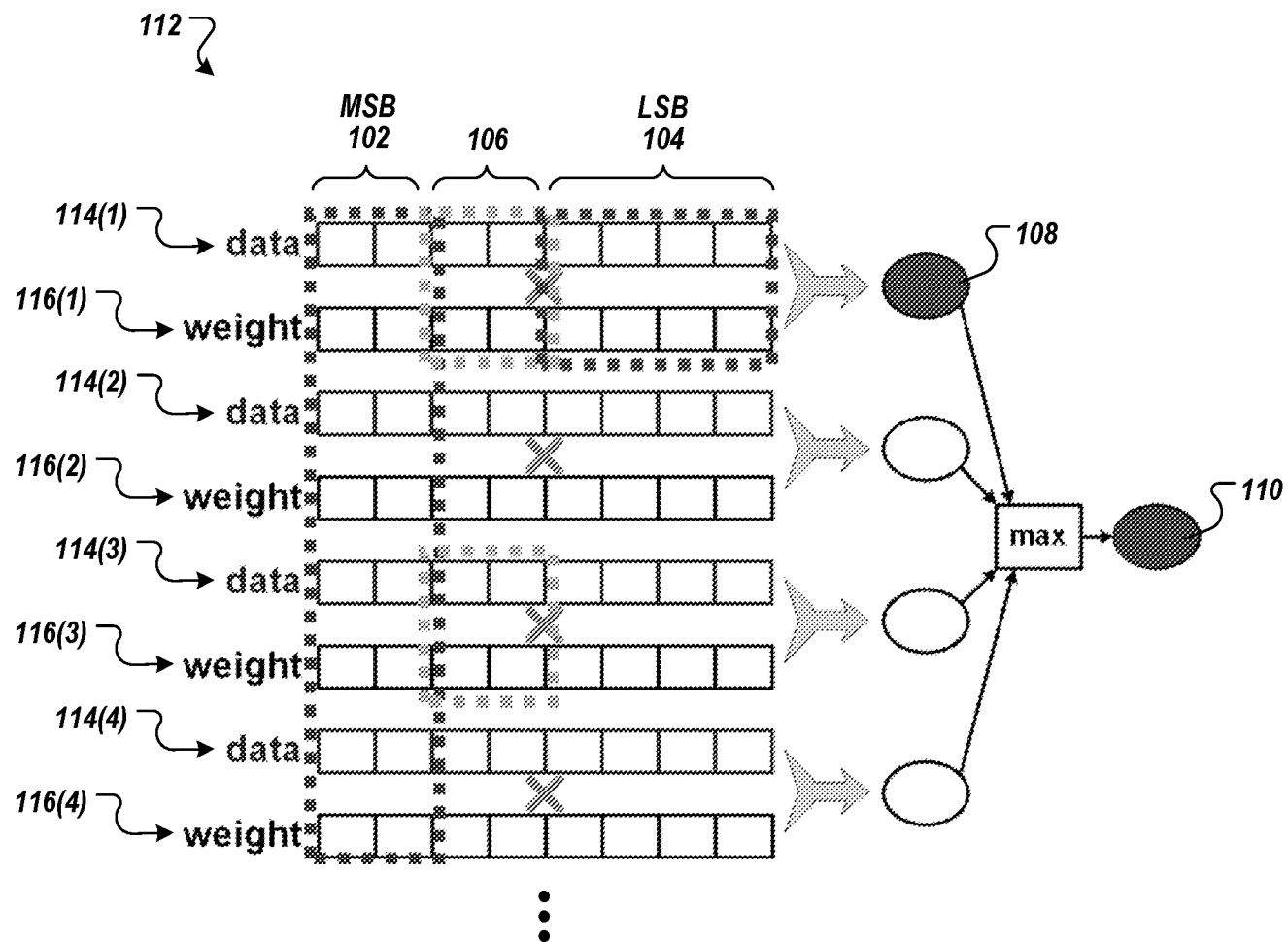


FIG. 1B

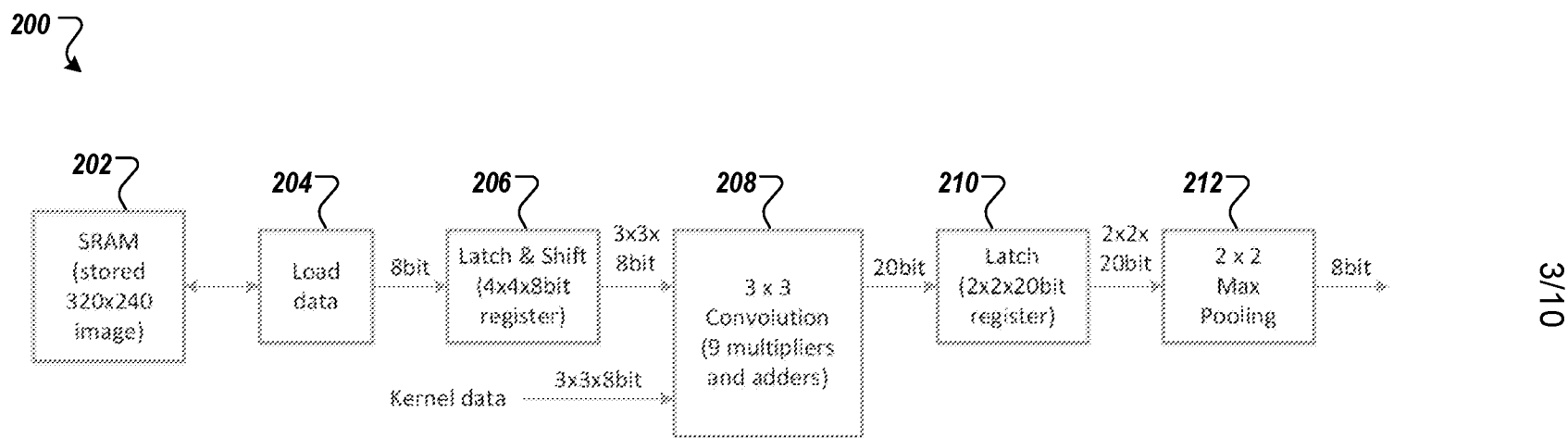


FIG. 2

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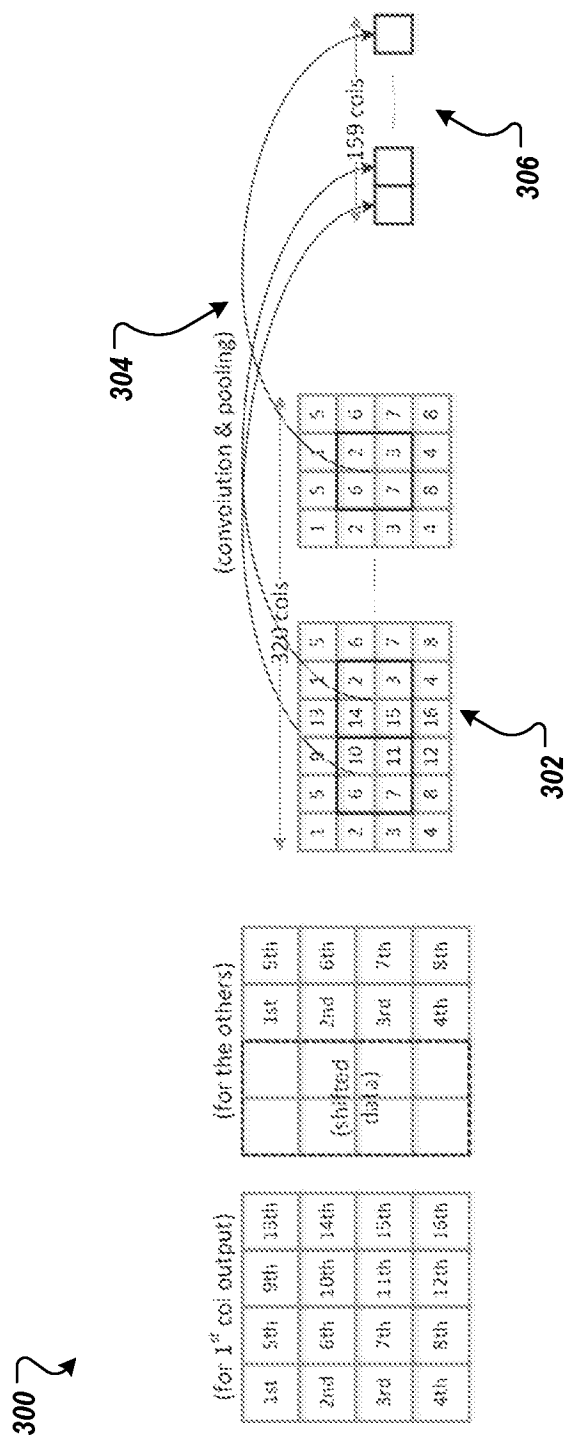
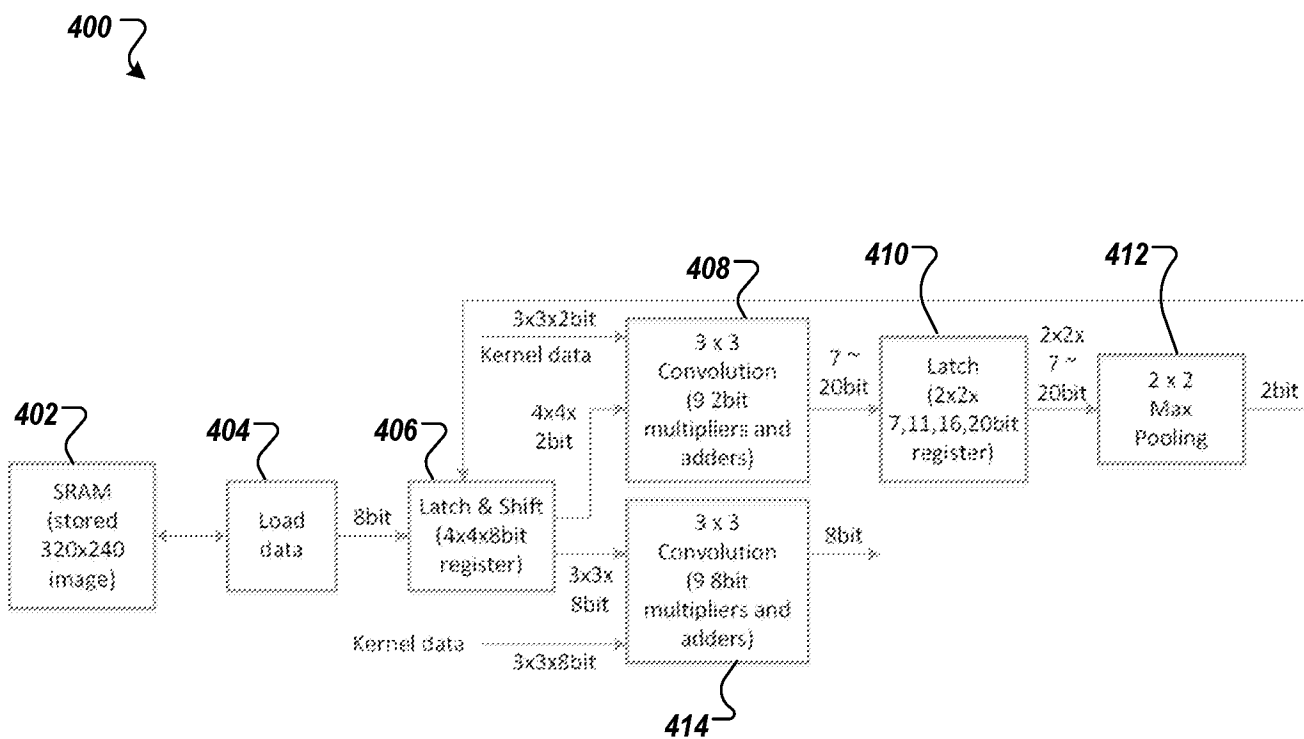


FIG. 3



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FIG. 4

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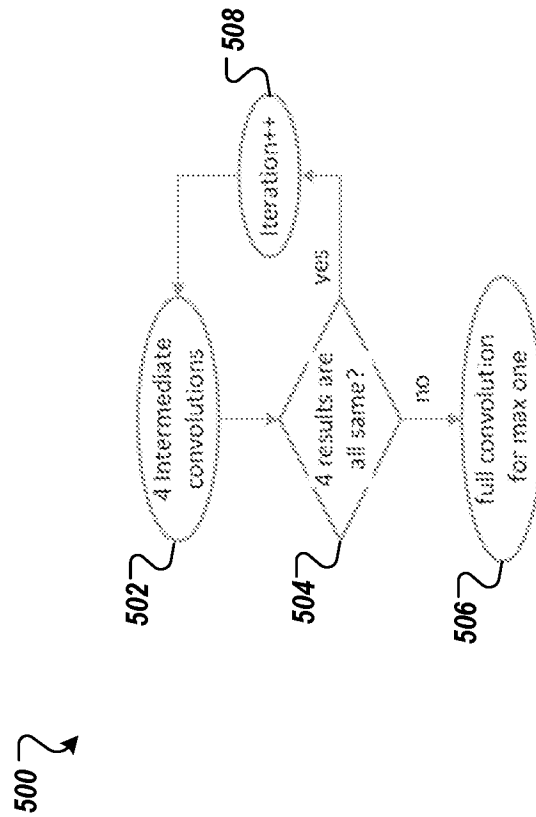


FIG. 5

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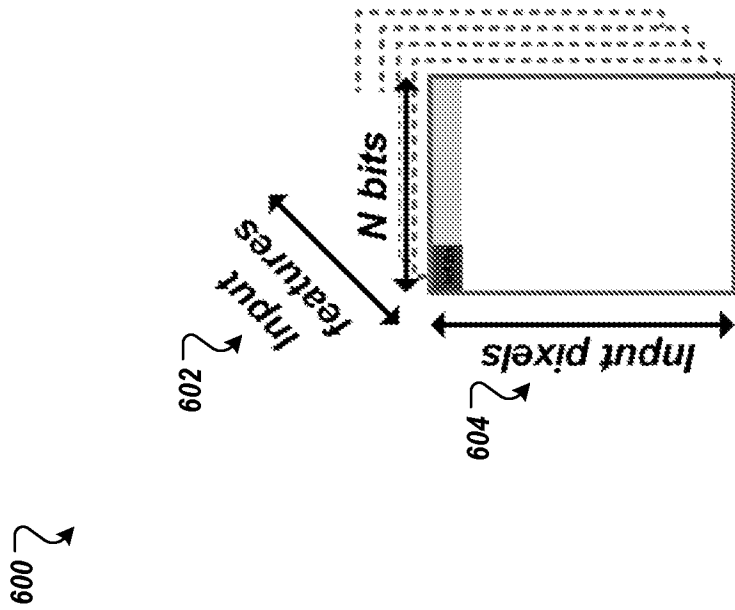


FIG. 6

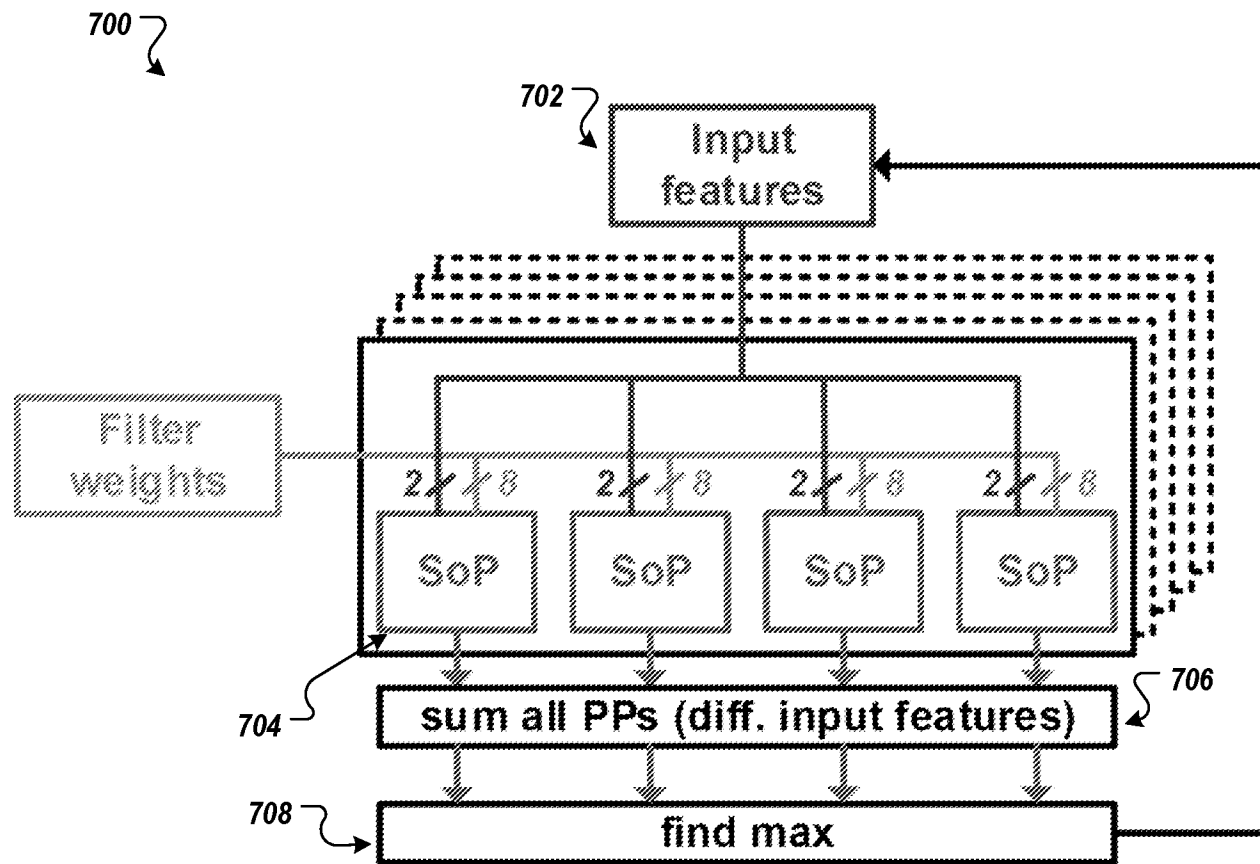


FIG. 7

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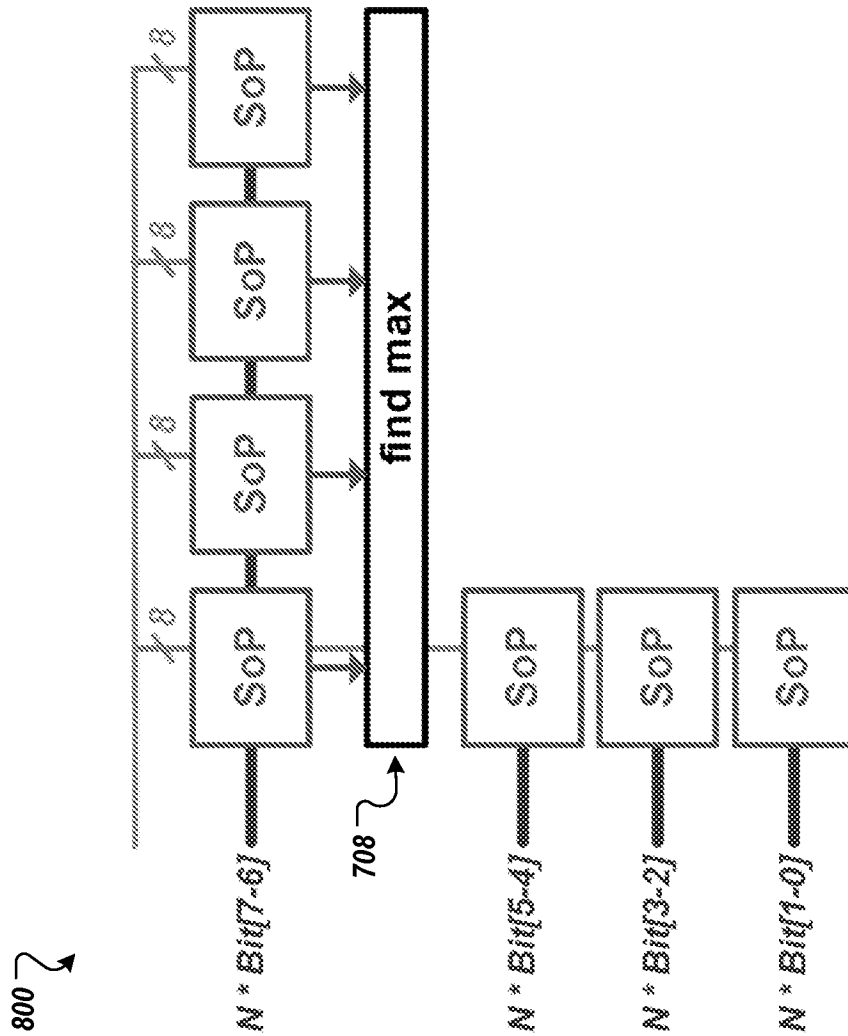


FIG. 8

10/10

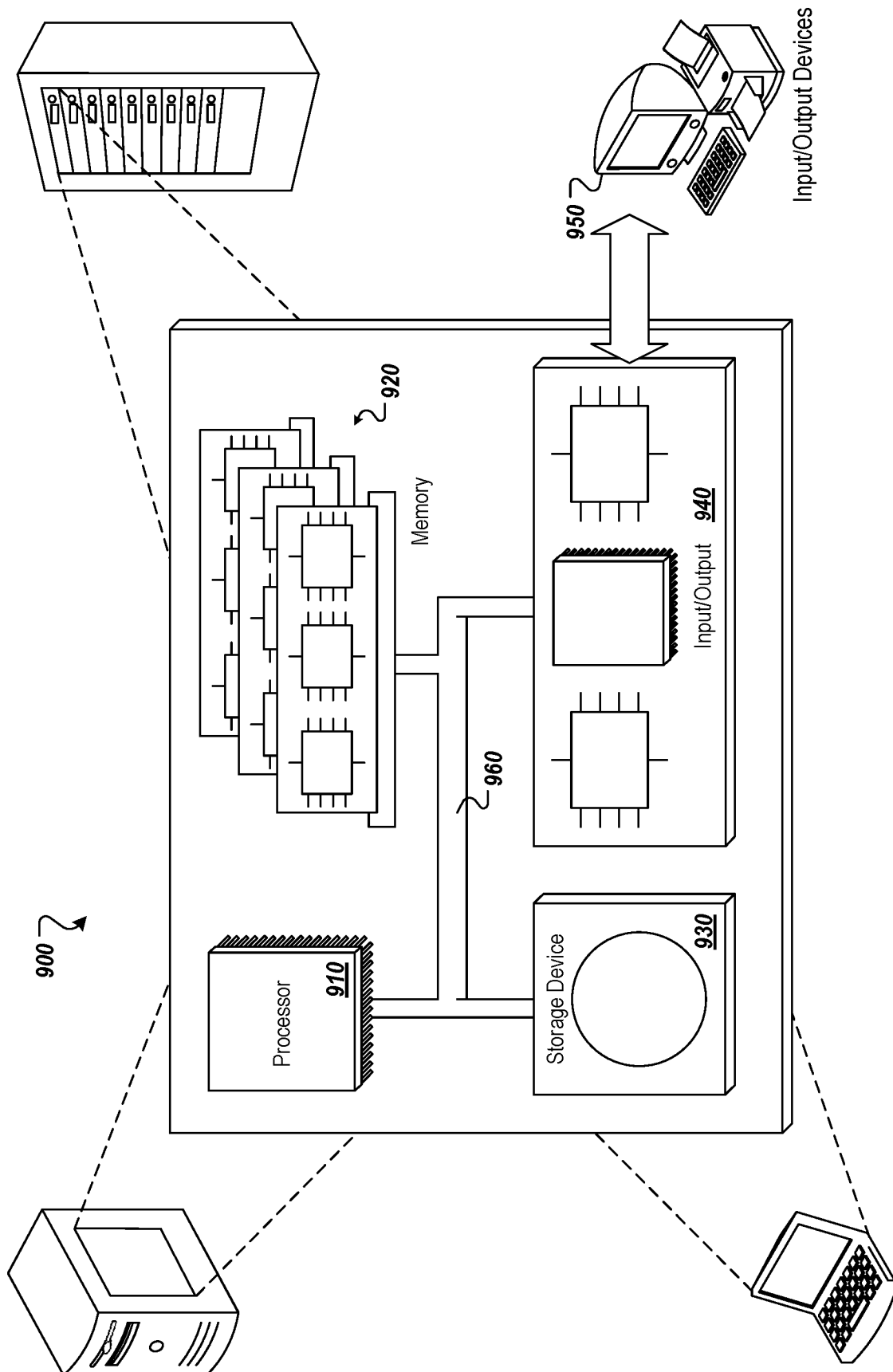


FIG. 9

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)**Title of Invention**

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

As the below named inventor, I hereby declare that:

This declaration [X] The attached application, or
is directed to:
[] United States application or PCT international application
number _____
filed on _____

The above-identified application was made or authorized to be made by me.

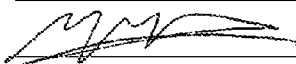
I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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Petitioner/applicant is cautioned to avoid submitting personal information in documents filed in a patent application that may contribute to identity theft. Personal information such as social security numbers, bank account numbers, or credit card numbers (other than a check or credit card authorization form PTO-2038 submitted for payment purposes) is never required by the USPTO to support a petition or an application. If this type of personal information is included in documents submitted to the USPTO, petitioners/applicants should consider redacting such personal information from the documents before submitting them to the USPTO. Petitioner/applicant is advised that the record of a patent application is available to the public after publication of the application (unless a non-publication request in compliance with 37 CFR 1.213(a) is made in the application) or issuance of a patent. Furthermore, the record from an abandoned application may also be available to the public if the application is referenced in a published application or an issued patent (see 37 CFR 1.14). Checks and credit card authorization forms PTO-2038 submitted for payment purposes are not retained in the application file and therefore are not publicly available.

LEGAL NAME OF INVENTOR

Inventor: Jae-sun Seo Date (Optional) : 03/21/19Signature: 

Note: An application data sheet (PTO/SB/14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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DECLARATION (37 CFR 1.63) FOR UTILITY OR DESIGN APPLICATION USING AN APPLICATION DATA SHEET (37 CFR 1.76)Title of
Invention

CASCADING COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

As the below named inventor, I hereby declare that:

This declaration ☒ The attached application, or
is directed to:☐ United States application or PCT international application
number

filed on

The above-identified application was made or authorized to be made by me.

I believe that I am the original inventor or an original joint inventor of a claimed invention in the application.

I hereby acknowledge that any willful false statement made in this declaration is punishable under 18 U.S.C. 1001 by fine or imprisonment of not more than five (5) years, or both.

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LEGAL NAME OF INVENTOR

Inventor: Minkyu Kim

Date (Optional): 03/21/2019

Signature: 

Note: An application data sheet (PTO/GB-14 or equivalent), including naming the entire inventive entity, must accompany this form or must have been previously filed. Use an additional PTO/AIA/01 form for each additional inventor.

This collection of information is required by 35 U.S.C. 115 and 37 CFR 1.63. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.11 and 1.14. This collection is estimated to take 1 minute to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1480, Alexandria, VA 22313-1480.

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CERTIFICATION OF MICRO ENTITY STATUS (INSTITUTION OF HIGHER EDUCATION BASIS)					
Application Number or Control Number (if applicable):			Patent Number (if applicable):		
First Named Inventor: Jae-sun Seo			Title of Invention: CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		
CERTIFICATION ON THE BASIS OF EMPLOYMENT BY AN INSTITUTION OF HIGHER EDUCATION					
The applicant hereby certifies the following—					
The applicant qualifies as a small entity as defined in 37 CFR 1.27.					
The applicant's employer, from which the applicant obtains the majority of the applicant's income, is an institution of higher education as defined in section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a)).					
SIGNATURE by a party set for in 37 CFR 1.33(b)					
Signature					
Name					
Date		Telephone		Registration No.	
☐	There is more than one inventor and I am one of the inventors who are jointly identified as the applicant. Additional certification form(s) signed by the other joint inventor(s) are included with this form.				
CERTIFICATION ON THE BASIS OF ASSIGNMENT OR OBLIGATION TO ASSIGN TO AN INSTITUTION OF HIGHER EDUCATION					
The applicant hereby certifies the following—					
The applicant qualifies as a small entity as defined in 37 CFR 1.27.					
The applicant has assigned, granted, conveyed, or is under an obligation by contract or law, to assign, grant, or convey, a license or other ownership interest in the particular application to an institution of higher education as defined in section 101(a) of the Higher Education Act of 1965 (20 U.S.C. 1001(a)).					
SIGNATURE by a party set for in 37 CFR 1.33(b)					
Signature		/Heather L. Flanagan/			
Name		Heather L. Flanagan			
Date	January 13, 2023	Telephone	+1 (512) 226-8156	Registration No.	54,101
☐	There is more than one inventor and I am one of the inventors who are jointly identified as the applicant. Additional certification form(s) signed by the other joint inventor(s) are included with this form.				

NOTE: A signed copy of this "institution of higher education basis" micro entity certification form (PTO/SB/15B) filed together with a signed copy of the "gross income basis" micro entity certification form (PTO/SB/15A) will be taken to be a representation that any inventor or person applying for a patent as provided in 37 CFR 1.46 not qualifying on the "gross income basis" qualifies on the "institution of higher education basis."

Privacy Act Statement

The **Privacy Act of 1974 (P.L. 93-579)** requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a continuation of U.S. Patent Application No. 16/335,775,
 5 titled “Cascaded Computing For Convolutional Neural Networks” filed on March 22, 2019, which
 is a U.S. National Stage Application under 35 USC § 371 and claims the benefit of International
 Patent Application No. PCT/US2017/052736 titled “Cascaded Computing for Convolutional
 Neural Networks,” filed on September 21, 2017, which is related to, and claims priority to, U.S.
 Provisional Patent Application Serial No. 62/399,753, titled “Cascaded Computing for
 10 Convolutional Neural Networks,” filed on September 26, 2016, all of which are incorporated
 herein by reference in their entirety.

BACKGROUND

[0002] Convolutional Neural Networks (CNNs) have gained popularity in many computer
 15 vision applications (image, video, speech, etc.), because of their ability to train and classify with
 high accuracy. Due to multiple layers of convolution and pooling operations that are compute-
 /memory-intensive, it is difficult to perform real-time classification with low power consumption
 on today’s computing systems.

20 SUMMARY

[0003] Implementations of the present disclosure are generally directed to a technique for
 efficiently reducing the amount of total computation in CNNs without affecting the output result
 or classification accuracy.

[0004] In general, innovative aspects of the subject matter described in this specification can be
 25 embodied in methods that include actions of: in one or more layers of a convolutional neural
 network (CNN), performing a first iteration that includes computing a value based on a first set of
 most significant bits (MSBs) for each of a plurality of data sets; examining a first set of values
 computed for the plurality of data sets in the first iteration to determine whether a maximum value
 is present among the first set of values; responsive to identifying the maximum value, performing

a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and propagating the full precision computation of the value to a subsequent layer of the CNN.

[0005] Implementations can optionally include one or more of the following features: the actions further include, responsive to determining that the first set of values are the same, performing a second iteration that includes computing the value based on a second set of MSBs for each of the plurality of data sets, the second set of MSBs being larger than the first set of MSBs; the actions further include examining a second set of values computed for the plurality of data sets in the second iteration to determine whether the maximum value is present among the second set of values; the actions further include, responsive to identifying the maximum value among the second set of values, performing the full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value in the second iteration; the computing in each of the first iteration and the second iteration employs a convolution and a pooling; the convolution is a $N \times N$ convolution, where N is any integer; the pooling is a $N \times N$ pooling, where N is any integer; the convolution is a 3×3 convolution, and the pooling is a 2×2 pooling; at least one of the first iteration and the second iteration is performed with a precision less than that of the full precision computation; the precision is 8-bit precision; the CNN is employed to analyze an image; the first iteration computes a value that approximates the full precision computation of the value; and/or the full precision computation is performed on the data set the includes less data than the plurality of data sets.

[0006] Other implementations of any of the above aspects include corresponding systems, apparatus, and computer programs that are configured to perform the actions of the methods, encoded on computer storage devices. The present disclosure also provides a computer-readable storage medium coupled to one or more processors and having instructions stored thereon which, when executed by the one or more processors, cause the one or more processors to perform operations in accordance with implementations of the methods provided herein. The present disclosure further provides a system for implementing the methods provided herein. The system includes one or more processors, and a computer-readable storage medium coupled to the one or more processors having instructions stored thereon which, when executed by the one or more processors, cause the one or more processors to perform operations in accordance with implementations of the methods provided herein.

[0007] It is appreciated that aspects and features in accordance with the present disclosure can include any combination of the aspects and features described herein. That is, aspects and features in accordance with the present disclosure are not limited to the combinations of aspects and features specifically described herein, but also include any combination of the aspects and features provided.

[0008] The details of one or more implementations of the present disclosure are set forth in the accompanying drawings and the description below. Other features and advantages of the present disclosure will be apparent from the description and drawings, and from the claims.

BRIEF DESCRIPTION OF DRAWINGS

[0009] FIG. 1A is a schematic depicting an example of a computing system for cascaded computing for CNNs, according to implementations of the present disclosure.

[0010] FIG. 1B is a schematic depicting an example of objectives addressed through implementations of the present disclosure.

[0011] FIG. 2 is a flow diagram depicting an example of a conventional convolution and pooling scheme, according to implementations of the present disclosure.

[0012] FIG. 3 is a schematic depicting an example of a conventional convolution and pooling scheme, according to implementations of the present disclosure.

[0013] FIG. 4 is a flow diagram depicting an example process for convolution and pooling, according to implementations of the present disclosure.

[0014] FIG. 5 is a flow diagram depicting an example process for convolution and pooling, according to implementations of the present disclosure.

[0015] FIG. 6 is a schematic depicting an example architecture, according to implementations of the present disclosure.

[0016] FIG. 7 is a schematic depicting an example architecture, according to implementations of the present disclosure.

[0017] FIG. 8 is a schematic depicting an example architecture, according to implementations of the present disclosure.

[0018] FIG. 9 depicts an example computing system, according to implementations of the present disclosure.

DETAILED DESCRIPTION

5 [0019] Implementations of the present disclosure are directed to systems, devices, methods, and/or computer-readable media for efficiently reducing the amount of total computation in CNNs without affecting the output result or classification accuracy. CNNs are traditionally computationally and memory intensive, and may consume a large amount of computing resources such as active memory, processing capacity, and so forth, and may involve many redundant
10 operations. Implementations identify the redundant operations at an early stage in processing, and avoid performing the redundant operations for which the results may not be employed subsequently in the analysis, and which therefore may not affect the overall outcome of the analysis. Accordingly, implementations may be particularly advantageous on computing devices which have limiting processing capacity, limited power available, limited active memory, and/or
15 otherwise limited available resources, by avoiding the expenditure of computing resources on redundant operations that may not affect the overall outcome of the analysis.

[0020] One of the largest redundancies in conventional CNNs is that a large amount of data is thrown away at each pooling layer, because only the maximum value is conveyed to the next layer. For example, in 2x2 max-pooling, 75% of convolution computation data is thrown away at each
20 pooling layer by only conveying the maximum value to the next layer. In 3x3 max-pooling, 89% of convolution computing data is thrown away at each pooling layer. Implementations avoid such redundancies by performing convolution first with a small number of most significant bits (MSBs), computing the pooling, and if the maximum value is known, performing full-precision convolution on the entry that is the maximum value. If the maximum value is not known based on the small
25 number of MSBs, the process may proceed with lower bits of convolution for multiple entries. The number of bits on which convolution is performed largely affects the critical path delay (e.g., matrix multiplication with a smaller dimension), and may be a design parameter. In this way, implementations perform computation using an amount of data that is close to or at the amount of data that is minimally necessary to perform the computation, without large redundancies. The
30 redundant computations that are present in conventional CNNs are reduced and/or removed by

performing a new computation scheme, described herein, that exploits integration of primary computing primitives.

[0021] In some implementations, the input bits (e.g., those used in a full-precision computation) may be divided into a number of groups that each include a smaller number of bits (e.g., for low-precision). Starting from the MSB side, implementations may perform approximate computing group-by-group, and these approximate computing steps are cascaded. In some implementations, the same approximate hardware engine may be reused for cascaded precision computing operations, thus reducing the hardware footprint. At each iteration, by finding the maximum value of approximate computations, a decision may be made whether the next approximate convolution iteration needs to be performed. In this way, only the necessary amount of computations may be performed, significantly reducing the amount of total computation compared to traditional methods of iterative computation performed in conventional CNNs. Implementations perform approximate computations of neural networks (e.g., based on the MSBs), make a decision based on the approximate results which data set to proceed with, and then (e.g., only) perform the more fine-grain, full precision, (e.g., more accurate) computations on the narrowed-down set of data that exhibited the maximum. Accordingly, the first iteration computes a value that approximates the full precision computation of the value, and the full precision computation is performed only on the data set that exhibited the maximum, that data set including less data than the entire plurality of data sets.

[0022] FIG. 1A is a schematic depicting an example of a computing environment 130 for cascaded computing for CNNs, according to implementations of the present disclosure. As shown in the example of FIG. 1A, the environment 130 includes one or more computing devices 120 of any suitable number and type of computing device. In some implementations, the computing device(s) 120 include small and/or portable device(s), and/or device(s) that have limited hardware capabilities, such as wearable computing devices (e.g., with a wristwatch, headset, glasses, fitness tracker, or other form factor), smart phones, embedded computing devices, devices that are included in automobiles, drones, and/or other vehicles, and so forth. The device(s) 120 may execute one or more CNNs 122 that accept and process input data 124 to generate output data 126. The input and/or output data may be any type of data that is suitable to provide a particular function of the device 120. For example, CNN(s) 122 executing in an autonomous or semi-autonomous vehicle (e.g., a self-driving vehicle) may perform operations related to the navigation and/or

operation of the vehicle. In such examples, the CNN(s) may accept input data in the form of current environment data regarding the position and movement of the vehicle relative to any number of proximal objects, and the position and movement of the proximal objects, and generate output data in the form of commands to operate the vehicle, e.g., adjust its position, speed, orientation, and so forth. The greater computational efficiencies provided by the implementations described herein may enable the vehicle to operate with quick response to environmental changes and with computational efficiency and accuracy. Other examples herein describe the use of cascaded computing for CNNs in the context of image analysis.

[0023] Implementations are not limited to these examples. The implementations described herein support the deployment of CNNs in a wide variety of applications, such as internet-of-things (IoT) systems, self-driving vehicles, and so forth. Implementations may be especially useful in environments with limited hardware resources, given that implementations enable the hardware footprint and/or processing power to be substantially reduced while producing the same or similar output as conventional CNNs.

[0024] FIG. 1B is a schematic depicting an example of objectives addressed through implementations of the present disclosure. As shown in the example of FIG. 1B, the objective of at least some implementations is to reduce the redundancy present in dense convolution through use of pooling, e.g., cascaded precision. If the MSB convolution reveals a maximum, LSB convolution may be skipped. Implementations start with coarse computations, and may proceed to more fine-grained computations if necessary.

[0025] In the example of FIG. 1B, the analysis is performed on four sets of data 114(1)-114(4) that are each associated with a set of weights 116. Implementations support analysis of any suitable number of data sets and/or weights. In some instances, convolution may include a plurality of multiply and add operations, in which the data and corresponding weight is to be multiplied and the results added to other products of data * weight multiplication in the data set(s). For example, adjacent 2 x 2 data sets (e.g., pixel sets) may be multiplied to determine individual convolution results for each of the (e.g., four) data sets. From the convolution results for each of the (e.g., four) data sets, a maximum 108 may be determined which is propagated to a next layer of convolution 110. In conventional CNNs, the convolution results that have a lower value than

the maximum (e.g., first set of data) may not be used in the next layer(s), e.g., the later stage(s) of the analysis, and may therefore be discarded.

[0026] In some implementations, the data may include one or more most significant bits (MSB) 102, one or more least significant bits (LSB) 104, and one or more bits 106 in between the MSB and LSB. MSB may include the coarser level of data and LSB may include the more fine-grained data. In some implementations, convolution may be performed on the MSB initially. Based on the results of the MSB-driven convolution(s), a maximum may be determined. If one of the data sets exhibits a maximum, with a high confidence, over the other data sets based on the MSB-driven convolution(s), the algorithm may proceed to the next layers using that data set maximum and discarding the others. Compared to conventional methods, this MSB-driven convolution may produce similar results given that the lower precision bits in the data set would not have altered the maximum determination computation even if they had been included in the original computation. Accordingly, implementations initially perform a minimal amount of computation to determine and compare maximums among the data sets, and avoid the initial full convolution performed by conventional CNNs. In some implementations, after determining the maximum based on the low precision MSB-based computations, the full precision (e.g., all bits) computation may be performed on the data set for which the maximum was identified.

[0027] In some instances, two data sets may exhibit the same value or a similar value following the initial low precision convolution, such that a clear maximum may not be determined among the data sets. In some implementations, if the difference between the initial results is less than a predetermined threshold then a cascaded convolution may be performed by repeating the convolution using a large set of the bits of the data, e.g., the MSB 102 and the intermediary bits 106. A maximum may then be determined from among the results of this computation for each data set. If a clear maximum is not determined based on this slightly higher precision computation, the process may cascade further and perform another iteration with yet more bits, and so forth. The algorithm may perform any suitable number of iterations, up to the full precision (e.g., full data set) convolution, until a maximum is determined from among the data sets. In some implementations, each iteration may include an additional two bits in the computation, compared to the previous iteration. In some implementations, the additional iterations may be performed on those data sets that are candidates to exhibit the eventual maximum, e.g., those data sets for which the result value is close to the result(s) of other data set(s). Accordingly, each iteration may reduce

the number of candidate data sets for the eventual maximum value, until only one such data set remains to proceed to the next layer of analysis. This iterative algorithm provided by implementations is also described as a cascading algorithm.

[0028] FIG. 2 is a flow diagram 200 depicting an example of a conventional convolution and pooling scheme. FIG. 2 shows a flow diagram, or block diagram, of a conventional convolution and pooling scheme that employs 3x3 convolution, 2x2 pooling, and 8-bit precision. The scheme of FIG. 2 may proceed according to the convolution equation below, Example Equation 1.

Example Equation 1

$$= \sum_{n=1}^{M \times N} D_n K_n \text{ (} D: \text{data, } K: \text{kernel, } M \times N: \text{kernel window size)}$$

[0029] Kernel may refer to the weights described with respect to FIG. 1B. Accordingly, the example equation 1 describes a full precision convolution of all the bits in a particular data set, and/or all the bits that are within a particular $M \times N$ window size (e.g., $M \times N$ pixel portion(s) of an image). In a conventional method, an image (e.g., 320×240) may be stored (202) in SRAM and the data of the image loaded (204) into registers (206) for processing. Convolution (208) may be performed on the data in the registers, e.g., 3×3 convolution based on 3×3 kernel data (e.g., weighting). The convolution results may be stored in 2×2 bit registers (210), and 2×2 max pooling (212) may be performed to determine the maximum value for the particular layer of analysis before proceeding to the next layer.

[0030] Although various examples herein describe applying a particular convolution, pooling, and precision, such as 3×3 convolution, 2×2 pooling, and 8-bit precision, implementations are not so limited. Implementations may employ any $N \times N$ convolution, where N is any suitable integer. Implementations may employ any $N \times N$ pooling, where N is any suitable integer (different than, or same as, the dimension of the convolution). Implementations may also employ any suitable level of precision in the computation.

[0031] FIG. 3 is a schematic 300 depicting an example of a conventional convolution and pooling scheme. FIG. 3 describes an operation clock cycle corresponding to the algorithm described with reference to FIG. 2, which may require 16 clocks for the first column output after the convolution and pooling process, and which may require 8 clocks for the other column outputs.

[0032] As shown in FIG. 3, the 3×3 window of analysis may be applied to different portions of the image 302 during a particular layer of convolution and pooling 304, to generate a convolution output 306. A 3×3 kernel (e.g., weight) may be overlaid and the kernel may be multiplied by the data for the particular portion of pixels, to output a particular value. This value
 5 may then be compared to other output values to determine the maximum, and the portion exhibiting the maximum may be further analyzed in subsequent layers.

[0033] Convolution and pooling may be performed at the various layers of analysis for a particular kernel size, with regard to one or more channels of input and/or output. The various convolution and pooling results for various layers may be stacked on top of one another to form a
 10 deep neural network hierarchy. Traversing from the low level to the higher level may include convolution and/or various non-linear operation(s) to determine a higher level (e.g., more abstract) representation of the image as the analysis progresses deeper. For example, a first layer of analysis may identify edges in an image, subsequent layer(s) may combined the edges to identify shapes or other features within the image, the shapes may be combined at further higher level(s), and so forth
 15 to determine what is shown in the image.

[0034] FIG. 4 is a flow diagram 400 depicting an example process for convolution and pooling, according to implementations of the present disclosure. FIG. 4 shows an example of a flow diagram, e.g., logic and/or block diagram, for a convolution and pooling scheme that employs 3×3 convolution, 2×2 pooling, and 8-bit precision.

20 [0035] An image (e.g., 320×240) may be stored (402) (e.g., in SRAM) and the data of the image loaded (404) into registers (406) for processing.

[0036] Using the two most significant bits of image data and convolution kernel, approximate multiply-and-add operations are performed (408). The intermediate approximate results are stored into registers (410), and 2×2 max-pooling is performed on the approximate 2-bit multiply-and-
 25 add results (412). The output of the pooling computation is fed back to the input data registers (406), which govern the following computations.

[0037] As shown in the example of FIG. 4, 2×2 max pooling may be performed and, based on whether a maximum was found or not, the process may iterate. If a maximum is found, the 3×3 convolution may be performed and full precision convolution may be performed on the maximum-
 30 exhibiting data set (414). If a maximum is not found, then the next group of (e.g., higher precision)

bits may be retrieved and used to compute results (408) in the next iteration, with any suitable number of iterations performed until a maximum is found.

[0038] The scheme of FIG. 4 may proceed according to the intermediate convolution equation below, Example Equation 2.

5 Example Equation 2

$$= \sum_{i=0}^{itr-1} \sum_{n=1}^{M \times N} 4^{itr-1-i} D[MSB - 2 \times i: MSB - 2 \times i - 1]_n K[MSB - 2 \times i: MSB - 2 \times i - 1]_n \quad (itr: \#iteration)$$

[0039] Example Equations 3, 4, and 5 illustrate the first, second, and third iterations respectively, for 8-bit precision and 3×3 convolution.

10 Example Equation 3

$$= \sum_{n=1}^9 D[7:6]_n K[7:6]_n$$

Example Equation 4

$$= \left(\sum_{n=1}^9 D[7:6]_n K[7:6]_n \right) \times 4 + \sum_{n=1}^9 D[5:4]_n K[5:4]_n$$

15

Example Equation 5

$$= \left(\sum_{n=1}^9 D[7:6]_n K[7:6]_n \right) \times 16 + \left(\sum_{n=1}^9 D[5:4]_n K[5:4]_n \right) \times 4 + \sum_{n=1}^9 D[3:2]_n K[3:2]_n$$

[0040] For the example equations 2-5, the left hand side of the equation may be the output
20 convolution pixel value. Although examples herein describe using the cascading (e.g., iterative) CNNs for image analysis, implementations may also be applied in other data analysis scenarios.

[0041] FIG. 5 is a flow diagram 500 depicting an example process for convolution and pooling, according to implementations of the present disclosure. For a 2×2 pooling, four intermediate (e.g., approximate) convolutions may be performed (502) and the results of the four convolutions may be examined (504) to determine whether any of the convolutions exhibit a maximum, or whether the four results are the same. If the four results are the same, or sufficiently similar (e.g., within a predetermined threshold range of one another), the process may perform (508) another iteration (e.g., cascade) as described above, performing a convolution using more bits of data. If the four results are not the same and/or are not similar (e.g., if a clear maximum is exhibited by one of the convolutions), the analysis may proceed (506) to perform the full (e.g., full precision) convolution for the data set that exhibited the maximum of the low precision, MSB-based convolution.

[0042] FIG. 6 is a schematic 600 depicting an example arrangement of input data, according to implementations of the present disclosure. As shown in the example of FIG. 6, the MSBs of various input features 602 may be loaded first, instead of loading the full precision input as in conventional schemes. In some implementations, the input data may include a plurality of input features 602, which may also be described as input channels. Each input feature 602 may include an array of input pixels 604. For example, for a data set of 100×100 pixels, there may be multiple layers as each pixel includes N bits. As a particular example, the different channels may be different color channels (e.g., three color dimensions for a RGB color format image). In some implementations, the result values for the same pixel may be added across different channels.

[0043] FIGS. 7 and 8 are schematics 700 and 800 respectively depicting an example architecture, according to implementations of the present disclosure. FIG. 7 shows the various input features or channels that may be present in some instances. For each input feature 702, implementations may process two bits at a time and the two bits may be multiplied by the 8 bits of weight data by a SoP module 704, e.g., a sum-or-product or multiply-and-add module. Each SoP 704 may accumulate the various multiplication results from different channels, and the partial products (PPs) may be summed (706) for the different input features or channels. The maximum may be identified (708) among these various (e.g., four) results. As shown in FIG. 8, if a maximum is found (708) a full precision calculation may be performed for the data set that exhibited the maximum value. If not, then higher precision calculations may be performed until a maximum is identified, as described above. After the maximum value is found, the same SoP modules that

were used in the computation with most significant bits of data can be re-used for computation of the less significant bits of data, thus maximizing hardware utilization.

[0044] Table 1 below shows test results of using the implementations described herein to analyze two test images, image1 and image2, compared to the results of using conventional techniques. For the tests described below, the input data is $320 \times 240 \times 3$, the convolution kernel is $7 \times 7 \times 3$, the pooling window is 2×2 , the width of input and kernel data is 8 bit and 12 bit respectively, the maximum frequency is 500 MHz, and an 8×3 -bit multiplier is used for the tests using the implementations described herein.

Table 1

	Conventional techniques	Implementations described herein
Power (mW)	$92.8^1, 88.6^2$	$44.1^1, 41.8^2$
Total delay (ns)	629,145	$746,150^1, 752,770^2$
Energy (J)	$58.384 \times 10^{-9}^1, 55.742 \times 10^{-9}^2$	$32.905 \times 10^{-9}^1, 31.466 \times 10^{-9}^2$
Total cell area	687,876	222,784
Difference average		$0.0042^1, 0.0073^2$
Difference maximum		$3^1, 6^2$

[0045] In Table 1, the 1 superscript refers to the results of using image1 for input data, and the 2 superscript refers to the results of using image2 for input data. The number of iterations performed may be dependent on the image being processed. On average, the use of the implementations described herein may results in a power reduction of greater than a factor of two.

Table 2 below shows a distribution of the number of iterations for processing image1 and image 2.

Table 2

	Image1	Image2
1 iteration	18,368 (100%)	17,261 (94%)

2 iterations	0 (0%)	0 (0%)
3 iterations	0 (0%)	0 (0%)
4 iterations	1 (0%)	1,108 (6%)

[0046] Table 3 below describes test results using a second layer of AlexNet for particular test image, comparing results achieved using implementations described herein versus conventional techniques. For the tests described below, the input data is $55 \times 55 \times 48$, the convolution kernel is $5 \times 5 \times 48$, the pooling window is 2×2 , the width of input and kernel data is 12 bit, the maximum frequency is 455 MHz and 500 MHz for the conventional techniques and implementations described herein respectively, and 12×3 -bit multiplier is used for the tests using the implementations described herein.

Table 3

	Conventional techniques	Implementations described herein
Logic power (mW)	84.8	37.8
SRAM power (mW)	136.1	94.4
Total power (mW)	220.9	132.2
Total delay (ns)	594,132	971,939
Total cell area (μm^2)	634,601	203,939
Difference average		0.31
Difference maximum		4

[0047] Table 4 below shows a distribution of the number of iterations for processing the test image.

Table 4

	Image
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1 iteration	567 (91%)
2 iterations	58 (9%)
3 iterations	0 (0%)
4 iterations	0 (0%)

[0048] As shown in Table 4, 91% of the approximate computations found a maximum in the first iteration, using the implementations described herein. For 2×2 pooling, 91% of 3 (out of 4) outputs did not reach a second, third, or fourth iteration. The test results of Tables 1-4 indicate that implementations of the cascading CNNs described herein provide for CNNs that identify a maximum with high likelihood in the first or second iteration, thus avoiding subsequent iterations and foregoing redundant calculations present in conventional CNNs. The Tables 1-4 also illustrate that implementations provide for lower power consumption and/or energy consumption compared to conventional techniques, as well as other advantages.

[0049] Although various examples herein describe using implementations for image analysis, implementations are not limited to this particular application. Implementations may also use the cascading CNNs described herein for other applications, such as in speech analysis, biomedical applications, and so forth.

[0050] FIG. 9 depicts an example computing system, according to implementations of the present disclosure. The system 900 may be used, in whole or in part, for any of the operations described with respect to the various implementations discussed herein. The system 900 may include one or more processors 910, a memory 920, one or more storage devices 930, and one or more input/output (I/O) devices 950 controllable through one or more I/O interfaces 940. The various components 910, 920, 930, 940, or 950 may be interconnected through at least one system bus 960, which may enable the transfer of data between the various modules and components of the system 900.

[0051] The processor(s) 910 may be configured to process instructions for execution within the system 900. The processor(s) 910 may include single-threaded processor(s), multi-threaded processor(s), or both. The processor(s) 910 may be configured to process instructions stored in the memory 920 or on the storage device(s) 930. The processor(s) 910 may include hardware-

based processor(s) each including one or more cores. The processor(s) 910 may include general purpose processor(s), special purpose processor(s), or both.

[0052] The memory 920 may store information within the system 900. In some implementations, the memory 920 includes one or more computer-readable media. The memory 920 may include any number of volatile memory units, any number of non-volatile memory units, or both volatile and non-volatile memory units. The memory 920 may include read-only memory, random access memory, or both. In some examples, the memory 920 may be employed as active or physical memory by one or more executing software modules.

[0053] The storage device(s) 930 may be configured to provide (e.g., persistent) mass storage for the system 900. In some implementations, the storage device(s) 930 may include one or more computer-readable media. For example, the storage device(s) 930 may include a floppy disk device, a hard disk device, an optical disk device, or a tape device. The storage device(s) 930 may include read-only memory, random access memory, or both. The storage device(s) 930 may include one or more of an internal hard drive, an external hard drive, or a removable drive.

[0054] One or both of the memory 920 or the storage device(s) 930 may include one or more computer-readable storage media (CRSM). The CRSM may include one or more of an electronic storage medium, a magnetic storage medium, an optical storage medium, a magneto-optical storage medium, a quantum storage medium, a mechanical computer storage medium, and so forth. The CRSM may provide storage of computer-readable instructions describing data structures, processes, applications, programs, other modules, or other data for the operation of the system 900. In some implementations, the CRSM may include a data store that provides storage of computer-readable instructions or other information in a non-transitory format. The CRSM may be incorporated into the system 900 or may be external with respect to the system 900. The CRSM may include read-only memory, random access memory, or both. One or more CRSM suitable for tangibly embodying computer program instructions and data may include any type of non-volatile memory, including but not limited to: semiconductor memory devices, such as EPROM, EEPROM, and flash memory devices; magnetic disks such as internal hard disks and removable disks; magneto-optical disks; and CD-ROM and DVD-ROM disks. In some examples, the processor(s) 910 and the memory 920 may be supplemented by, or incorporated into, one or more application-specific integrated circuits (ASICs).

[0055] The system 900 may include one or more I/O devices 950. The I/O device(s) 950 may include one or more input devices such as a keyboard, a mouse, a pen, a game controller, a touch input device, an audio input device (e.g., a microphone), a gestural input device, a haptic input device, an image or video capture device (e.g., a camera), or other devices. In some examples, the I/O device(s) 950 may also include one or more output devices such as a display, LED(s), an audio output device (e.g., a speaker), a printer, a haptic output device, and so forth. The I/O device(s) 950 may be physically incorporated in one or more computing devices of the system 900, or may be external with respect to one or more computing devices of the system 900.

[0056] The system 900 may include one or more I/O interfaces 940 to enable components or modules of the system 900 to control, interface with, or otherwise communicate with the I/O device(s) 950. The I/O interface(s) 940 may enable information to be transferred in or out of the system 900, or between components of the system 900, through serial communication, parallel communication, or other types of communication. For example, the I/O interface(s) 940 may comply with a version of the RS-232 standard for serial ports, or with a version of the IEEE 1284 standard for parallel ports. As another example, the I/O interface(s) 940 may be configured to provide a connection over Universal Serial Bus (USB) or Ethernet. In some examples, the I/O interface(s) 940 may be configured to provide a serial connection that is compliant with a version of the IEEE 1394 standard.

[0057] The I/O interface(s) 940 may also include one or more network interfaces that enable communications between computing devices in the system 900, or between the system 900 and other network-connected computing systems. The network interface(s) may include one or more network interface controllers (NICs) or other types of transceiver devices configured to send and receive communications over one or more networks using any network protocol.

[0058] Computing devices of the system 900 may communicate with one another, or with other computing devices, using one or more networks. Such networks may include public networks such as the internet, private networks such as an institutional or personal intranet, or any combination of private and public networks. The networks may include any type of wired or wireless network, including but not limited to local area networks (LANs), wide area networks (WANs), wireless WANs (WWANs), wireless LANs (WLANs), mobile communications networks (e.g., 3G, 4G, Edge, etc.), and so forth. In some implementations, the communications

between computing devices may be encrypted or otherwise secured. For example, communications may employ one or more public or private cryptographic keys, ciphers, digital certificates, or other credentials supported by a security protocol, such as any version of the Secure Sockets Layer (SSL) or the Transport Layer Security (TLS) protocol.

5 [0059] The system 900 may include any number of computing devices of any type. The computing device(s) may include, but are not limited to: a personal computer, a smartphone, a tablet computer, a wearable computer, an implanted computer, a mobile gaming device, an electronic book reader, an automotive computer, a desktop computer, a laptop computer, a notebook computer, a game console, a home entertainment device, a network computer, a server
10 computer, a mainframe computer, a distributed computing device (e.g., a cloud computing device), a microcomputer, a system on a chip (SoC), a system in a package (SiP), and so forth. Although examples herein may describe computing device(s) as physical device(s), implementations are not so limited. In some examples, a computing device may include one or more of a virtual computing environment, a hypervisor, an emulation, or a virtual machine executing on one or more physical
15 computing devices. In some examples, two or more computing devices may include a cluster, cloud, farm, or other grouping of multiple devices that coordinate operations to provide load balancing, failover support, parallel processing capabilities, shared storage resources, shared networking capabilities, or other aspects.

[0060] Implementations and all of the functional operations described in this specification may
20 be realized in digital electronic circuitry, or in computer software, firmware, or hardware, including the structures disclosed in this specification and their structural equivalents, or in combinations of one or more of them. Implementations may be realized as one or more computer program products, i.e., one or more modules of computer program instructions encoded on a computer readable medium for execution by, or to control the operation of, data processing
25 apparatus. The computer readable medium may be a machine-readable storage device, a machine-readable storage substrate, a memory device, a composition of matter effecting a machine-readable propagated signal, or a combination of one or more of them. The term “computing system” encompasses all apparatus, devices, and machines for processing data, including by way of example a programmable processor, a computer, or multiple processors or computers. The
30 apparatus may include, in addition to hardware, code that creates an execution environment for the computer program in question, e.g., code that constitutes processor firmware, a protocol stack, a

database management system, an operating system, or a combination of one or more of them. A propagated signal is an artificially generated signal, e.g., a machine-generated electrical, optical, or electromagnetic signal that is generated to encode information for transmission to suitable receiver apparatus.

5 [0061] A computer program (also known as a program, software, software application, script, or code) may be written in any appropriate form of programming language, including compiled or interpreted languages, and it may be deployed in any appropriate form, including as a standalone program or as a module, component, subroutine, or other unit suitable for use in a computing environment. A computer program does not necessarily correspond to a file in a file system. A
10 program may be stored in a portion of a file that holds other programs or data (e.g., one or more scripts stored in a markup language document), in a single file dedicated to the program in question, or in multiple coordinated files (e.g., files that store one or more modules, sub programs, or portions of code). A computer program may be deployed to be executed on one computer or on multiple computers that are located at one site or distributed across multiple sites and
15 interconnected by a communication network.

[0062] The processes and logic flows described in this specification may be performed by one or more programmable processors executing one or more computer programs to perform functions by operating on input data and generating output. The processes and logic flows may also be performed by, and apparatus may also be implemented as, special purpose logic circuitry, e.g., an
20 FPGA (field programmable gate array) or an ASIC (application specific integrated circuit).

[0063] Processors suitable for the execution of a computer program include, by way of example, both general and special purpose microprocessors, and any one or more processors of any appropriate kind of digital computer. Generally, a processor may receive instructions and data from a read only memory or a random access memory or both. Elements of a computer can include
25 a processor for performing instructions and one or more memory devices for storing instructions and data. Generally, a computer may also include, or be operatively coupled to receive data from or transfer data to, or both, one or more mass storage devices for storing data, e.g., magnetic, magneto optical disks, or optical disks. However, a computer need not have such devices. Moreover, a computer may be embedded in another device, e.g., a mobile telephone, a personal
30 digital assistant (PDA), a mobile audio player, a Global Positioning System (GPS) receiver, to

name just a few. Computer readable media suitable for storing computer program instructions and data include all forms of non-volatile memory, media and memory devices, including by way of example semiconductor memory devices, e.g., EPROM, EEPROM, and flash memory devices; magnetic disks, e.g., internal hard disks or removable disks; magneto optical disks; and CD ROM and DVD-ROM disks. The processor and the memory may be supplemented by, or incorporated in, special purpose logic circuitry.

[0064] To provide for interaction with a user, implementations may be realized on a computer having a display device, e.g., a CRT (cathode ray tube) or LCD (liquid crystal display) monitor, for displaying information to the user and a keyboard and a pointing device, e.g., a mouse or a trackball, by which the user may provide input to the computer. Other kinds of devices may be used to provide for interaction with a user as well; for example, feedback provided to the user may be any appropriate form of sensory feedback, e.g., visual feedback, auditory feedback, or tactile feedback; and input from the user may be received in any appropriate form, including acoustic, speech, or tactile input.

[0065] Implementations may be realized in a computing system that includes a back end component, e.g., as a data server, or that includes a middleware component, e.g., an application server, or that includes a front end component, e.g., a client computer having a graphical UI or a web browser through which a user may interact with an implementation, or any appropriate combination of one or more such back end, middleware, or front end components. The components of the system may be interconnected by any appropriate form or medium of digital data communication, e.g., a communication network. Examples of communication networks include a local area network ("LAN") and a wide area network ("WAN"), e.g., the Internet.

[0066] The computing system may include clients and servers. A client and server are generally remote from each other and typically interact through a communication network. The relationship of client and server arises by virtue of computer programs running on the respective computers and having a client-server relationship to each other. The computing system may also include any number of peers which may be distributed and/or remote from one another. The peers may enter into peer-to-peer relationships and establish peer-to-peer connections for communications.

[0067] While this specification contains many specifics, these should not be construed as limitations on the scope of the disclosure or of what may be claimed, but rather as descriptions of

features specific to particular implementations. Certain features that are described in this specification in the context of separate implementations may also be implemented in combination in a single implementation. Conversely, various features that are described in the context of a single implementation may also be implemented in multiple implementations separately or in any suitable sub-combination. Moreover, although features may be described above as acting in certain combinations and even initially claimed as such, one or more features from a claimed combination may in some examples be excised from the combination, and the claimed combination may be directed to a sub-combination or variation of a sub-combination.

[0068] Similarly, while operations are depicted in the drawings in a particular order, this should not be understood as requiring that such operations be performed in the particular order shown or in sequential order, or that all illustrated operations be performed, to achieve desirable results. In certain circumstances, multitasking and parallel processing may be advantageous. Moreover, the separation of various system components in the implementations described above should not be understood as requiring such separation in all implementations, and it should be understood that the described program components and systems may generally be integrated together in a single software product or packaged into multiple software products.

[0069] A number of implementations have been described. Nevertheless, it will be understood that various modifications may be made without departing from the spirit and scope of the disclosure. For example, various forms of the flows shown above may be used, with steps re-ordered, added, or removed. Accordingly, other implementations are within the scope of the following claims.

[0001] What is claimed is:

CLAIMS:

1. A computer-implemented method performed by at least one processor, the method comprising:

in one or more layers of a convolutional neural network (CNN) executed by the at least one processor, performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets;

examining, by the at least one processor, a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values;

responsive to identifying the maximum value, performing, by the at least one processor, a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and

propagating, by the at least one processor, the full precision computation of the value to a subsequent layer of the CNN.

2. The method of claim 1, further comprising:

responsive to determining that the first set of values are the same, performing, by the at least one processor, a second iteration that includes computing the value based on a second set of MSBs for each of the plurality of data sets, the second set of MSBs being larger than the first set of MSBs.

3. The method of claim 2, further comprising:

examining, by the at least one processor, a second set of values computed for the plurality of data sets in the second iteration to determine whether the maximum value is present among the second set of values; and

responsive to identifying the maximum value among the second set of values, performing, by the at least one processor, the full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value in the second iteration.

4. The method of claim 2, wherein the computing in each of the first iteration and the second iteration employs a convolution and a pooling.

5. The method of claim 4, wherein the convolution is a $N \times N$ convolution, where N is any integer.
6. The method of claim 4, wherein the pooling is a $N \times N$ pooling, where N is any integer.
7. The method of claim 4, wherein the convolution is a 3×3 convolution, and the pooling is a 2×2 pooling.
8. The method of claim 2, wherein at least one of the first iteration and the second iteration is performed with a precision less than that of the full precision computation.
9. The method of claim 8, wherein the precision is 8-bit precision.
10. The method of claim 1, wherein the CNN is employed to analyze an image.
11. The method of claim 1, wherein:
 - the first iteration computes a value that approximates the full precision computation of the value; and
 - the full precision computation is performed on the data set the includes less data than the plurality of data sets.
12. A system comprising:
 - at least one processor; and
 - memory communicatively coupled to the at least one processor, the memory storing instructions which, when executed by the at least one processor, cause the at least one processor to perform operations comprising:
 - in one or more layers of a convolutional neural network (CNN), performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets;

examining a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values; responsive to identifying the maximum value, performing a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and propagating the full precision computation of the value to a subsequent layer of the CNN.

13. The system of claim 12, the operations further comprising:
responsive to determining that the first set of values are the same, performing, by the at least one processor, a second iteration that includes computing the value based on a second set of MSBs for each of the plurality of data sets, the second set of MSBs being larger than the first set of MSBs.
14. The system of claim 13, the operations further comprising:
examining, by the at least one processor, a second set of values computed for the plurality of data sets in the second iteration to determine whether the maximum value is present among the second set of values; and
responsive to identifying the maximum value among the second set of values, performing, by the at least one processor, the full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value in the second iteration.
15. The system of claim 13, wherein the computing in each of the first iteration and the second iteration employs a convolution and a pooling.
16. The system of claim 15, wherein the convolution is a $N \times N$ convolution, where N is any integer.
17. The system of claim 15, wherein the pooling is a $N \times N$ pooling, where N is any integer.

18. The system of claim 15, wherein at least one of the first iteration and the second iteration is performed with a precision less than that of the full precision computation.
19. The system of claim 12, wherein:
 - the first iteration computes a value that approximates the full precision computation of the value; and
 - the full precision computation is performed on the data set the includes less data than the plurality of data sets.
20. One or more computer-readable storage media storing instructions which, when executed by at least one processor, cause the at least one processor to perform operations comprising:
 - in one or more layers of a convolutional neural network (CNN), performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets;
 - examining a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values;
 - responsive to identifying the maximum value, performing a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and
 - propagating the full precision computation of the value to a subsequent layer of the CNN.

ABSTRACT

Techniques are described for efficiently reducing the amount of total computation in convolutional neural networks (CNNs) without affecting the output result or classification accuracy. Computation redundancy in CNNs is reduced by exploiting the computing nature of the convolution and subsequent pooling (e.g., sub-sampling) operations. In some implementations, the input features may be divided into a group of precision values and the operation(s) may be cascaded. A maximum may be identified (e.g., by 90% probability) using a small number of bits in the input features, and the full-precision convolution may then be performed on the maximum input. Accordingly, the total number of bits used to perform the convolution is reduced without affecting the output features or the final classification accuracy.

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	22193-0137002
		Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		
The application data sheet is part of the provisional or nonprovisional application for which it is being submitted. The following form contains the bibliographic data arranged in a format specified by the United States Patent and Trademark Office as outlined in 37 CFR 1.76. This document may be completed electronically and submitted to the Office in electronic format using the Electronic Filing System (EFS) or the document may be printed and included in a paper filed application.			

Secrecy Order 37 CFR 5.2:

☐	Portions or all of the application associated with this Application Data Sheet may fall under a Secrecy Order pursuant to 37 CFR 5.2 (Paper filers only. Applications that fall under Secrecy Order may not be filed electronically.)
--------------------------	---

Inventor Information:

Inventor	1	Remove			
Legal Name					
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Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
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Inventor	2	Remove			
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Prefix	Given Name	Middle Name	Family Name	Suffix	
	Minkyu		Kim		
Residence Information (Select One) ☒ US Residency ☐ Non US Residency ☐ Active US Military Service					
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Postal Code	85224	Country	US	

All Inventors Must Be Listed - Additional Inventor Information blocks may be generated within this form by selecting the **Add** button.

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Correspondence Information:Enter either Customer Number or complete the Correspondence Information section below.
For further information see 37 CFR 1.33(a).

IPR2025-01399

CrowdStrike EX1002 Page 47

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	22193-0137002
		Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

☐ An Address is being provided for the correspondence information of this application.

Customer Number	20985		
Email Address		Add Email	Remove Email

Application Information:

Title of the Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		
Attorney Docket Number	22193-0137002	Small Entity Status Claimed	☐
Application Type	Nonprovisional		
Subject Matter	Utility		
Total Number of Drawing Sheets (if any)	10	Suggested Figure for Publication (if any)	

Filing By Reference:

Only complete this section when filing an application by reference under 35 U.S.C. 111(c) and 37 CFR 1.57(a). Do not complete this section if application papers including a specification and any drawings are being filed. Any domestic benefit or foreign priority information must be provided in the appropriate section(s) below (i.e., "Domestic Benefit/National Stage Information" and "Foreign Priority Information").

For the purposes of a filing date under 37 CFR 1.53(b), the description and any drawings of the present application are replaced by this reference to the previously filed application, subject to conditions and requirements of 37 CFR 1.57(a).

Application number of the previously filed application	Filing date (YYYY-MM-DD)	Intellectual Property Authority or Country

Publication Information:

☐ Request Early Publication (Fee required at time of Request 37 CFR 1.219)

☐ **Request Not to Publish.** I hereby request that the attached application not be published under 35 U.S.C. 122(b) and certify that the invention disclosed in the attached application **has not and will not** be the subject of an application filed in another country, or under a multilateral international agreement, that requires publication at eighteen months after filing.

Representative Information:

Representative information should be provided for all practitioners having a power of attorney in the application. Providing this information in the Application Data Sheet does not constitute a power of attorney in the application (see 37 CFR 1.32). Either enter Customer Number or complete the Representative Name section below. If both sections are completed the customer Number will be used for the Representative Information during processing.

Please Select One:	☒ Customer Number	☐ US Patent Practitioner	☐ Limited Recognition (37 CFR 11.9)
Customer Number	20985		

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	22193-0137002
		Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

Domestic Benefit/National Stage Information:

This section allows for the applicant to either claim benefit under 35 U.S.C. 119(e), 120, 121, 365(c), or 386(c) or indicate National Stage entry from a PCT application. Providing benefit claim information in the Application Data Sheet constitutes the specific reference required by 35 U.S.C. 119(e) or 120, and 37 CFR 1.78.

When referring to the current application, please leave the "Application Number" field blank.

Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
	Continuation of	16335775	2019-03-22
Prior Application Status	Pending	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
16335775	a 371 of international	PCT/US2017/052736	2017-09-21
Prior Application Status	Expired	Remove	
Application Number	Continuity Type	Prior Application Number	Filing or 371(c) Date (YYYY-MM-DD)
PCT/US2017/052736	Claims benefit of provisional	62399753	2016-09-26
Additional Domestic Benefit/National Stage Data may be generated within this form by selecting the Add button.			Add

Foreign Priority Information:

This section allows for the applicant to claim priority to a foreign application. Providing this information in the application data sheet constitutes the claim for priority as required by 35 U.S.C. 119(b) and 37 CFR 1.55. When priority is claimed to a foreign application that is eligible for retrieval under the priority document exchange program (PDX)ⁱ the information will be used by the Office to automatically attempt retrieval pursuant to 37 CFR 1.55(i)(1) and (2). Under the PDX program, applicant bears the ultimate responsibility for ensuring that a copy of the foreign application is received by the Office from the participating foreign intellectual property office, or a certified copy of the foreign priority application is filed, within the time period specified in 37 CFR 1.55(g)(1).

			Remove
Application Number	Country ⁱ	Filing Date (YYYY-MM-DD)	Access Code ⁱ (if applicable)
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Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications

Application Data Sheet 37 CFR 1.76	Attorney Docket Number	22193-0137002
	Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS	

☐	This application (1) claims priority to or the benefit of an application filed before March 16, 2013 and (2) also contains, or contained at any time, a claim to a claimed invention that has an effective filing date on or after March 16, 2013. NOTE: By providing this statement under 37 CFR 1.55 or 1.78, this application, with a filing date on or after March 16, 2013, will be examined under the first inventor to file provisions of the AIA.
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Application Data Sheet 37 CFR 1.76	Attorney Docket Number	22193-0137002
	Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS	

Authorization or Opt-Out of Authorization to Permit Access:

When this Application Data Sheet is properly signed and filed with the application, applicant has provided written authority to permit a participating foreign intellectual property (IP) office access to the instant application-as-filed (see paragraph A in subsection 1 below) and the European Patent Office (EPO) access to any search results from the instant application (see paragraph B in subsection 1 below).

Should applicant choose not to provide an authorization identified in subsection 1 below, applicant **must opt-out** of the authorization by checking the corresponding box A or B or both in subsection 2 below.

NOTE: This section of the Application Data Sheet is **ONLY** reviewed and processed with the **INITIAL** filing of an application. After the initial filing of an application, an Application Data Sheet cannot be used to provide or rescind authorization for access by a foreign IP office(s). Instead, Form PTO/SB/39 or PTO/SB/69 must be used as appropriate.

1. Authorization to Permit Access by a Foreign Intellectual Property Office(s)

A. Priority Document Exchange (PDX) - Unless box A in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the European Patent Office (EPO), the Japan Patent Office (JPO), the Korean Intellectual Property Office (KIPO), the State Intellectual Property Office of the People's Republic of China (SIPO), the World Intellectual Property Organization (WIPO), and any other foreign intellectual property office participating with the USPTO in a bilateral or multilateral priority document exchange agreement in which a foreign application claiming priority to the instant patent application is filed, access to: (1) the instant patent application-as-filed and its related bibliographic data, (2) any foreign or domestic application to which priority or benefit is claimed by the instant application and its related bibliographic data, and (3) the date of filing of this Authorization. See 37 CFR 1.14(h)(1).

B. Search Results from U.S. Application to EPO - Unless box B in subsection 2 (opt-out of authorization) is checked, the undersigned hereby **grants the USPTO authority** to provide the EPO access to the bibliographic data and search results from the instant patent application when a European patent application claiming priority to the instant patent application is filed. See 37 CFR 1.14(h)(2).

The applicant is reminded that the EPO's Rule 141(1) EPC (European Patent Convention) requires applicants to submit a copy of search results from the instant application without delay in a European patent application that claims priority to the instant application.

2. Opt-Out of Authorizations to Permit Access by a Foreign Intellectual Property Office(s)

☐ A. Applicant **DOES NOT** authorize the USPTO to permit a participating foreign IP office access to the instant application-as-filed. If this box is checked, the USPTO will not be providing a participating foreign IP office with any documents and information identified in subsection 1A above.

☐ B. Applicant **DOES NOT** authorize the USPTO to transmit to the EPO any search results from the instant patent application. If this box is checked, the USPTO will not be providing the EPO with search results from the instant application.

NOTE: Once the application has published or is otherwise publicly available, the USPTO may provide access to the application in accordance with 37 CFR 1.14.

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	22193-0137002
		Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

Applicant Information:

Providing assignment information in this section does not substitute for compliance with any requirement of part 3 of Title 37 of CFR to have an assignment recorded by the Office.				
Applicant	1			Remove
If the applicant is the inventor (or the remaining joint inventor or inventors under 37 CFR 1.45), this section should not be completed. The information to be provided in this section is the name and address of the legal representative who is the applicant under 37 CFR 1.43; or the name and address of the assignee, person to whom the inventor is under an obligation to assign the invention, or person who otherwise shows sufficient proprietary interest in the matter who is the applicant under 37 CFR 1.46. If the applicant is an applicant under 37 CFR 1.46 (assignee, person to whom the inventor is obligated to assign, or person who otherwise shows sufficient proprietary interest) together with one or more joint inventors, then the joint inventor or inventors who are also the applicant should be identified in this section.				
Clear				
Assignee	Legal Representative under 35 U.S.C. 117		Joint Inventor	
Person to whom the inventor is obligated to assign.		Person who shows sufficient proprietary interest		
If applicant is the legal representative, indicate the authority to file the patent application, the inventor is:				
Name of the Deceased or Legally Incapacitated Inventor:				
If the Applicant is an Organization check here. ☐				
Prefix	Given Name	Middle Name	Family Name	Suffix
Mailing Address Information For Applicant:				
Address 1				
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Additional Applicant Data may be generated within this form by selecting the Add button. Add				

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Application Data Sheet 37 CFR 1.76		Attorney Docket Number	22193-0137002
		Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

Assignee 1				
Complete this section if assignee information, including non-applicant assignee information, is desired to be included on the patent application publication. An assignee-applicant identified in the "Applicant Information" section will appear on the patent application publication as an applicant. For an assignee-applicant, complete this section only if identification as an assignee is also desired on the patent application publication.				
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Signature:					Remove
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This Application Data Sheet must be signed by a patent practitioner if one or more of the applicants is a juristic entity (e.g., corporation or association). If the applicant is two or more joint inventors, this form must be signed by a patent practitioner, all joint inventors who are the applicant, or one or more joint inventor-applicants who have been given power of attorney (e.g., see USPTO Form PTO/AIA/81) on behalf of all joint inventor-applicants.					
See 37 CFR 1.4(d) for the manner of making signatures and certifications.					
Signature	/Heather L. Flanagan/			Date (YYYY-MM-DD)	2023-01-13
First Name	Heather	Last Name	Flanagan	Registration Number	54101
Additional Signature may be generated within this form by selecting the Add button. Add					

Application Data Sheet 37 CFR 1.76		Attorney Docket Number	22193-0137002
		Application Number	
Title of Invention	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

This collection of information is required by 37 CFR 1.76. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 23 minutes to complete, including gathering, preparing, and submitting the completed application data sheet form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

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1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether the Freedom of Information Act requires disclosure of these records.
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3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
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5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspections or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation or potential violation of law or regulation.



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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
18/154,727	01/13/2023		0	22193-0137002	20	3

CONFIRMATION NO. 4440

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FILING RECEIPT



0000000054014458

Date Mailed: 02/23/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

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Inventor(s)

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Minkyu Kim, Chandler, AZ;

Applicant(s)

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Minkyu Kim, Chandler, AZ;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 16/335,775 03/22/2019 PAT 11,556,779
which is a 371 of PCT/US2017/052736 09/21/2017
which claims benefit of 62/399,753 09/26/2016

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 02/22/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/154,727**

Projected Publication Date: To Be Determined - pending completion of Missing Parts.

Non-Publication Request: No

Early Publication Request: No

Title

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

The applicant has been granted a license under 35 U.S.C. 184, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" followed by a date appears on this form. Such licenses are issued in all applications where the conditions for issuance of a license have been met, regardless of whether or not a license may be required as set forth in 37 CFR 5.15. The scope and limitations of this license are set forth in 37 CFR 5.15(a) unless an earlier license has been issued under 37 CFR 5.15(b). The license is subject to revocation upon written notification. The date indicated is the effective date of the license, unless an earlier license of similar scope has been granted under 37 CFR 5.13 or 5.14.

This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
18/154,727

APPLICATION AS FILED - PART I

(Column 1)		(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	320
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	700
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	800
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x =	0
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x =	0
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	1820

APPLICATION AS AMENDED - PART II

	(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY		
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)		ADDITIONAL FEE(\$)	RATE(\$)	ADDITIONAL FEE(\$)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002

CONFIRMATION NO. 4440

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

FORMALITIES LETTER



OC000000054014460

Date Mailed: 02/23/2023

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to the above-identified nonprovisional application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee has not been received.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Surcharge as set forth in 37 CFR 1.16(f) has not been received.

The surcharge is due for any one of:

- late submission of the basic filing fee, search fee, or examination fee,
- late submission of inventor's oath or declaration,
- filing an application that does not contain at least one claim on filing, or
- submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required (including the fees noted above) are as follows. No entity status discount is in effect. If applicant is qualified for small entity status, a written assertion of small entity status must be submitted to establish small entity status. (See 37 CFR 1.27). If applicant is qualified for micro entity status, an acceptable Certification of Micro Entity Status must be submitted to establish micro entity status. (See 37 CFR 1.29 and forms PTO/SB/15A and 15B.)

- **\$320** basic filing fee.
- **\$160** surcharge.
- **\$700** search fee.
- **\$800** examination fee.
- **\$(0)** previous unapplied payment amount.
- **\$1980** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be addressed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

REPLY VIA ELECTRONIC FILING

A reply may be submitted via electronic filing only by registered users of the appropriate USPTO patent electronic filing system and must include:

- A separate document having the document description, "**Applicant response to Pre-Exam Formalities Notice**"; and
- the item(s) for which a reply period is set forth above.

For more information about electronic filing, contact the Patent Electronic Business Center (EBC) 1-866-217-9197 or visit <https://www.uspto.gov/ebc>

NOTE: If the reply is not being submitted electronically, a copy of this notice must be included.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at **(571) 272-4000** or **(571) 272-4200** or **1-888-786-0101**.

/azahmed/



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/154,727		Jae-sun Seo	22193-0137002

CONFIRMATION NO. 4440

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

WITHDRAWAL NOTICE



OC000000054065795

Date Mailed: 02/24/2023

Letter Regarding a New Notice and/or the Status of the Application

If a new notice or Filing Receipt is enclosed, applicant may disregard the previous notice mailed on 02/23/2023. The time period for reply runs from the mail date of the new notice. Within the time period for reply, applicant is required to file a reply in compliance with the requirements set forth in the new notice to avoid abandonment of the application.

Registered users of EFS-Web may alternatively submit their reply to this notice via EFS-Web.
<https://sportal.uspto.gov/authenticate/AuthenticateUserLocalEPF.html>

For more information about EFS-Web please call the USPTO Electronic Business Center at **1-866-217-9197** or visit our website at <http://www.uspto.gov/ebc>.

If the reply is not filed electronically via EFS-Web, the reply must be accompanied by a copy of the new notice.

If the Office previously granted a petition to withdraw the holding of abandonment or a petition to revive under 37 CFR 1.137, the status of the application has been returned to pending status.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/ngfissha/



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
18/154,727	01/13/2023		0	22193-0137002	20	3

CONFIRMATION NO. 4440

20985

FISH & RICHARDSON P.C. (SD)

P.O. BOX 1022

MINNEAPOLIS, MN 55440-1022

FILING RECEIPT



0000000054065864

Date Mailed: 02/24/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Jae-sun Seo, Tempe, AZ;
Minkyu Kim, Chandler, AZ;

Applicant(s)

Jae-sun Seo, Tempe, AZ;
Minkyu Kim, Chandler, AZ;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 16/335,775 03/22/2019 PAT 11,556,779
which is a 371 of PCT/US2017/052736 09/21/2017
which claims benefit of 62/399,753 09/26/2016

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 02/22/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/154,727**

Projected Publication Date: To Be Determined - pending completion of Missing Parts.

Non-Publication Request: No

Early Publication Request: No

**** MICRO ENTITY ****

Title

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

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For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

page 2 of 4

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

LICENSE FOR FOREIGN FILING UNDER
Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

GRANTED

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

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SelectUSA

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The U.S. offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to promote and facilitate business investment. SelectUSA provides information assistance to the international investor community; serves as an ombudsman for existing and potential investors; advocates on behalf of U.S. cities, states, and regions competing for global investment; and counsels U.S. economic development organizations on investment attraction best practices. To learn more about why the United States is the best country in the world to develop

technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
18/154,727

APPLICATION AS FILED - PART I

(Column 1)		(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	64
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	140
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	160
TOTAL CLAIMS (37 CFR 1.16(i))	20 minus 20 =	*			OR	x =	0
INDEPENDENT CLAIMS (37 CFR 1.16(h))	3 minus 3 =	*				x =	0
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	364

APPLICATION AS AMENDED - PART II

	(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY		
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)		ADDITIONAL FEE(\$)	RATE(\$)	ADDITIONAL FEE(\$)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002

CONFIRMATION NO. 4440

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

FORMALITIES LETTER



OC000000054065888

Date Mailed: 02/24/2023

NOTICE TO FILE MISSING PARTS OF NONPROVISIONAL APPLICATION

FILED UNDER 37 CFR 1.53(b)

Filing Date Granted

An application number and filing date have been accorded to the above-identified nonprovisional application. The item(s) indicated below, however, are missing. Applicant is given **TWO MONTHS** from the date of this Notice within which to file all required items below to avoid abandonment. Extensions of time may be obtained by filing a petition accompanied by the extension fee under the provisions of 37 CFR 1.136(a).

- The statutory basic filing fee has not been received.
- The application search fee must be submitted.
- The application examination fee must be submitted.
- Surcharge as set forth in 37 CFR 1.16(f) has not been received.

The surcharge is due for any one of:

- late submission of the basic filing fee, search fee, or examination fee,
- late submission of inventor's oath or declaration,
- filing an application that does not contain at least one claim on filing, or
- submission of an application filed by reference to a previously filed application.

SUMMARY OF FEES DUE:

The fee(s) required (including the fees noted above) are as follows. Micro entity discount is in effect.

- **\$64** basic filing fee.
- **\$32** surcharge.
- **\$140** search fee.
- **\$160** examination fee.
- **\$(0)** previous unapplied payment amount.
- **\$396** TOTAL FEE BALANCE DUE.

Replies must be received in the USPTO within the set time period or must include a proper Certificate of Mailing or Transmission under 37 CFR 1.8 with a mailing or transmission date within the set time period. For more information and a suggested format, see Form PTO/SB/92 and MPEP 512.

Replies should be addressed to:

Mail Stop Missing Parts
Commissioner for Patents
P.O. Box 1450
Alexandria VA 22313-1450

REPLY VIA ELECTRONIC FILING

A reply may be submitted via electronic filing only by registered users of the appropriate USPTO patent electronic filing system and must include:

- A separate document having the document description, "**Applicant response to Pre-Exam Formalities Notice**"; and
- the item(s) for which a reply period is set forth above.

For more information about electronic filing, contact the Patent Electronic Business Center (EBC) 1-866-217-9197 or visit <https://www.uspto.gov/ebc>

NOTE: If the reply is not being submitted electronically, a copy of this notice must be included.

Questions about the contents of this notice and the requirements it sets forth should be directed to the Office of Data Management, Application Assistance Unit, at (571) 272-4000 or (571) 272-4200 or 1-888-786-0101.

/ngfissha/

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875				Application or Docket Number 18/154,727		Filing Date 01/13/2023		☐ To be Mailed		
ENTITY: ☐ LARGE ☐ SMALL ☒ MICRO										
APPLICATION AS FILED - PART I										
		(Column 1)	(Column 2)							
FOR		NUMBER FILED	NUMBER EXTRA	RATE (\$)		FEE (\$)				
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))		N/A	N/A	N/A						
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))		N/A	N/A	N/A						
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))		N/A	N/A	N/A						
TOTAL CLAIMS (37 CFR 1.16(i))		minus 20 =	*	X \$ =						
INDEPENDENT CLAIMS (37 CFR 1.16(h))		minus 3 =	*	X \$ =						
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))		If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).								
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))										
* If the difference in column 1 is less than zero, enter "0" in column 2.				TOTAL						
APPLICATION AS AMENDED - PART II										
		(Column 1)	(Column 2)	(Column 3)						
AMENDMENT	03/30/2023	CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)		
	Total (37 CFR 1.16(i))	* 19	Minus	** 20	= 0	X \$ =		0		
	Independent (37 CFR 1.16(h))	* 2	Minus	*** 3	= 0	X \$ =		0		
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE		0		
		(Column 1)	(Column 2)	(Column 3)						
AMENDMENT		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE (\$)		ADDITIONAL FEE (\$)		
	Total (37 CFR 1.16(i))	*	Minus	**	=	X \$ =				
	Independent (37 CFR 1.16(h))	*	Minus	***	=	X \$ =				
	☐ Application Size Fee (37 CFR 1.16(s))									
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))									
						TOTAL ADD'L FEE				
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.						LIE				
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".						/AMANDA N FORD/				
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".										
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.										

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	Unknown
Application No. :	18/154,727	Examiner :	Unknown
Filed :	January 13, 2023	Conf. No. :	4440
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

PRELIMINARY AMENDMENT

Prior to examination, please amend the application as indicated on the following pages.

Amendments to the Claims:

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1. - 20. (Cancelled)

21. (New) A method of synthesizing upconverting nanoparticles, the method comprising:

heating a precursor solution comprising two or more rare earth salts, an alkali metal salt or an alkaline earth salt, and a solvent in a microwave reactor to yield a product mixture; and cooling the product mixture to yield the upconverting nanoparticles,

wherein at least one of the two or more rare earth salts comprises trifluoroacetate and at least one of the two or more rare earth salts comprises acetate, and the solvent comprises oleic acid and a plasticizer including one or both of dioctyl terephthalate and bis(2-ethylhexyl) adipate.

23. (New) The method of claim 21, wherein the one or more rare earth salts comprise one or more of yttrium, ytterbium, and erbium.

24. (New) The method of claim 21, wherein a boiling point of the plasticizer at atmospheric pressure is at least 320°C.

25. (New) The method of claim 21, wherein a dielectric permittivity of the plasticizer is at least 4.

26. (New) The method of claim 21, wherein the plasticizer further comprises dibutyl phthalate.

27. (New) The method of claim 21, comprising heating the precursor solution to a temperature of at least 280 °C.

28. (New) The method of claim 27, comprising heating the precursor solution to a temperature of at least 305 °C.
29. (New) The method of claim 21, wherein heating the product mixture comprises heating for a length of time between 5 minutes and 45 minutes.
30. (New) The method of claim 21, further comprising flowing the precursor solution through the microwave reactor.
31. (New) A method of synthesizing core-shell upconverting nanoparticles, the method comprising:
heating a precursor solution comprising two or more rare earth metal salts, an alkali metal salt or an alkaline earth metal salt, and a solvent in a microwave reactor;
combining the upconverting nanoparticles of claim 1 with the precursor solution to yield a nanoparticle mixture;
heating the nanoparticle mixture in the microwave reactor to yield a product mixture; and
cooling the product mixture to yield the core-shell upconverting nanoparticles,
wherein at least one of the two or more rare earth salts comprises trifluoroacetate and at least one of the two or more rare earth salts comprises acetate, and the solvent comprises oleic acid and a plasticizer including one or both of dioctyl terephthalate and bis(2-ethylhexyl) adipate.
32. (New) The method of claim 31, wherein the upconverting nanoparticles comprise cubic nanoparticles.
33. (New) The method of claim 31, wherein the upconverting nanoparticles comprise hexagonal nanoparticles.
34. (New) The method of claim 31, wherein a boiling point of the plasticizer at atmospheric pressure is at least 320°C.

35. (New) The method of claim 31, wherein a dielectric permittivity of the plasticizer is at least 4.

36. (New) The method of claim 31, wherein the plasticizer further comprises dibutyl phthalate.

37. (New) The method of claim 31, comprising heating the precursor solution to a temperature of at least 280 °C.

38. (New) The method of claim 37, comprising heating the precursor solution to a temperature of at least 305 °C.

39. (New) The method of claim 31, further comprising flowing the precursor solution through the microwave reactor.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 5 of 5

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

REMARKS

Claims 1-20 have been cancelled. Claims 21-39 have been added, with claims 21 and 31 being independent. No new matter has been introduced. Applicant asks that all claims be examined in view of the amendments to the claims.

Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: March 30, 2023

/Heather L. Flanagan/

Heather L. Flanagan, Reg. No. 54,101

Customer Number 20985
Fish & Richardson P.C.
Telephone: +1 (512) 226-8156
Facsimile: (877) 769-7945

100850824.doc

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	Unknown
Application No. :	18/154,727	Examiner :	Unknown
Filed :	January 13, 2023	Conf. No. :	4440
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

MAIL STOP MISSING PARTS

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY TO NOTICE TO FILE MISSING PARTS OF APPLICATION

In response to the Notice to File Missing Parts of Application under 37 CFR §1.53(b) dated February 24, 2023, applicant claims micro entity status (see 37 CFR §1.27) and submits herewith the following:

- ☒ Payment of the basic filing fee of \$64;
- ☒ Payment of the search fee of \$140;
- ☒ Payment of the examination fee of \$160;
- ☒ Payment of the surcharge of \$32 for late filing of the basic filing fee and/or declaration; and
- ☒ Certification of Micro Entity Status.

The fees in the amount of \$396 are being paid with this reply on the Electronic Filing System. Apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: March 30, 2023

/Heather L. Flanagan/

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100850821.doc



ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
03/30/2023 02:33:15 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica Juarez

PATENT CENTER # 61841350

FILING DATE 01/13/2023

CUSTOMER # 20985

FIRST NAMED
INVENTOR Jae-sun Seo

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Heather Flanagan

Documents

TOTAL DOCUMENTS: 4

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
22193-0137002_PA.PDF		5	-	58 KB
22193-0137002_PA-A.PE.pdf	(1-1)	1	Preliminary Amendment	40 KB
22193-0137002_PA-CLM.pdf	(2-4)	3	Claims	53 KB
22193-0137002_PA-REM.pdf	(5-5)	1	Applicant Arguments/Remarks Made in an Amendment	41 KB
22193-0137002_RespMP.PDF		1	Applicant Response to Pre-Exam Formalities Notice	58 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
22193-0137002_PA.PDF	391E29F2450795719687B4610BB351A6674DA98A9EF2D97CEF 32F614002D61EEE6099F3008BDB040BFB39C00362323A83D31 2804EF8B9EE324EBE7D71ED99D95
22193-0137002_PA-A.PE.pdf	874B32D8F6A556925CFB32DF8B4F58CE0D809FEB9E802E032 65E255FC6FA06A306B46EB2628C6D535DFD7A27871F13A9FF 98A3EA0A10ACAF1D28A0551C371BC8
22193-0137002_PA-CLM.pdf	7830CFE3F5C33697045919FF482DFCB78030C8C940140F3C72 2C672B11520CB9C8E30FB4564EEA58F0D3BC5A7BBAE234CF 5184AC8C812A5019193AB9676E9D22
22193-0137002_PA-REM.pdf	AEE6E58B0F80DA63D9FB1F36497A9B78A51E19B582F5AB5D9 3224D6FE6E4CCAAC8946AF8DBD7CD0D921DF334A99B5E92D C674E3E367325201C6E3CB1842B8D38
22193-0137002_RespMP.PDF	66C3587AA60E03E4DE5FED34DA6CC436E2593177A230370B4 8A023BFB80C2CFD67ED84C6C630C281C6BA81EDB14A458EB 0F0A91F2A3657CD4F2F7088E3F998F4

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES
PATENT AND TRADEMARK OFFICE

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Alexandria, VA 22313 - 1450
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ELECTRONIC PAYMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
03/30/2023 02:33:15 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica Juarez

PATENT CENTER # 61841350

AUTHORIZED BY Heather Flanagan

CUSTOMER # 20985

FILING DATE 01/13/2023

CORRESPONDENCE ADDRESS -

FIRST NAMED INVENTOR Jae-sun Seo

Payment Information

PAYMENT METHOD
DA / 061050

PAYMENT TRANSACTION ID
E20233TE34096121

PAYMENT AUTHORIZED BY
Veronica Juarez

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
3051	SURCHARGE- LATE FILING FEE, SEARCH FEE, EXAMINATION FEE, INVENTOR'S OATH OR DECLARATION, OR APPLICATION FILED WITHOUT AT LEAST ONE CLAIM OR BY REFERENCE	32.00	1	32.00
3111	UTILITY PATENT APPL. SEARCH FEE	140.00	1	140.00
3011	BASIC FILING FEE - UTILITY (PAPER FILING ALSO REQUIRES NON-ELECTRONIC FILING FEE UNDER 1.16(T))	64.00	1	64.00

3311	EXAMINATION OF ORIGINAL PATENT APPLICATION	160.00	1	160.00
TOTAL AMOUNT:				\$396.00

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
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www.uspto.gov

APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
18/154,727	01/13/2023		396	22193-0137002	18	2

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

CONFIRMATION NO. 4440
UPDATED FILING RECEIPT



0000000055548389

Date Mailed: 04/04/2023

Receipt is acknowledged of this non-provisional utility patent application. The application will be taken up for examination in due course. Applicant will be notified as to the results of the examination. Any correspondence concerning the application must include the following identification information: the U.S. APPLICATION NUMBER, FILING DATE, NAME OF FIRST INVENTOR, and TITLE OF INVENTION. Fees transmitted by check or draft are subject to collection.

Please verify the accuracy of the data presented on this receipt. If an error is noted on this Filing Receipt, please submit a written request for a corrected Filing Receipt, including a properly marked-up ADS showing the changes with strike-through for deletions and underlining for additions. If you received a "Notice to File Missing Parts" or other Notice requiring a response for this application, please submit any request for correction to this Filing Receipt with your reply to the Notice. When the USPTO processes the reply to the Notice, the USPTO will generate another Filing Receipt incorporating the requested corrections provided that the request is grantable.

Inventor(s)

Jae-sun Seo, Tempe, AZ;
Minkyu Kim, Chandler, AZ;

Applicant(s)

Jae-sun Seo, Tempe, AZ;
Minkyu Kim, Chandler, AZ;

Power of Attorney: None

Domestic Priority data as claimed by applicant

This application is a CON of 16/335,775 03/22/2019 PAT 11,556,779
which is a 371 of PCT/US2017/052736 09/21/2017
which claims benefit of 62/399,753 09/26/2016

Foreign Applications for which priority is claimed (You may be eligible to benefit from the **Patent Prosecution Highway** program at the USPTO. Please see <http://www.uspto.gov> for more information.) - None.

Foreign application information must be provided in an Application Data Sheet in order to constitute a claim to foreign priority. See 37 CFR 1.55 and 1.76.

Permission to Access Application via Priority Document Exchange: Yes

Permission to Access Search Results: Yes

Applicant may provide or rescind an authorization for access using Form PTO/SB/39 or Form PTO/SB/69 as appropriate.

If Required, Foreign Filing License Granted: 02/22/2023

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 18/154,727**

Projected Publication Date: 07/13/2023

Non-Publication Request: No

Early Publication Request: No

**** MICRO ENTITY ****

Title

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Preliminary Class

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

PROTECTING YOUR INVENTION OUTSIDE THE UNITED STATES

Since the rights granted by a U.S. patent extend only throughout the territory of the United States and have no effect in a foreign country, an inventor who wishes patent protection in another country must apply for a patent in a specific country or in regional patent offices. Applicants may wish to consider the filing of an international application under the Patent Cooperation Treaty (PCT). An international (PCT) application generally has the same effect as a regular national patent application in each PCT-member country. The PCT process **simplifies** the filing of patent applications on the same invention in member countries, but **does not result** in a grant of "an international patent" and does not eliminate the need of applicants to file additional documents and fees in countries where patent protection is desired.

Almost every country has its own patent law, and a person desiring a patent in a particular country must make an application for patent in that country in accordance with its particular laws. Since the laws of many countries differ in various respects from the patent law of the United States, applicants are advised to seek guidance from specific foreign countries to ensure that patent rights are not lost prematurely.

Applicants also are advised that in the case of inventions made in the United States, the Director of the USPTO must issue a license before applicants can apply for a patent in a foreign country. The filing of a U.S. patent application serves as a request for a foreign filing license. The application's filing receipt contains further information and guidance as to the status of applicant's license for foreign filing.

Applicants may wish to consult the USPTO booklet, "General Information Concerning Patents" (specifically, the section entitled "Treaties and Foreign Patents") for more information on timeframes and deadlines for filing foreign patent applications. The guide is available either by contacting the USPTO Contact Center at 800-786-9199, or it can be viewed on the USPTO website at <http://www.uspto.gov/web/offices/pac/doc/general/index.html>.

For information on preventing theft of your intellectual property (patents, trademarks and copyrights), you may wish to consult the U.S. Government website, <http://www.stopfakes.gov>. Part of a Department of Commerce initiative, this website includes self-help "toolkits" giving innovators guidance on how to protect intellectual property in specific

page 2 of 4

countries such as China, Korea and Mexico. For questions regarding patent enforcement issues, applicants may call the U.S. Government hotline at 1-866-999-HALT (1-866-999-4258).

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Title 35, United States Code, Section 184
Title 37, Code of Federal Regulations, 5.11 & 5.15

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This license is to be retained by the licensee and may be used at any time on or after the effective date thereof unless it is revoked. This license is automatically transferred to any related applications(s) filed under 37 CFR 1.53(d). This license is not retroactive.

The grant of a license does not in any way lessen the responsibility of a licensee for the security of the subject matter as imposed by any Government contract or the provisions of existing laws relating to espionage and the national security or the export of technical data. Licensees should apprise themselves of current regulations especially with respect to certain countries, of other agencies, particularly the Office of Defense Trade Controls, Department of State (with respect to Arms, Munitions and Implements of War (22 CFR 121-128)); the Bureau of Industry and Security, Department of Commerce (15 CFR parts 730-774); the Office of Foreign Assets Control, Department of Treasury (31 CFR Parts 500+) and the Department of Energy.

NOT GRANTED

No license under 35 U.S.C. 184 has been granted at this time, if the phrase "IF REQUIRED, FOREIGN FILING LICENSE GRANTED" DOES NOT appear on this form. Applicant may still petition for a license under 37 CFR 5.12, if a license is desired before the expiration of 6 months from the filing date of the application. If 6 months has lapsed from the filing date of this application and the licensee has not received any indication of a secrecy order under 35 U.S.C. 181, the licensee may foreign file the application pursuant to 37 CFR 5.15(b).

SelectUSA

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technology, manufacture products, deliver services, and grow your business, visit <http://www.SelectUSA.gov> or call +1-202-482-6800.

PATENT APPLICATION FEE DETERMINATION RECORD

Substitute for Form PTO-875

Application or Docket Number
18/154,727

APPLICATION AS FILED - PART I

(Column 1)		(Column 2)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY	
FOR	NUMBER FILED	NUMBER EXTRA	RATE(\$)	FEE(\$)		RATE(\$)	FEE(\$)
BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A			N/A	64
SEARCH FEE (37 CFR 1.16(k), (l), or (m))	N/A	N/A	N/A			N/A	140
EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A			N/A	160
TOTAL CLAIMS (37 CFR 1.16(i))	18 minus 20 =	*			OR	x =	0
INDEPENDENT CLAIMS (37 CFR 1.16(h))	2 minus 3 =	*				x =	0
APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).						0
MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))							0
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL			TOTAL	364

APPLICATION AS AMENDED - PART II

	(Column 1)		(Column 2)	(Column 3)	SMALL ENTITY		OR	OTHER THAN SMALL ENTITY		
		CLAIMS REMAINING AFTER AMENDMENT		HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	RATE(\$)		ADDITIONAL FEE(\$)	RATE(\$)	ADDITIONAL FEE(\$)
AMENDMENT A	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		
AMENDMENT B	Total (37 CFR 1.16(i))	*	Minus	**	=	x =		OR	x =	
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x =		OR	x =	
	Application Size Fee (37 CFR 1.16(s))							OR		
	FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))							OR		
					TOTAL ADD'L FEE		OR	TOTAL ADD'L FEE		

* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.

** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".

*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".

The "Highest Number Previously Paid For" (Total or Independent) is the highest found in the appropriate box in column 1.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	Unknown
Application No. :	18/154,727	Examiner :	Unknown
Filed :	January 13, 2023	Conf. No. :	4440
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

SECOND PRELIMINARY AMENDMENT

Prior to examination, please amend the application as indicated on the following pages.

Amendments to the Claims:

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1. - 39. (Cancelled)

40. (New) One or more computer-readable storage media storing instructions which, when executed by at least one processor, cause the at least one processor to perform operations comprising:

in one or more layers of a convolutional neural network (CNN), performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets;

examining a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values;

responsive to identifying the maximum value, performing a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and propagating the full precision computation of the value to a subsequent layer of the CNN.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 3 of 3

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

REMARKS

Claim 40 is pending. Claims 21-39 have been cancelled, and claim 40 has been added. No new matter has been introduced. Applicant asks that all claims be examined in view of the amendments to the claims.

Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: April 5, 2023

/Heather L. Flanagan/

Heather L. Flanagan, Reg. No. 54,101

Customer Number 20985
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Facsimile: (877) 769-7945

100850824.doc



ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
04/05/2023 03:44:12 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica Juarez

PATENT CENTER # 61872741

FILING DATE 01/13/2023

CUSTOMER # 20985

FIRST NAMED
INVENTOR Jae-sun Seo

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Heather Flanagan

Documents

TOTAL DOCUMENTS: 3

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
22193-0137002_PA2.PDF		3	-	47 KB
22193-0137002_PA2-A.PE.pdf	(1-1)	1	Preliminary Amendment	40 KB
22193-0137002_PA2-CLM.pdf	(2-2)	1	Claims	42 KB
22193-0137002_PA2-REM.pdf	(3-3)	1	Applicant Arguments/Remarks Made in an Amendment	40 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
22193-0137002_PA2.PDF	891F49B89A29BC881C4FFDCF1196B6AD057CDB2BAB848E8C 57EA7DDAD4251EB9D9E7A2CBF6C8BFF7C7E812FE8DDB043 9BF0DF8C517464A8328CC9CB1D67A52DC
22193-0137002_PA2-A.PE.pdf	6E0230377BCE02258A4571A49F05DEBCBB8A4D5E5110F0650 71D50F2B80402D9B6E4ECFE903BE2B37FC13AC63E12BFFC9 E6AAA91DD14B4ECC7C8E303DADDD597
22193-0137002_PA2-CLM.pdf	76F31CD192643A3E04BB987AAA26713DA3BA7924A2EA0D571 BBF1A2691557786F416E7DB01EA911F2DA2F895057F270935E 79AB384BC1E77AFDD2E89816ED486
22193-0137002_PA2-REM.pdf	2C3884D1C63094A96D716720CBDF6FA9289D34E1B10FC74EF CC0CC0E54EAAAC266C5D8C35D88A638034C0F473AACAB8301 C2909C6C44548CB3BF7B3AD03CDCCF7

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

PATENT APPLICATION FEE DETERMINATION RECORD Substitute for Form PTO-875	Application or Docket Number 18/154,727	Filing Date 01/13/2023	☐ To be Mailed
---	--	---------------------------	---------------------------------------

ENTITY: ☐ LARGE ☐ SMALL ☒ MICRO

APPLICATION AS FILED - PART I

FOR	(Column 1) NUMBER FILED	(Column 2) NUMBER EXTRA	RATE (\$)	FEE (\$)
☐ BASIC FEE (37 CFR 1.16(a), (b), or (c))	N/A	N/A	N/A	
☐ SEARCH FEE (37 CFR 1.16(k), (i), or (m))	N/A	N/A	N/A	
☐ EXAMINATION FEE (37 CFR 1.16(o), (p), or (q))	N/A	N/A	N/A	
TOTAL CLAIMS (37 CFR 1.16(i))	minus 20 = *		x \$20 =	
INDEPENDENT CLAIMS (37 CFR 1.16(h))	minus 3 = *		x \$96 =	
☐ APPLICATION SIZE FEE (37 CFR 1.16(s))	If the specification and drawings exceed 100 sheets of paper, the application size fee due is \$310 (\$155 for small entity) for each additional 50 sheets or fraction thereof. See 35 U.S.C. 41(a)(1)(G) and 37 CFR 1.16(s).			
☐ MULTIPLE DEPENDENT CLAIM PRESENT (37 CFR 1.16(j))				
* If the difference in column 1 is less than zero, enter "0" in column 2.			TOTAL	

APPLICATION AS AMENDED - PART II

	(Column 1)		(Column 2)	(Column 3)	RATE (\$)	ADDITIONAL FEE (\$)
AMENDMENT	04/17/2023		CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	
	Total (37 CFR 1.16(i))	* 11	Minus	** 20	= 0	x \$20 = 0
	Independent (37 CFR 1.16(h))	* 1	Minus	*** 3	= 0	x \$96 = 0
	☐ Application Size Fee (37 CFR 1.16(s))					
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					
TOTAL ADD'L FEE						0
AMENDMENT			CLAIMS REMAINING AFTER AMENDMENT	HIGHEST NUMBER PREVIOUSLY PAID FOR	PRESENT EXTRA	
	Total (37 CFR 1.16(i))	*	Minus	**	=	x \$0 =
	Independent (37 CFR 1.16(h))	*	Minus	***	=	x \$0 =
	☐ Application Size Fee (37 CFR 1.16(s))					
	☐ FIRST PRESENTATION OF MULTIPLE DEPENDENT CLAIM (37 CFR 1.16(j))					
TOTAL ADD'L FEE						
* If the entry in column 1 is less than the entry in column 2, write "0" in column 3.						LIE
** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 20, enter "20".						/VENICE M WILLIAMS/
*** If the "Highest Number Previously Paid For" IN THIS SPACE is less than 3, enter "3".						
The "Highest Number Previously Paid For" (Total or Independent) is the highest number found in the appropriate box in column 1.						

This collection of information is required by 37 CFR 1.16. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. **SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.**

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	Unknown
Application No. :	18/154,727	Examiner :	Unknown
Filed :	January 13, 2023	Conf. No. :	4440
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

THIRD PRELIMINARY AMENDMENT

Prior to examination, please amend the application as indicated on the following pages.

Amendments to the Claims:

This listing of claims replaces all prior versions and listings of claims in the application:

Listing of Claims:

1. - 39. (Cancelled)

40. (Currently Amended) One or more non-transitory, computer-readable storage media storing instructions which, when executed by at least one processor, cause the at least one processor to perform operations comprising:

in one or more layers of a convolutional neural network (CNN), performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets;

examining a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values;

responsive to identifying the maximum value, performing a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and

propagating the full precision computation of the value to a subsequent layer of the CNN.

41. (New) The one or more non-transitory, computer-readable storage media of claim 40, further comprising:

responsive to determining that the first set of values are the same, performing, by the at least one processor, a second iteration that includes computing the value based on a second set of MSBs for each of the plurality of data sets, the second set of MSBs being larger than the first set of MSBs.

42. (New) The one or more non-transitory, computer-readable storage media of claim 41, further storing instructions, which, when executed by the at least one processor, cause the at least one processor to perform operations comprising:

examining a second set of values computed for the plurality of data sets in the second iteration to determine whether the maximum value is present among the second set of values; and

responsive to identifying the maximum value among the second set of values, performing, by the at least one processor, the full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value in the second iteration.

43. (New) The one or more non-transitory, computer-readable storage media of claim 41, wherein the computing in each of the first iteration and the second iteration employs a convolution and a pooling.

44. (New) The one or more non-transitory, computer-readable storage media of claim 43, wherein the convolution is a $N \times N$ convolution, where N is any integer.

45. (New) The one or more non-transitory, computer-readable storage media of claim 43, wherein the pooling is a $N \times N$ pooling, where N is any integer.

46. (New) The one or more non-transitory, computer-readable storage media of claim 43, wherein the convolution is a 3×3 convolution, and the pooling is a 2×2 pooling.

47. (New) The one or more non-transitory, computer-readable storage media of claim 41, wherein at least one of the first iteration and the second iteration is performed with a precision less than that of the full precision computation.

48. (New) The one or more non-transitory, computer-readable storage media of claim 47, wherein the precision is 8-bit precision.

49. (New) The one or more non-transitory, computer-readable storage media of claim 40, wherein the CNN is employed to analyze an image.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 4 of 5

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

50. (New) The one or more non-transitory, computer-readable storage media of claim 40, wherein:

the first iteration computes a value that approximates the full precision computation of the value; and

the full precision computation is performed on the data set that includes less data than the plurality of data sets.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 5 of 5

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

REMARKS

Claims 40-50 are pending. Claims 1-39 have been cancelled, claim 40 has been amended, and claims 41-50 have been added. No new matter has been introduced. Applicant asks that all claims be examined in view of the amendments to the claims.

Please apply any necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

Respectfully submitted,

Date: April 17, 2023

/Heather L. Flanagan/
Heather L. Flanagan,
Reg. No. 54,101

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ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
04/17/2023 04:49:38 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica Juarez

PATENT CENTER # 61934080

FILING DATE 01/13/2023

CUSTOMER # 20985

FIRST NAMED
INVENTOR Jae-sun Seo

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Heather Flanagan

Documents

TOTAL DOCUMENTS: 3

DOCUMENT		PAGES	DESCRIPTION	SIZE (KB)
22193-0137002_PA3.PDF		5	-	58 KB
22193-0137002_PA3-A.PE.pdf	(1-1)	1	Preliminary Amendment	41 KB
22193-0137002_PA3-CLM.pdf	(2-4)	3	Claims	53 KB
22193-0137002_PA3-REM.pdf	(5-5)	1	Applicant Arguments/Remarks Made in an Amendment	42 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
22193-0137002_PA3.PDF	0C11C4C23BF3790E45AA7ADA05CEA026E7E8A9BE3D38ED6E 4B540566E1486CC2B667C70F3AC992A67D40DCF4C29B7F99F B21A2CFCCBD7885DC82F5DF8DC9C480
22193-0137002_PA3-A.PE.pdf	92FC550272DD7F883E47079F5AAC3E9C9E4F0946DD216CB4D DE78124ED1343A6CC00D5924D19F103058F8D93703F59F4FB2 C724A9A776E62F17D926F0CF02E29
22193-0137002_PA3-CLM.pdf	FAC2EDC6730030D3E62D57C6005DD79793D9464B9AABB687 F36BDA9DD59874A8C23FC3B47ECC02DDE76C99128BFFEC26 825291D1D748A33BDC1D9AD7A872687B
22193-0137002_PA3-REM.pdf	641C93D2B62A2BABE4467584D0B365F3729675E8DD282E08B 589FD88D812A59C6318490EAB997B5334F6F28E5788509E0E1 2E3AB269DCCBE57E9FE7A4DD72B0A

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application.

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	2616
Application No. :	18/154,727	Examiner :	Xilin Guo
Filed :	January 13, 2023	Conf. No. :	4440
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

MAIL STOP AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Please consider the documents listed on the disclosure form submitted with this statement. Copies of the documents are being submitted with this statement to the extent required under 37 C.F.R. § 1.98(a)(2).

This application relies on the earlier filing date of application number 16/335,775, filed on March 22, 2019. Under 37 CFR § 1.98 (a)(2) and 37 CFR § 1.98(d), the earlier application is properly identified and is relied on for an earlier effective filing date under 35 U.S.C. § 120 and therefore copies of foreign and non-patent literature documents cited in the earlier application are not provided. Copies of U.S. patents and U.S. patent application publications also are not provided. The documents corresponding to Desig. ID Nos. 5 and 16 have not been submitted to and/or cited by the Office in the earlier application.

This statement is being filed before the receipt of a first action on the merits.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 2 of 2

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

Apply any necessary charges or credits applicable under 37 C.F.R. § 1.17(p) to deposit account 06-1050, referencing the above attorney docket number.

Please contact the undersigned if there are any questions regarding this statement.

Respectfully submitted,

Date: May 15, 2023

/Heather L. Flanagan/

Heather L. Flanagan, Reg. No. 54,101

Customer Number 20985
Fish & Richardson P.C.
Telephone: +1 (512) 226-8156
Facsimile: (877) 769-7945

63201231.doc

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 22193-0137002	Application No. 18/154,727
Information Disclosure Statement by Applicant (Use several sheets if necessary)		Applicant Jae-sun Seo et al.	
		Filing Date January 13, 2023	Group Art Unit 2616
(37 CFR §1.98(b))			

U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass
	1.	5822452	10/13/1998	Tarolli et al.			
	2.	9436895	9/6/2016	Jones et al.			
	3.	9466362	10/11/2016	Yu et al.			
	4.	9934463	4/3/2018	Seo et al.			
	5.	11556779	1/17/2023	Seo et al.			
	6.	20150032449	1/29/2015	Sainath et al.			
	7.	20150255062	9/10/2015	Penn et al.			
	8.	20150339571	11/26/2015	Krizhevsky et al.			
	9.	20170220929	8/3/2017	Rozen et al.			
	10.	20170300815	10/19/2017	Seo			
	11.	20170316307	11/2/2017	Koster et al.			
	12.	20190080755	3/14/2019	Seo et al.			
	13.	20190087719	3/21/2019	Seo et al.			
	14.	20190150794	5/23/2019	Vrudhula et al.			
	15.	20190164538	5/30/2019	Seo et al.			
	16.	20190244100	8/8/2019	Seo et al.			

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
	17.	WO 2016033506	3/3/2016	WO			
	18.	WO 2017190089	11/2/2017	WO			
	19.	WO 2018022821	2/1/2018	WO			

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	20.	International Search Report and Written Opinion in International Appln. No. PCT/US2017/052736, dated January 8, 2018, 9 pages

Examiner Signature	Date Considered
--------------------	-----------------

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form

IPR2025-01399



ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
05/15/2023 03:44:07 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Beth Schachtner

PATENT CENTER # 62091913

FILING DATE 01/13/2023

CUSTOMER # 20985

FIRST NAMED
INVENTOR Jae-sun Seo

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Heather Flanagan

Documents

TOTAL DOCUMENTS: 1

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
22193-0137002_IDS.pdf	3	Information Disclosure Statement (IDS) Form (SB08)	135 KB

Warning: This is not a USPTO supplied IDS fillable form. Data in the form cannot be automatically loaded to other USPTO systems.

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
22193-0137002_IDS.pdf	BEBF4937E04F8D1919EE2FD3919E9737DC3BA8FA48BC23728 8DF3C2BA9451517EB64A0AF6202E01D37EAFB5E5930E4AF18

663982453611D8A8DFBA9738FF612F

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New Applications Under 35 U.S.C. 111

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National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NUMBER	FILING OR 371(C) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002

CONFIRMATION NO. 4440

20985
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

PUBLICATION NOTICE



OC000000059313170

Date Mailed: 07/13/2023

Title:CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Publication No.US-2023-0222339-A1

Publication Date:07/13/2023

NOTICE OF PUBLICATION OF APPLICATION

The above-identified application will be electronically published as a patent application publication pursuant to 37 CFR 1.211, et seq. The patent application publication number and publication date are set forth above.

The publication may be accessed through the USPTO's publically available Searchable Databases via the Internet at www.uspto.gov. The direct link to access the publication is currently <http://www.uspto.gov/patft/>.

The publication process established by the Office does not provide for mailing a copy of the publication to applicant. A copy of the publication may be obtained from the Office upon payment of the appropriate fee set forth in 37 CFR 1.19(a)(1). Orders for copies of patent application publications are handled by the USPTO's Public Records Division. The Public Records Division can be reached by telephone at (571) 272-3150 or (800) 972-6382, by facsimile at (571) 273-3250, by mail addressed to the United States Patent and Trademark Office, Public Records Division, Alexandria, VA 22313-1450 or via the Internet.

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<i>Examiner-Initiated Interview Summary</i>	Application No. 18/154,727	Applicant(s) Seo et al.		
	Examiner Xilin Guo	Art Unit 2616	AIA (First Inventor to File) Status Yes	Page 1 of 1

All Participants (applicant, applicants representative, PTO personnel)	Title	Type
Xilin Guo	Primary Examiner	Telephonic
Heather Flanagan	Attorney of Record	

Date of Interview: 17 July 2023

Issues Discussed:

Other

Examiner and applicant's representative discussed the claim invention. In particular, the preamble of claim 1 was discussed. Examiner suggested Applicant amend each claim to remove “,” after “non-transitory” in order to place all claims in allowable form. Applicant agreed to incorporate these changes and authorization for the examiner’s amendment was given in the telephone interview.

/XILIN GUO/ Primary Examiner, Art Unit 2616	
Applicant is reminded that a complete written statement as to the substance of the interview must be made of record in the application file. It is the applicants responsibility to provide the written statement, unless the interview was initiated by the Examiner and the Examiner has indicated that a written summary will be provided. See MPEP 713.04 Please further see: MPEP 713.04 Title 37 Code of Federal Regulations (CFR) § 1.133 Interviews, paragraph (b) 37 CFR § 1.2 Business to be transacted in writing	

Applicant recordation instructions: It is not necessary for applicant to provide a separate record of the substance of interview.

Examiner recordation instructions: Examiners must summarize the substance of any interview of record. A complete and proper recordation of the substance of an interview should include the items listed in MPEP 713.04 for complete and proper recordation including the identification of the general thrust of each argument or issue discussed, a general indication of any other pertinent matters discussed regarding patentability and the general results or outcome of the interview, to include an indication as to whether or not agreement was reached on the issues raised.

Notice of References Cited	Application/Control No. 18/154,727		Applicant(s)/Patent Under Reexamination Seo et al.	
	Examiner Xilin Guo		Art Unit 2616	Page 1 of 1

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*		Document Number Country Code-Number-Kind Code	Date MM-YYYY	Name	CPC Classification	US Classification
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*	B	US-5822452-A	10-1998	Tarolli; Gary	G06T9/002	345/582
*	C	US-20170316307-A1	11-2017	Koster; Urs	G06F7/5443	1/1
*	D	US-20170220929-A1	08-2017	Rozen; Piotr	G06F7/483	1/1
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	Examiner Xilin Guo	Art Unit 2616

CPC						
Symbol					Type	Version
G06N	/	3	/	08	F	2013-01-01
G06N	/	3	/	045	I	2023-01-01
G06N	/	3	/	0464	I	2023-01-01
G06F	/	7	/	48	I	2013-01-01

CPC Combination Sets					
Symbol				Type	Set
	/		/		

NONE (Assistant Examiner) _____ (Date) _____		Total Claims Allowed: 11	
/XILIN GUO/ Primary Examiner, Art Unit 2616 (Primary Examiner) _____ (Date) 17 July 2023		O.G. Print Claim(s) 40	O.G. Print Figure 4

Issue Classification 	Application/Control No. 18/154,727	Applicant(s)/Patent Under Reexamination Seo et al.
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US ORIGINAL CLASSIFICATION	
CLASS	SUBCLASS

CROSS REFERENCES(S)						
CLASS	SUBCLASS (ONE SUBCLASS PER BLOCK)					

NONE		Total Claims Allowed:	
(Assistant Examiner)	(Date)	11	
/XILIN GUO/ Primary Examiner, Art Unit 2616 (Primary Examiner)	17 July 2023 (Date)	O.G. Print Claim(s) 40	O.G. Print Figure 4

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	Examiner Xilin Guo	Art Unit 2616

☐ Claims renumbered in the same order as presented by applicant ☐ CPA ☐ T.D. ☐ R.1.47															
CLAIMS															
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2	41	11	50												
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4	43														
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7	46														
8	47														
9	48														

NONE	Total Claims Allowed:	
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/XILIN GUO/	17 July 2023	O.G. Print Claim(s)
Primary Examiner, Art Unit 2616	(Date)	O.G. Print Figure
(Primary Examiner)		40
		4

<i>Search Notes</i> 	Application/Control No. 18/154,727	Applicant(s)/Patent Under Reexamination Seo et al.
	Examiner Xilin Guo	Art Unit 2616

CPC - Searched*		
Symbol	Date	Examiner
G06F7/48 G06N3/0454 G06N3/08	07/11/2023	XLG

CPC Combination Sets - Searched*		
Symbol	Date	Examiner

US Classification - Searched*			
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Search Notes	Date	Examiner
Inventor name search	07/11/2023	XLG
Assignee search	07/11/2023	XLG
CPC search (G06F7/48 G06N3/0454 ...) limited by (comput\$3 most significant bit\$1 neural network\$1 ...)	07/11/2023	XLG
PE2E text search	07/11/2023	XLG
NPL search -ip.com; google scholar, IEEE Xplore	07/12/2023	XLG
Updated search	07/12/2023	XLG
Interview with Applicant	07/17/2023	XLG
Interference search	07/17/2023	XLG

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<i>Search Notes</i> 	Application/Control No. 18/154,727	Applicant(s)/Patent Under Reexamination Seo et al.
	Examiner Xilin Guo	Art Unit 2616

Interference Search			
US Class/CPC Symbol	US Subclass/CPC Group	Date	Examiner
G06N3/08		07/17/2023	XLG
G06N3/045		07/17/2023	XLG
G06F7/48		07/17/2023	XLG
G06N3/0464		07/17/2023	XLG

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☐ Hierarchical Digital Modulation Classification Using Cascaded Convolutional Neural Network

Juanjuan Huang; Sai Huang; Yuqi Zeng; Hao Chen; Shuo Chang; Yifan Zhang
Journal of Communications and Information Networks
Year: 2021 | Volume: 6, Issue: 1 | Journal Article | Publisher: PTP
Cited by: Papers (10)

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Hierarchical Digital Modulation Classification Using Cascaded Convolutional Neural Network

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Journal of Communications and Information Networks
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☐ Small-scale image recognition based on Cascaded Convolutional Neural Network

Enji Sun
2021 IEEE 5th Advanced Information Technology, Electronic and Automation Control Conference (IAEAC)
Year: 2021 | Conference Paper | Publisher: IEEE
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Small-scale image recognition based on Cascaded Convolutional Neural Network

Enji Sun
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Supplemental Items

Cascaded Neural Network for Memristor based Neuromorphic Computing

Sheng-Xiang Sun, Fan Xu, Jiwu Li, Baoguo Liu, Qinggang Li

2021 International Joint Conference on Neural Networks (IJCNN)

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Cascaded Neural Network for Memristor based Neuromorphic Computing

Sheng-Yang Sun; Hui Xu; Jiwei Li; Haijun Liu; Qingjiang Li
 2019 International Joint Conference on Neural Networks (IJCNN)
 Year: 2019 | Conference Paper | Publisher: IEEE

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Di Zang; Junqi Zhang; Dongdong Zhang; Maomao Bao; Jijun Cheng; Keshuang Tang
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Minkyu Kim; Jae-Sun Seo
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☐ Cascaded Learning with Generative Adversarial Networks for Low Dose CT Denoising

Sepehr Ataie; Paul Babyn; Alireza Ahmadian; Jayad Alirezaie
 2021 43rd Annual International Conference of the IEEE Engineering in Medicine & Biology Society (EMBC)

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☐ Target Detection Based on Cascade Network and Densely Connected Network in Remote Sensing Image

Jihao Wang; Yangping Wang; Jianwu Dang; Linjing Wei

2018 IEEE 16th Intl Conf on Dependable, Autonomic and Secure Computing, 16th Intl Conf on

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☐ Convolutional Neural Network based Virtual Exam Controller

Kavish Garg; Kunal Verma; Kunal Patidar; Nitesh Teja; Kunal Patidar

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☐ Driver Assistant System using Haar Cascade and Convolution Neural Networks(CNN)

Aditya Nair; Shoaib Mansoori; Rajeev Mohe; Paval Shahr; Kiran Talele

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Haar Cascade and Convolutional Neural Network Face Detection in Client-Side for Cloud Computing Face Recognition

Rosa Andrie Asmara; Muhammad Ridwan; Gunawan Budiprasetyo
 2021 International Conference on Electrical and Information Technology (IEIT)
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An Improved Algorithm Based on Convolutional Neural Network for Smoke Detection

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 2019 IEEE International Conferences on Ubiquitous Computing & Communications (IUCC) and Data Science and Computational Intelligence (DSCI) and Smart Computing, Networking and Services (SmartCNS)
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Segmentation of Brain Tumors using traditional Multiscale bilateral Convolutional Neural Networks

P. Asha; Dr. B. Ankayarkanni; L. K. Joshila Grace; Km. Kaarthik; M. Hemanth Reddy
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Detection of Real Time Face Mask using Convolutional Neural Network

N. Jeyanrakash; Devi M. Divyathirar; A. Vignesh; T. D. Sudhakar
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Kai Hu; Qinghai Gan; Yuan Zhang; Shuhua Deng; Fen Xiao; Wei Huang;

Chunhong Cao; Xieping Gao

IEEE Access

Year: 2019 | Volume: 7 | Journal Article | Publisher: IEEE

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Brain Tumor Segmentation Using Multi-Cascaded Convolutional Neural Networks and Conditional Random Field

Kai Hu; Qinghai Gan; Yuan Zhang; Shuhua Deng; Fen Xiao; Wei Huang; Chunhong Cao;

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☐ Multi-Task Cascaded Convolutional Neural Networks (MTCNN) based Driver Drowsiness Detection

K. Kalyan Suhas; M. Syam Prakash; Y. Venkatesh; P. Madhavi Latha

2023 7th International Conference on Computing Methodologies and Communication (ICCMC)

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☐ Pancreas Segmentation in Abdominal CT Scans using Inter-/Intra-Slice Contextual Information with a Cascade Neural Network

Zhengzheng Yang; Lei Zhang; Min Zhang; Jun Feng; Zheng Wu; Fenggang Ren; Yi Lv

2019 41st Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)

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☐ CNF+CT: Context Network Fusion of Cascade-Trained Convolutional Neural Networks for

Image Super-Resolution

Haoyu Ren; Mostafa El-Khamy; Jungwon Lee

IEEE Transactions on Computational Imaging

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IEEE Transactions on Computational Imaging

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Cascaded coarse-to-fine convolutional neural networks for pericardial effusion localization and segmentation on CT scans

Jiamin Liu; Jinzheng Cai; Karthik Chellamuthu; Mohammadi Bagheri; Le Lu; Ronald M. Summers

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Blinking Eyes Detection using Convolutional Neural Network on Video Data

F. M. Sigit; E.M. Yunarno; R.F. Rachmadi; A. Zaini

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Detection of Pin Defects in Aerial Images Based on Cascaded Convolutional Neural Network

Yewei Xiao; Zhiqiang Li; Dongbo Zhang; Lianwei Teng

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- ☐ **Facial Emotion Recognition of Students using Convolutional Neural Network** 
 Imane Lasti; Anouar Riad Solhi; Mourad El Belkacemi
 2019 Third International Conference on Intelligent Computing in Data Sciences (ICDS)
 Year: 2019 | Conference Paper | Publisher: IEEE
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- ☐ **Image-domain material decomposition for single-energy CT images using cascaded network** 
 YiZhong Wang; ZhiWei Feng; XiaoHuan Yu; Lei Li; Bin Yan
 2021 International Conference on Artificial Intelligence and Electromechanical Automation (AIEA)
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- ☐ **Convolutional Neural Network for Cooperative Spectrum Sensing with Spatio-Temporal Dataset** 
 P. Shachi; K.R. Sudhindra; M.N. Suma
 2020 International Conference on Artificial Intelligence and Signal Processing (AISP)
 Year: 2020 | Conference Paper | Publisher: IEEE
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Application No: 18/154,727

Foreign Priority claimed: ☐ Yes ☒ No

35 USC 119 (a-d) conditions met: ☐ Yes ☒ No ☐ Met After Allowance

Verified and Acknowledged:

/XILIN GUO/

Examiner's Signature

Initials

Title:

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

FILING or 371(c) DATE	CLASS	GROUP ART UNIT	ATTORNEY DOCKET NO.
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APPLICANTS

INVENTORS

Jae-sun Seo, Tempe, AZ, UNITED STATES

Minkyu Kim, Chandler, AZ, UNITED STATES

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This application is a CON of 16335775 03/22/2019 PAT 11556779

16335775 is a 371 of PCT/US2017/052736 09/21/2017

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PE2E SEARCH - Search History (Prior Art)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
L123	298	(SEO near2 JAE\$1SUN).in. (KIM near2 MINKYU).in.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 09:44 AM
L124	6	L123 AND (most ADJ significant ADJ bit\$1).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 09:44 AM
L125	4	L124 AND (neural near2 network\$1).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:10 AM
L127	1896	((ARIZONA near2 BOARD near2 REGENTS) WITH (ARIZONA near2 STATE near2 UNIVERSITY)).as.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:27 AM
L128	6	L127 AND (most ADJ significant ADJ bit\$1).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:28 AM
L129	3	L128 AND (neural near2 network\$1).clm.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:28 AM
L130	258401	(G06F7/48 G06N3/0454 G06N3/08).CPC.	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:29 AM
L131	147	L130 AND (comput\$3 WITH ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:29 AM
L132	118	L131 AND (neural near2 network\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:29 AM
L133	81	L132 AND precision	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:30 AM
L134	388	(neural near2 network\$1) AND (comput\$3 WITH ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:30 AM
L135	199	L134 AND ((G06N3/08 OR G06N3/0454 OR	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2023/07/11 10:30 AM

		G06N3/084 OR G06N3/0445 OR G06N3/0472 OR G06F9/30036 OR G06F9/30014 OR G06F2207/4824 OR G06F9/3818 OR G06F9/30149 OR G06F9/325 OR G06F9/38 OR G06F9/30018 OR G06F9/30065 OR G06F7/506 OR G06F9/30185 OR G06F7/02 OR G06F7/727).cpc.)	JPO; DERWENT; IBM_TDB)				
L137	159	L135 AND precision	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:31 AM
L138	9877	((comput\$3 calculat\$3) WITH ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:32 AM
L139	1168	L138 AND (G06F7/483 OR G06F9/30036 OR G06F9/30014 OR G06F9/3001 OR G06F17/16 OR G06F9/3885 OR G06F9/3016 OR G06F9/30112 OR G06F9/30018 OR G06F5/012 OR G06F21/64 OR G06F7/544 OR G06F7/722 OR G06F7/74 OR G06F7/49915 OR G06F9/30025 OR G06F2207/4824 OR G06F9/30007 OR G06F9/3824 OR G06F12/0284 OR G06F12/0292 OR G06F16/2255 OR G06F7/607 OR G06F2207/5355 OR G06F9/30065 OR G06N3/0454 OR G06N3/084).cpc.)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:32 AM
L140	316	L139 AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:32 AM

L141	156	L140 AND (maximum near3(value\$1 result\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:33 AM
L142	61	L141 AND (propagat\$3 WITH layer\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:33 AM
L143	151751	layer\$1 WITH ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:33 AM
L144	296	L143 AND ((comput\$3 calculat\$3) WITH ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:33 AM
L145	208	L144 AND precision	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:34 AM
L146	144	L145 AND propagat\$3	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:34 AM
L147	97	L143 SAME ((most ADJ significant ADJ bit\$1) MSB\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:35 AM
L148	2325	L143 AND ((most ADJ significant ADJ bit\$1) MSB\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:36 AM
L149	1129	L148 AND propagat\$3 AND precision	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:36 AM
L150	1027	L149 AND ((comput\$3 calculat\$3) near5 (value\$1 result\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:37 AM
L151	13	L150 AND (((most ADJ significant ADJ bit\$1) MSB\$1) WITH (data near2 set\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:37 AM
L152	24	L150 AND (((most ADJ significant ADJ bit\$1) MSB\$1) SAME (data near2 set\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:38 AM
L153	4917	(image\$1 WITH ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:38 AM
L154	332	L153 AND ((neural near2 network\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2023/07/11 10:39 AM

L155	36	((machine deep) near2 learn\$3)) L154 AND ((most ADJ significant ADJ bit\$1) MSB\$1) AND (maximum near3(value\$1 result\$1 number))	JPO; DERWENT; IBM_TDB) (US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:39 AM
L156	323	L154 AND (most ADJ significant ADJ bit\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:39 AM
L157	25	L143 AND L156	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 10:40 AM
L158	3444	((comput\$3 calculat\$3) near3 (value\$1 result\$1)) SAME (most ADJ significant ADJ bit\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:40 PM
L159	240	L158 AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:40 PM
L160	125	L159 AND precision	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:40 PM
L162	68	L160 AND propagat\$3	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:41 PM
L163	911	(most ADJ significant ADJ bit\$1) WITH ((image\$1 data) near2 set\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:41 PM
L164	36	L163 AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:41 PM
L165	1650	(most ADJ significant ADJ bit\$1) AND (precision near3 (comput\$3 computation\$1 optimizat\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:42 PM
L166	828	L165 AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:42 PM
L167	547	L166 AND (propagat\$3 WITH layer\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT;	OR	ON	ON	2023/07/11 03:43 PM

L168	3	L167 AND (((most ADJ significant ADJ bit\$1) MSB\$1) SAME (data near2 set\$1))	IBM_TDB) (US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:43 PM
L170	3	L163 AND L167	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:44 PM
L171	34	L167 AND (determin\$3 near5 (maximum near3 value\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/11 03:46 PM
L172	30264	(data image\$1) WITH (most ADJ significant ADJ bit\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:35 AM
L173	5340	L172 AND ((comput\$3 calculat\$3) SAME ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:35 AM
L174	547	L173 AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:36 AM
L175	83	L174 AND (propagat\$3 WITH layer\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:36 AM
L177	2933	((precision accurary) near2 (comput\$3 computation)) AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:39 AM
L178	789	L177 AND (propagat\$3 WITH layer\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:40 AM
L179	3	L178 AND (((most ADJ significant ADJ bit\$1) MSB\$1) WITH ((image\$1 data) near2 set\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:40 AM
L180	540	L178 AND ((most ADJ significant ADJ bit\$1) MSB\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:40 AM
L181	536	L180 AND ((image\$1 data) near2 set\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:41 AM
L182	9	L181 AND ((comput\$3 calculat\$3) WITH	(US-PGPUB; USPAT; USOCR; FPRS; EPO;	OR	ON	ON	2023/07/12 09:42 AM

L183	9	((most ADJ significant ADJ bit\$1) MSB\$1))	JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:42 AM
L185	21051	L180 AND ((comput\$3 calculat\$3) WITH ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:43 AM
L186	972	(propagat\$3 WITH layer\$1) AND ((neural near2 network\$1) ((machine deep) near2 learn\$3))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:44 AM
L187	11	L185 AND ((most ADJ significant ADJ bit\$1) MSB\$1)	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:44 AM
L188	897	L186 AND (((most ADJ significant ADJ bit\$1) MSB\$1) WITH (data near2 set\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:44 AM
L189	536	L186 AND ((comput\$3 calculat\$3) near5 (value\$1 result\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:44 AM
L190	106	L188 AND ((precision accurary) near2 (comput\$3 computation))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:45 AM
L191	145	L189 AND (maximum near3(value\$1 result\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:45 AM
L192	8	((precision accurary) near2 (comput\$3 computation)) SAME (maximum near3(value\$1 result\$1)))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:46 AM
L194	9	L191 AND ((comput\$3 calculat\$3) SAME ((most ADJ significant ADJ bit\$1) MSB\$1))	(US-PGPUB; USPAT; USOCR; FPRS; EPO; JPO; DERWENT; IBM_TDB)	OR	ON	ON	2023/07/12 09:46 AM

PE2E SEARCH - Search History (Interference)

There are no Interference searches to show.

Minimum signed digit approximation for faster and **more efficient convolutional neural network computation** on embedded devices

KS Zaman, MBI Reaz, AAA Bakar, MAS Bhuiyan... - Science and Technology ..., 2022 - Elsevier

... and only the **most significant bit (MSB)** to approximate the ... activations are **computed** and forwarded to the next **layer**. The ... only the nonzero **bits** in the mantissa **group** are considered for ...

☆ Save Cite Cited by 4 Related articles

An efficient **bit-flip** resilience optimization method for **deep neural networks**

C Schom, A Guntero, G Ascheld - 2019 Design, Automation & ..., 2019 - IEEE Xplore

... energy efficiency and faster **computation of neural networks** [2]. ... for all neurons of the **network based on a set D** of training ... for faults on the **most significant bit (MSB)** of neuron outputs, ...

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ERDNN: Error-resilient **deep neural networks with** a new error correction **layer** and piece-wise rectified linear unit

MS Ali, TB Iqbal, KH Lee, A Mugeel, S Lee, L Kim... - IEEE ..., 2020 - IEEE Xplore

... , thus observing that errors in **most significant bit (MSB)** ... , resulting in a **significant** reduction of **computation** complexity in ... **Based on** empirical results we **set the value** of a as $a_1 = 0.5, a_2 ...$

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ISAAC: A **convolutional neural network** accelerator **with** in-situ analog arithmetic in crossbars

A Shafiee, A Nag, N Muralimanohar... - ACM SIGARCH ..., 2016 - dl.acm.org

... Thus, **one** IMA can process the 8 **most significant bits** of the ... an **MSB** of 0, the ADC size requirement is lowered by **one bit**. ... Similarly, **based on** our benchmark behaviors, we **estimate** that ...

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Deep convolutional neural network accelerator featuring conditional computing and low external memory access

M Kim, JS Seo - 2020 IEEE Custom Integrated Circuits ..., 2020 - IEEE Xplore

... with only the **most significant bits (MSBs)** are performed first. ... a **deep convolutional neural network** includes pooling **layers** ... the **computation** time of **convolution** operation on **MSB group** ...

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On-chip learning of a domain-wall-synapse-crossbar-array-based **convolutional neural network**

VB Desai, D Kaushik, J Sharda... - Neuromorphic ..., 2022 - IOPscience

... for different **data sets** including the CIFAR-10 **data set** and ... (LSBs) to a LSB crossbar and the other ten **bits** to two **MSB** ... after forward **computation** on every sample of the training **set**. A ...

☆ Save Cite Cited by 4 Related articles

Predictive multitask **deep neural network** models for ADME-Tox properties: learning from large **data sets**

J Wenzel, H Matter, F Schmidt - Journal of chemical information ..., 2019 - ACS Publications

... are **computed** for every **data set** and feed into the input **layers**. ... An algorithm is **used** to **compute bits** describing **one** feature, ... The **most important** HPs can be classified as **network** ...

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Mosaic-CNN: A combined two-step zero prediction approach to trade off accuracy and **computation energy in convolutional neural networks**

C Kim, D Shin, B Kim, J Park - IEEE Journal on Emerging and ..., 2018 - IEEE Xplore

... a **most significant bits (MSBs)** only **computation** scheme, ... using ILSVRC2012 validation **data set** image inputs (50,000 images) in the layout **level** including parasitic capacitances **using** ...

☆ Save Cite Cited by 21 Related articles All 3 versions

Efficient Mitchell's approximate log multipliers for **convolutional neural networks**

MS Kim, AA Del Barrio, LT Oliveira... - IEEE Transactions ..., 2018 - [ieeexplore.ieee.org](#)

... **One** distinction to make in **neural network computation** is the ... is given by the **most significant bit (MSB)**. Thus, if $X \neq 0$ the ... We can see that **using more significant bits** with $w = 8$ results in ...

☆ Save  Cite Cited by 100 Related articles All 5 versions

An energy-efficient **deep convolutional neural network** accelerator featuring conditional computing and low external memory access

M Kim, JS Seo - IEEE Journal of Solid-State Circuits, 2020 - [ieeexplore.ieee.org](#)

... been demonstrated for large-scale **data sets** such as ImageNet. ... **Based** on this approximate **convolution**, if we can **find** the ... We only **use 2 bits** of zero sparsity map **data** for the **MSB** and ...

☆ Save  Cite Cited by 10 Related articles All 6 versions

PE2E SEARCH - Search History (Prior Art)

There are no Prior Art searches to show.

PE2E SEARCH - Search History (Interference)

Ref #	Hits	Search Query	DBs	Default Operator	Plurals	British Equivalents	Time Stamp
N11	65879	(G06N3/08 G06N3/045 G06F7/48 G06N3/0464).CPC.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:44 PM
N12	55	N11 AND ((comput\$3 calculat\$3) SAME ((most ADJ significant ADJ bit\$1) MSB\$1)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:44 PM
N13	16	N12 AND (layer\$1 WITH (neural near2 network\$1)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:44 PM
N14	3	N13 AND (precision near2 (comput\$3 computation)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:45 PM
N15	7	N11 AND ((precision near2 (comput\$3 computation)) SAME (layer\$1 WITH (neural near2 network\$1))).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:45 PM
N16	3	N15 AND ((most ADJ significant ADJ bit\$1) MSB\$1).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:45 PM
N17	18	N11 AND (((comput\$3 calculat\$3) near5 (value\$1 result\$1)) SAME ((most ADJ significant ADJ bit\$1) MSB\$1)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:45 PM
N18	7	N17 AND (layer\$1 WITH (neural near2 network\$1)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:45 PM
N19	4	N18 AND (maximum near3(value\$1 result\$1)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:46 PM
N20	3	N19 AND ((precision accurary) near2 (comput\$3 computation)).clm.	(US-PGPUB; USPAT)	OR	ON	ON	2023/07/17 01:46 PM

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	2616
Application No. :	18/154,727	Examiner :	Xilin Guo
Filed :	January 13, 2023	Conf. No. :	4440
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

MAIL STOP AMENDMENT

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

INFORMATION DISCLOSURE STATEMENT

Please consider the documents listed on the disclosure form submitted with this statement. Copies of the documents are being submitted with this statement to the extent required under 37 C.F.R. § 1.98(a)(2).

This application relies on the earlier filing date of application number 16/335,775, filed on March 22, 2019. Under 37 CFR § 1.98 (a)(2) and 37 CFR § 1.98(d), the earlier application is properly identified and is relied on for an earlier effective filing date under 35 U.S.C. § 120 and therefore copies of foreign and non-patent literature documents cited in the earlier application are not provided. Copies of U.S. patents and U.S. patent application publications also are not provided. The documents corresponding to Desig. ID Nos. 5 and 16 have not been submitted to and/or cited by the Office in the earlier application.

This statement is being filed before the receipt of a first action on the merits.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 2 of 2

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

Apply any necessary charges or credits applicable under 37 C.F.R. § 1.17(p) to deposit
account 06-1050, referencing the above attorney docket number.

Please contact the undersigned if there are any questions regarding this statement.

Respectfully submitted,

Date: May 15, 2023

/Heather L. Flanagan/

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63201231.doc

Sheet 1 of 1

Substitute Disclosure Form	U.S. Department of Commerce Patent and Trademark Office	Attorney Docket No. 22193-0137002	Application No. 18/154,727
Information Disclosure Statement by Applicant (Use several sheets if necessary)		Applicant Jae-sun Seo et al.	
		Filing Date January 13, 2023	Group Art Unit 2616
(37 CFR §1.98(b))			

U.S. Patent Documents							
Examiner Initial	Desig. ID	Document Number	Publication Date	Patentee	Filing Date If Appropriate	Class	Subclass
	1.	5822452	10/13/1998	Tarolli et al.			
	2.	9436895	9/6/2016	Jones et al.			
	3.	9466362	10/11/2016	Yu et al.			
	4.	9934463	4/3/2018	Seo et al.			
	5.	11556779	1/17/2023	Seo et al.			
	6.	20150032449	1/29/2015	Sainath et al.			
	7.	20150255062	9/10/2015	Penn et al.			
	8.	20150339571	11/26/2015	Krizhevsky et al.			
	9.	20170220929	8/3/2017	Rozen et al.			
	10.	20170300815	10/19/2017	Seo			
	11.	20170316307	11/2/2017	Koster et al.			
	12.	20190080755	3/14/2019	Seo et al.			
	13.	20190087719	3/21/2019	Seo et al.			
	14.	20190150794	5/23/2019	Vrudhula et al.			
	15.	20190164538	5/30/2019	Seo et al.			
	16.	20190244100	8/8/2019	Seo et al.			

Foreign Patent Documents or Published Foreign Patent Applications							
Examiner Initial	Desig. ID	Document Number	Publication Date	Country or Patent Office	Translation	Class	Subclass
	17.	WO 2016033506	3/3/2016	WO			
	18.	WO 2017190089	11/2/2017	WO			
	19.	WO 2018022821	2/1/2018	WO			

Other Documents (include Author, Title, Date, and Place of Publication)		
Examiner Initial	Desig. ID	Document
	20.	International Search Report and Written Opinion in International Appln. No. PCT/US2017/052736, dated January 8, 2018, 9 pages

Examiner Signature /XILIN GUO/	Date Considered 07/11/2023
---------------------------------------	-----------------------------------

EXAMINER: Initials citation considered. Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

Substitute Disclosure Form

IPR2025-01399



3. Cascaded computing for convolutional neural networks

Techniques are described for efficiently reducing the amount of total computation in convolutional neural networks (CNNs) without affecting the output result or classification accuracy. Computation redundancy in CNNs is reduced by exploiting the computing nature of the convolution and subsequent...

ARIZONA STATE UNIV

US11558779 | US Patents | 2023-01-17 | 5

4. Accelerating processor based artificial neural network computation

An apparatus employed in a processing device comprises a processor configured to process data of a predefined data structure. A memory fetch device is coupled to the processor and is configured to determine addresses of the packed data for the processor. The packed data is stored on a memory device...

INFINEON TECH AG

US20220086776 | US Applications | 2022-03-03 | 4

5. Neural network device and method using bitwise operations

A neural network device and method using bitwise operations are disclosed. The neural network processing method comprises the following steps: obtaining a kernel bit serial block corresponding to first data of a weight kernel of a layer in a neural network; generating a feature map bit serial block...

SAMSUNG ELINC CO LTD

CN111352656A | China Applications | 2020-08-30 | 4

Relevance

Publication Date

First Cur Assignees by Relevan

ARIZONA STATE UNIV (5)

More 1

Result 1

https://iq.ip.com/discover

IPR2025-01399

CrowdStrike EX1002 Page 135

1/1



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

NOTICE OF ALLOWANCE AND FEE(S) DUE

20985 7590 07/24/2023
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

EXAMINER

GUO, XILIN

ART UNIT

PAPER NUMBER

2616

DATE MAILED: 07/24/2023

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002	4440

TITLE OF INVENTION: CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	MICRO	\$240	\$0.00	\$0.00	\$240	10/24/2023

THE APPLICATION IDENTIFIED ABOVE HAS BEEN EXAMINED AND IS ALLOWED FOR ISSUANCE AS A PATENT. PROSECUTION ON THE MERITS IS CLOSED. THIS NOTICE OF ALLOWANCE IS NOT A GRANT OF PATENT RIGHTS. THIS APPLICATION IS SUBJECT TO WITHDRAWAL FROM ISSUE AT THE INITIATIVE OF THE OFFICE OR UPON PETITION BY THE APPLICANT. SEE 37 CFR 1.313 AND MPEP 1308.

THE ISSUE FEE AND PUBLICATION FEE (IF REQUIRED) MUST BE PAID WITHIN THREE MONTHS FROM THE MAILING DATE OF THIS NOTICE OR THIS APPLICATION SHALL BE REGARDED AS ABANDONED. THIS STATUTORY PERIOD CANNOT BE EXTENDED. SEE 35 U.S.C. 151. THE ISSUE FEE DUE INDICATED ABOVE DOES NOT REFLECT A CREDIT FOR ANY PREVIOUSLY PAID ISSUE FEE IN THIS APPLICATION. IF AN ISSUE FEE HAS PREVIOUSLY BEEN PAID IN THIS APPLICATION (AS SHOWN ABOVE), THE RETURN OF PART B OF THIS FORM WILL BE CONSIDERED A REQUEST TO REAPPLY THE PREVIOUSLY PAID ISSUE FEE TOWARD THE ISSUE FEE NOW DUE.

HOW TO REPLY TO THIS NOTICE:

I. Review the ENTITY STATUS shown above. If the ENTITY STATUS is shown as SMALL or MICRO, verify whether entitlement to that entity status still applies.

If the ENTITY STATUS is the same as shown above, pay the TOTAL FEE(S) DUE shown above.

If the ENTITY STATUS is changed from that shown above, on PART B - FEE(S) TRANSMITTAL, complete section number 5 titled "Change in Entity Status (from status indicated above)".

For purposes of this notice, small entity fees are 40% the amount of undiscounted fees, and micro entity fees are 20% the amount of undiscounted fees.

II. PART B - FEE(S) TRANSMITTAL, or its equivalent, must be completed and returned to the United States Patent and Trademark Office (USPTO) with your ISSUE FEE and PUBLICATION FEE (if required). If you are charging the fee(s) to your deposit account, section "4b" of Part B - Fee(s) Transmittal should be completed. If an equivalent of Part B is filed, a request to reapply a previously paid issue fee must be clearly made, and delays in processing may occur due to the difficulty in recognizing the paper as an equivalent of Part B.

III. All communications regarding this application must give the application number. Please direct all communications prior to issuance to Mail Stop ISSUE FEE unless advised to the contrary.

IMPORTANT REMINDER: Maintenance fees are due in utility patents issuing on applications filed on or after Dec. 12, 1980. It is patentee's responsibility to ensure timely payment of maintenance fees when due. More information is available at www.uspto.gov/PatentMaintenanceFees.

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web.

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22313-1450

By fax, send to: (571)-273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

20985 7590 07/24/2023
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)
(Signature)
(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002	4440

TITLE OF INVENTION: CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	MICRO	\$240	\$0.00	\$0.00	\$240	10/24/2023

EXAMINER	ART UNIT	CLASS-SUBCLASS
GUO, XILIN	2616	706-019000

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

☐ Change of correspondence address (or Change of Correspondence Address form PTO/AIA/122 or PTO/SB/122) attached.

☐ "Fee Address" indication (or "Fee Address" Indication form PTO/AIA/47 or PTO/SB/47; Rev 03-02 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

(1) The names of up to 3 registered patent attorneys or agents OR, alternatively,

1 _____

(2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed.

2 _____

3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Please check the appropriate assignee category or categories (will not be printed on the patent) : ☐ Individual ☐ Corporation or other private group entity ☐ Government

4a. Fees submitted: ☐ Issue Fee ☐ Publication Fee (if required)

4b. Method of Payment: (Please first reapply any previously paid fee shown above)

☐ Electronic Payment via Patent Center or EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)

☐ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment to Deposit Account No. _____

5. Change in Entity Status (from status indicated above)

☐ Applicant certifying micro entity status. See 37 CFR 1.29

☐ Applicant asserting small entity status. See 37 CFR 1.27

☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken to be a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken to be a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature _____

Date _____

Typed or printed name _____

Registration No. _____



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002	4440
20985	7590	07/24/2023	EXAMINER	
FISH & RICHARDSON P.C. (SD)			GUO, XILIN	
P.O. BOX 1022			ART UNIT	
MINNEAPOLIS, MN 55440-1022			PAPER NUMBER	
			2616	
DATE MAILED: 07/24/2023				

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (Applications filed on or after May 29, 2000)

The Office has discontinued providing a Patent Term Adjustment (PTA) calculation with the Notice of Allowance.

Section 1(h)(2) of the AIA Technical Corrections Act amended 35 U.S.C. 154(b)(3)(B)(i) to eliminate the requirement that the Office provide a patent term adjustment determination with the notice of allowance. See Revisions to Patent Term Adjustment, 78 Fed. Reg. 19416, 19417 (Apr. 1, 2013). Therefore, the Office is no longer providing an initial patent term adjustment determination with the notice of allowance. The Office will continue to provide a patent term adjustment determination with the Issue Notification Letter that is mailed to applicant approximately three weeks prior to the issue date of the patent, and will include the patent term adjustment on the patent. Any request for reconsideration of the patent term adjustment determination (or reinstatement of patent term adjustment) should follow the process outlined in 37 CFR 1.705.

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Customer Service Center of the Office of Patent Publication at 1-(888)-786-0101 or (571)-272-4200.

OMB Clearance and PRA Burden Statement for PTOL-85 Part B

The Paperwork Reduction Act (PRA) of 1995 requires Federal agencies to obtain Office of Management and Budget approval before requesting most types of information from the public. When OMB approves an agency request to collect information from the public, OMB (i) provides a valid OMB Control Number and expiration date for the agency to display on the instrument that will be used to collect the information and (ii) requires the agency to inform the public about the OMB Control Number's legal significance in accordance with 5 CFR 1320.5(b).

The information collected by PTOL-85 Part B is required by 37 CFR 1.311. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 30 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, Virginia 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, Virginia 22313-1450. Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

Privacy Act Statement

The Privacy Act of 1974 (P.L. 93-579) requires that you be given certain information in connection with your submission of the attached form related to a patent application or patent. Accordingly, pursuant to the requirements of the Act, please be advised that: (1) the general authority for the collection of this information is 35 U.S.C. 2(b)(2); (2) furnishing of the information solicited is voluntary; and (3) the principal purpose for which the information is used by the U.S. Patent and Trademark Office is to process and/or examine your submission related to a patent application or patent. If you do not furnish the requested information, the U.S. Patent and Trademark Office may not be able to process and/or examine your submission, which may result in termination of proceedings or abandonment of the application or expiration of the patent.

The information provided by you in this form will be subject to the following routine uses:

1. The information on this form will be treated confidentially to the extent allowed under the Freedom of Information Act (5 U.S.C. 552) and the Privacy Act (5 U.S.C. 552a). Records from this system of records may be disclosed to the Department of Justice to determine whether disclosure of these records is required by the Freedom of Information Act.
2. A record from this system of records may be disclosed, as a routine use, in the course of presenting evidence to a court, magistrate, or administrative tribunal, including disclosures to opposing counsel in the course of settlement negotiations.
3. A record in this system of records may be disclosed, as a routine use, to a Member of Congress submitting a request involving an individual, to whom the record pertains, when the individual has requested assistance from the Member with respect to the subject matter of the record.
4. A record in this system of records may be disclosed, as a routine use, to a contractor of the Agency having need for the information in order to perform a contract. Recipients of information shall be required to comply with the requirements of the Privacy Act of 1974, as amended, pursuant to 5 U.S.C. 552a(m).
5. A record related to an International Application filed under the Patent Cooperation Treaty in this system of records may be disclosed, as a routine use, to the International Bureau of the World Intellectual Property Organization, pursuant to the Patent Cooperation Treaty.
6. A record in this system of records may be disclosed, as a routine use, to another federal agency for purposes of National Security review (35 U.S.C. 181) and for review pursuant to the Atomic Energy Act (42 U.S.C. 218(c)).
7. A record from this system of records may be disclosed, as a routine use, to the Administrator, General Services, or his/her designee, during an inspection of records conducted by GSA as part of that agency's responsibility to recommend improvements in records management practices and programs, under authority of 44 U.S.C. 2904 and 2906. Such disclosure shall be made in accordance with the GSA regulations governing inspection of records for this purpose, and any other relevant (i.e., GSA or Commerce) directive. Such disclosure shall not be used to make determinations about individuals.
8. A record from this system of records may be disclosed, as a routine use, to the public after either publication of the application pursuant to 35 U.S.C. 122(b) or issuance of a patent pursuant to 35 U.S.C. 151. Further, a record may be disclosed, subject to the limitations of 37 CFR 1.14, as a routine use, to the public if the record was filed in an application which became abandoned or in which the proceedings were terminated and which application is referenced by either a published application, an application open to public inspection or an issued patent.
9. A record from this system of records may be disclosed, as a routine use, to a Federal, State, or local law enforcement agency, if the USPTO becomes aware of a violation of a Federal, State, or local law.

Notice of Allowability	Application No. 18/154,727	Applicant(s) Seo et al.	
	Examiner Xilin Guo	Art Unit 2616	AIA (FITF) Status Yes

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address--

All claims being allowable, PROSECUTION ON THE MERITS IS (OR REMAINS) CLOSED in this application. If not included herewith (or previously mailed), a Notice of Allowance (PTOL-85) or other appropriate communication will be mailed in due course. **THIS NOTICE OF ALLOWABILITY IS NOT A GRANT OF PATENT RIGHTS.** This application is subject to withdrawal from issue at the initiative of the Office or upon petition by the applicant. See 37 CFR 1.313 and MPEP 1308.

1. ☒ This communication is responsive to 04/17/2023.
☐ A declaration(s)/affidavit(s) under **37 CFR 1.130(b)** was/were filed on _____.

2. ☐ An election was made by the applicant in response to a restriction requirement set forth during the interview on _____; the restriction requirement and election have been incorporated into this action.

3. ☒ The allowed claim(s) is/are 40-50. As a result of the allowed claim(s), you may be eligible to benefit from the **Patent Prosecution Highway** program at a participating intellectual property office for the corresponding application. For more information, please see http://www.uspto.gov/patents/init_events/pph/index.jsp or send an inquiry to PPHfeedback@uspto.gov.

4. ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

Certified copies:

a) ☐ All b) ☐ Some* c) ☐ None of the:

1. ☐ Certified copies of the priority documents have been received.

2. ☐ Certified copies of the priority documents have been received in Application No. _____.

3. ☐ Copies of the certified copies of the priority documents have been received in this national stage application from the International Bureau (PCT Rule 17.2(a)).

* Certified copies not received: _____.

Applicant has THREE MONTHS FROM THE "MAILING DATE" of this communication to file a reply complying with the requirements noted below. Failure to timely comply will result in ABANDONMENT of this application.
THIS THREE-MONTH PERIOD IS NOT EXTENDABLE.

5. ☐ CORRECTED DRAWINGS (as "replacement sheets") must be submitted.
☐ including changes required by the attached Examiner's Amendment / Comment or in the Office action of Paper No./Mail Date _____.

Identifying indicia such as the application number (see 37 CFR 1.84(c)) should be written on the drawings in the front (not the back) of each sheet. Replacement sheet(s) should be labeled as such in the header according to 37 CFR 1.121(d).

6. ☐ DEPOSIT OF and/or INFORMATION about the deposit of BIOLOGICAL MATERIAL must be submitted. Note the attached Examiner's comment regarding REQUIREMENT FOR THE DEPOSIT OF BIOLOGICAL MATERIAL.

Attachment(s)

1. ☒ Notice of References Cited (PTO-892)	5. ☒ Examiner's Amendment/Comment
2. ☒ Information Disclosure Statements (PTO/SB/08), Paper No./Mail Date _____.	6. ☒ Examiner's Statement of Reasons for Allowance
3. ☐ Examiner's Comment Regarding Requirement for Deposit of Biological Material _____.	7. ☐ Other _____.
4. ☒ Interview Summary (PTO-413), Paper No./Mail Date. _____.	

/XILIN GUO/ Primary Examiner, Art Unit 2616	
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DETAILED ACTION

Notice of Pre-AIA or AIA Status

The present application, filed on or after March 16, 2013, is being examined under the first inventor to file provisions of the AIA.

Response to Preliminary Amendment

The preliminary amendment filed on March 30, 2023 has been entered.

In view of the amendment to the claims, claims 1-20 have been canceled. New claims 21-39 have been added.

The preliminary amendment filed on April 05, 2023 has been entered.

In view of the amendment to the claims, claims 21-39 have been canceled. New claim 41-50 have been added.

The preliminary amendment filed on April 17, 2023 has been entered.

In view of the amendment to the claims, claim 40 has been acknowledged. New claims 41- has been added.

Examiner has reviewed the specification and the claim invention of the present application. The present application is a continuation of the application #16/335,775, which was issued on 01/17/2023 (Patent No. 11,556,779).

Examiner has completed the prior art reference search. However, the examiner has not discovered prior art references which fully teaches the pending claims, either

singly or in an obvious combination. Examiner called Applicant amend each claim to remove “,” after “non-transitory” in order to place all claims in allowable form. Applicant agreed to incorporate these changes and the Applicant authorized the amendment by Examiner's Amendment. Accordingly, the Application is in condition for allowance.

EXAMINER'S AMENDMENT

An examiner's amendment to the record appears below. Should the changes and/or additions be unacceptable to applicant, an amendment may be filed as provided by 37 CFR 1.312. To ensure consideration of such an amendment, it MUST be submitted no later than the payment of the issue fee.

Authorization for this examiner's amendment was given in a telephone interview with Heather Flanagan (Reg. No. 54,101) on July 17, 2023.

Please amend claim 40 as follows:

40. (Currently Amended) One or more non-transitory[[,]] computer-readable storage media storing instructions which, when executed by at least one processor, cause the at least one processor to perform operations comprising:

in one or more layers of a convolutional neural network (CNN), performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets;

examining a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values;

responsive to identifying the maximum value, performing a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and

propagating the full precision computation of the value to a subsequent layer of the CNN.

Please amend claim 41 as follows:

41. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 40, further comprising:

responsive to determining that the first set of values are the same, performing, by the at least one processor, a second iteration that includes computing the value based on a second set of MSBs for each of the plurality of data sets, the second set of MSBs being larger than the first set of MSBs.

Please amend claim 42 as follows:

42. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 41, further storing instructions, which, when executed by the at least one processor, cause the at least one processor to perform operations comprising:

examining a second set of values computed for the plurality of data sets in the second iteration to determine whether the maximum value is present among the second set of values; and

responsive to identifying the maximum value among the second set of values, performing, by the at least one processor, the full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value in the second iteration.

Please amend claim 43 as follows:

43. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 41, wherein the computing in each of the first iteration and the second iteration employs a convolution and a pooling.

Please amend claim 44 as follows:

44. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 43, wherein the convolution is a $N \times N$ convolution, where N is any integer.

Please amend claim 45 as follows:

45. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 43, wherein the pooling is a $N \times N$ pooling, where N is any integer.

Please amend claim 46 as follows:

46. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 43, wherein the convolution is a 3×3 convolution, and the pooling is a 2×2 pooling.

Please amend claim 47 as follows:

47. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 41, wherein at least one of the first iteration and the second iteration is performed with a precision less than that of the full precision computation.

Please amend claim 48 as follows:

48. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 47, wherein the precision is 8-bit precision.

Please amend claim 49 as follows:

49. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 40, wherein the CNN is employed to analyze an image.

Please amend claim 50 as follows:

50. (Currently Amended) The one or more non-transitory[[,]] computer-readable storage media of claim 40, wherein:

the first iteration computes a value that approximates the full precision computation of the value; and

the full precision computation is performed on the data set that includes less data than the plurality of data sets.

Allowable Subject Matter

Claims 40-50 are allowed.

The following is an examiner's statement of reasons for allowance:

Independent claim 40 is directed to a non-transitory computer-readable storage media and recites the same limitations corresponding to the method claim 1 of Patent No. 11,556,779. More specifically, claim 40 requires "in one or more layers of a convolutional neural network (CNN), performing a first iteration that includes computing a value based on a first set of most significant bits (MSBs) for each of a plurality of data sets; examining a first set of values computed for the plurality of data sets in the first iteration to determine whether a maximum value is present among the first set of values; responsive to identifying the maximum value, performing a full precision computation of the value for a data set, of the plurality of data sets, that exhibited the maximum value; and propagating the full precision computation of the value to a subsequent layer of the CNN".

Examiner has completed the prior art reference search and discovered the closest prior art references:

The prior art reference Rozen et al (US Patent Application Publication 2017/0220929 A1) discloses techniques of implementing neural networks for speech recognition systems. Rozen discloses a system (FIG. 2) for providing speech recognition using a neural network (as shown in FIG. 3, includes an input layer, hidden

layers, and an output layer). More specifically, Rozen discloses the system generates feature vectors associated with speech and transfers feature vectors to neural network for determining classification scores for each evaluated time instance of speech from an output layer of neural network (Paragraph [0032]). FIG. 5 of Rozen discloses a process for converting weights of a layer of a neural network to fixed point integer values based on a scaling factor and generating correction values for one or more of the weights. The process converts a weight to an 8 bit signed integer value; determines a most significant bit of the weight is non-zero; determines the correction value may be a value associated with the most significant bit; then adds the correction value to the corrections list along with weight indices that indicate which weight in the layer of the neural network the correction value is associated with (Paragraph [0049]).

The prior art reference Koster et al (US Patent Application Publication 2017/0316307 A1) discloses techniques of performing a neural network computation based on the received sequence of tensor instructions to generate output tensors (As shown in FIG. 1). FIG. 4 of Koster shows an artificial neural network including three layers for performing forward propagation and determining activation values for each successive level of nodes are updated sequentially (Paragraphs [0033]-[0034]). More specifically, Koster discloses a tensor decimal position determination module (FIG. 5) determines the value of the decimal position for an output tensor based on the collected statistics and adjust the received decimal position based on the determination in order to maintain a high level of precision when performing tensor computations.

The prior art reference Tarolli et al (US Patent No. 5, 822, 452 A) discloses a system and method for compressing and decompressing a texture image. The invention of Tarolli selects a compression color space manually, or preferable, using a computer-based neural network algorithm. The invention initializes the neural network (As shown in FIG. 9) that includes an input layer of neurons and a hidden layer of neurons, e.g., Y neurons, A neurons, and B neurons (Col 3, lines 51-64). Tarolli discloses a conventional technique for reducing the number of bits used for each color channel is to determine a predefined number of most significant bits in an image in order to compress the image data (Col 2, lines 21-50). FIG. 8 of Tarolli describes the details of the YAB color space selection process using the neural network.

The prior art reference Langhammer (US Patent Application Publication 2018/0081632 A1) discloses techniques of performing reduced-precision floating-point arithmetic operations using specialized processing blocks with higher-precision floating-point arithmetic circuitry.

However, the closest prior art references and the references listed in IDSs submitted by Applicant failed to show the obviousness of the claims as a whole. None of the prior art cited alone or in combination provides the motivation to teach the limitations recited in claim 40. Accordingly, claim 40 is allowed.

Dependent claims 41-50 depend from independent claim 40. They are allowed at least due to their respective dependencies from an allowed claim.

Any comments considered necessary by applicant must be submitted no later than the payment of the issue fee and, to avoid processing delays, should preferably accompany the issue fee. Such submissions should be clearly labeled "Comments on Statement of Reasons for Allowance."

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Xilin Guo whose telephone number is (571)272-5786. The examiner can normally be reached Monday - Friday 9:00 AM-5:30 PM EST.

Examiner interviews are available via telephone, in-person, and video conferencing using a USPTO supplied web-based collaboration tool. To schedule an interview, applicant is encouraged to use the USPTO Automated Interview Request (AIR) at <http://www.uspto.gov/interviewpractice>.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Kee Tung can be reached on 571-272-7794. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of published or unpublished applications may be obtained from Patent Center. Unpublished application information in Patent Center is available to registered users. To file and manage patent submissions in Patent Center, visit: <https://patentcenter.uspto.gov>. Visit <https://www.uspto.gov/patents/apply/patent-center> for more information about Patent Center and <https://www.uspto.gov/patents/docx> for information about filing in DOCX format. For

Art Unit: 2616

additional questions, contact the Electronic Business Center (EBC) at 866-217-9197

(toll-free). If you would like assistance from a USPTO Customer Service

Representative, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/XILIN GUO/

Primary Examiner, Art Unit 2616

PART B - FEE(S) TRANSMITTAL

Complete and send this form, together with applicable fee(s), by mail or fax, or via EFS-Web

By mail, send to: Mail Stop ISSUE FEE
Commissioner for Patents
P.O. Box 1450
Alexandria, Virginia 22314-1450

By fax, send to: (571) 273-2885

INSTRUCTIONS: This form should be used for transmitting the ISSUE FEE and PUBLICATION FEE (if required). Blocks 1 through 5 should be completed where appropriate. All further correspondence including the Patent, advance orders and notification of maintenance fees will be mailed to the current correspondence address as indicated unless corrected below or directed otherwise in Block 1, by (a) specifying a new correspondence address; and/or (b) indicating a separate "FEE ADDRESS" for maintenance fee notifications. **Because electronic patent issuance may occur shortly after issue fee payment, any desired continuing application should preferably be filed prior to payment of this issue fee in order not to jeopardize copendency.**

CURRENT CORRESPONDENCE ADDRESS (Note: Use Block 1 for any change of address)

20985 7590 07/24/2023

FISH & RICHARDSON P.C.
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

Note: A certificate of mailing can only be used for domestic mailings of the Fee(s) Transmittal. This certificate cannot be used for any other accompanying papers. Each additional paper, such as an assignment or formal drawing, must have its own certificate of mailing or transmission.

Certificate of Mailing or Transmission

I hereby certify that this Fee(s) Transmittal is being deposited with the United States Postal Service with sufficient postage for first class mail in an envelope addressed to the Mail Stop ISSUE FEE address above, or being transmitted to the USPTO via EFS-Web or by facsimile to (571) 273-2885, on the date below.

(Typed or printed name)

(Signature)

(Date)

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002	4440

TITLE OF INVENTION: CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

APPLN. TYPE	ENTITY STATUS	ISSUE FEE DUE	PUBLICATION FEE DUE	PREV. PAID ISSUE FEE	TOTAL FEE(S) DUE	DATE DUE
nonprovisional	MICRO	\$240	\$0		\$240	10/24/2023
EXAMINER		ART UNIT	CLASS-SUBCLASS			
GUO, XILIN		2616	706-019000			

1. Change of correspondence address or indication of "Fee Address" (37 CFR 1.363).

- ☐ Change of correspondence address (or Change of Correspondence Address form PTO/SB/122) attached.
- ☐ "Fee Address" indication (or "Fee Address" Indication form PTO/SB/47; Rev 03-09 or more recent) attached. **Use of a Customer Number is required.**

2. For printing on the patent front page, list

- (1) The names of up to 3 registered patent attorneys or agents OR, alternatively, 1 Fish & Richardson P.C.
- (2) The name of a single firm (having as a member a registered attorney or agent) and the names of up to 2 registered patent attorneys or agents. If no name is listed, no name will be printed. 2 _____
- 3 _____

3. ASSIGNEE NAME AND RESIDENCE DATA TO BE PRINTED ON THE PATENT (print or type)

PLEASE NOTE: Unless an assignee is identified below, no assignee data will appear on the patent. If an assignee is identified below, the document must have been previously recorded, or filed for recordation, as set forth in 37 CFR 3.11 and 37 CFR 3.81(a). Completion of this form is NOT a substitute for filing an assignment.

(A) NAME OF ASSIGNEE

(B) RESIDENCE: (CITY and STATE OR COUNTRY)

Arizona Board of Regents on behalf of Arizona State University

Scottsdale, AZ

Please check the appropriate assignee category or categories (will not be printed on the patent): ☐ Individual ☒ Corporation or other private group entity ☐ Government4a. Fees Submitted: ☒ Issue Fee ☐ Publication Fee (if required)

4b. Method of Payment (Please first reapply any previously paid fee shown above):

☒ Electronic Payment via EFS-Web ☐ Enclosed check ☐ Non-electronic payment by credit card (Attach form PTO-2038)☒ The Director is hereby authorized to charge the required fee(s), any deficiency, or credit any overpayment, to Deposit Account No. 06-1050

5. Change of Entity Status (from status indicated above)

- ☐ Applicant certifying micro entity status. See 37 CFR 1.29
- ☐ Applicant asserting small entity status. See 37 CFR 1.27.
- ☐ Applicant changing to regular undiscounted fee status.

NOTE: Absent a valid Certification of Micro Entity Status (see forms PTO/SB/15A and 15B), issue fee payment in the micro entity amount will not be accepted at the risk of application abandonment.

NOTE: If the application was previously under micro entity status, checking this box will be taken as a notification of loss of entitlement to micro entity status.

NOTE: Checking this box will be taken as a notification of loss of entitlement to small or micro entity status, as applicable.

NOTE: This form must be signed in accordance with 37 CFR 1.31 and 1.33. See 37 CFR 1.4 for signature requirements and certifications.

Authorized Signature /Heather L. Flanagan/Date August 18, 2023Typed or printed name Heather L. FlanaganRegistration No. 54,101

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

First Named Inventor :	Jae-sun Seo	Art Unit :	2616
Application No. :	18/154,727	Examiner :	Xilin Guo
Filed :	January 13, 2023	Confirmation No. :	4440
		Notice of Allowance Date:	July 24, 2023
Title :	CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS		

MAIL STOP ISSUE FEE

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

REPLY TO NOTICE OF ALLOWANCE

In response to the Notice of Allowance dated July 24, 2023, enclosed is a completed Part B - Fee(s) Transmittal.

The issue fee is being paid with this reply on the Electronic Filing System. Apply that fee and any other necessary charges or credits to Deposit Account 06-1050, referencing the above attorney docket number.

COMMENTS ON EXAMINER'S REASONS FOR ALLOWANCE

It is recognized that, in accordance with M.P.E.P. § 1302.14, the Examiner's reasons for allowance need not set forth all of the details as to why the claims are allowed. In the above-referenced application, it is not conceded that the Examiner's stated reasons for allowance are the only reasons for which the claims are allowable. The Examiner's reasons for allowance indicate that particular claim elements are not disclosed or suggested by the prior art of record, yet the claims may be patentable for other reasons as well, including the inventive combination of all of the recited claim elements. It is not conceded that the specific limitations identified by the Examiner are necessary to distinguish the art of record or to satisfy the requirements of 35 U.S.C. § 112. Moreover, the Examiner does not assert, and it would not be conceded, that the Examiner's reasons have any bearing on the patentability of claims in any other applications directed to the disclosed subject matter.

First Named Inventor : Jae-sun Seo
Application No. : 18/154,727
Filed : January 13, 2023
Page : 2 of 2

Attorney Docket No.: 22193-0137002 / M16-180P-
US2-b

In addition, each dependent claim stands on its own and may be allowable on its own merits. In particular, each dependent claim may be allowable on the basis of a combination of some of the features recited in the dependent claim and its base claim(s), which combination of features may not include all of the limitations identified in the Examiner's reasons for allowance.

Respectfully submitted,

Date: August 18, 2023

/Heather L. Flanagan/

Heather L. Flanagan, Reg. No. 54,101

Customer Number 20985
Fish & Richardson P.C.
Telephone: +1 (512) 226-8156
Facsimile: (877) 769-7945

91570155.doc



ELECTRONIC ACKNOWLEDGEMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
08/18/2023 12:17:55 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica J uarez

PATENT CENTER # 62639369

FILING DATE 01/13/2023

CUSTOMER # 20985

FIRST NAMED
INVENTOR J ae-sun Seo

CORRESPONDENCE
ADDRESS -

AUTHORIZED BY Heather Flanagan

Documents

TOTAL DOCUMENTS: 2

DOCUMENT	PAGES	DESCRIPTION	SIZE (KB)
22193-0137002resproa.PDF	2	Post Allowance Communication - Incoming	60 KB
22193-0137002_partb.PDF	1	Issue Fee Payment (PTO-85B)	139 KB

Digest

DOCUMENT	MESSAGE DIGEST(SHA-512)
22193-0137002resproa.PDF	7285B3E5D5987198CBBD0AF317270B833FFCCF1FFA048BF6E 1EBDF5329341DE9F23E58EAE692D8087419B2B01AC941A31E FF6CB95D50DCE86835DEA91A1B1CD3

22193-0137002_partb.PDF

243D27AF5DA6F40356850F3B52A77743677BF5A8C29A9895D8
075B6953CFD98A6E23FA144923F41ED53F84186C9C488E25A4
6B51DFA510CEC78C8604CAAB8B17

This Acknowledgement Receipt evidences receipt on the noted date by the USPTO of the indicated documents, characterized by the applicant, and including page counts, where applicable. It serves as evidence of receipt similar to a Post Card, as described in MPEP 503.

New Applications Under 35 U.S.C. 111

If a new application is being filed and the application includes the necessary components for filing date (see 37 CFR 1.53(b)-(d) and MPEP 506), a Filing Receipt (37 CFR 1.54) will be issued in due course and the date shown on this Acknowledgement Receipt will establish the filing date of the application

National Stage of an International Application under 35 U.S.C. 371

If a timely submission to enter the national stage of an international application is compliant with the conditions of 35 U.S.C. 371 and other applicable requirements a Form PCT/DO/EO/903 indicating acceptance of the application as a national stage submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



ELECTRONIC PAYMENT RECEIPT

APPLICATION #
18/154,727

RECEIPT DATE / TIME
08/18/2023 12:17:55 PM ET

ATTORNEY DOCKET #
22193-0137002

Title of Invention

CASCADED COMPUTING FOR CONVOLUTIONAL NEURAL NETWORKS

Application Information

APPLICATION TYPE Utility - Nonprovisional Application
under 35 USC 111(a)

PATENT # -

CONFIRMATION # 4440

FILED BY Veronica J uarez

PATENT CENTER # 62639369

AUTHORIZED BY Heather Flanagan

CUSTOMER # 20985

FILING DATE 01/13/2023

CORRESPONDENCE
ADDRESS -

FIRST NAMED
INVENTOR J ae-sun Seo

Payment Information

PAYMENT METHOD
DA / 061050

PAYMENT TRANSACTION ID
E20238HC18357480

PAYMENT AUTHORIZED BY
Veronica J uarez

FEE CODE	DESCRIPTION	ITEM PRICE(\$)	QUANTITY	ITEM TOTAL(\$)
3501	UTILITY ISSUE FEE	240.00	1	240.00
TOTAL AMOUNT:				\$240.00

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submission under 35 U.S.C. 371 will be issued in addition to the Filing Receipt, in due course.

New International Application Filed with the USPTO as a Receiving Office

If a new international application is being filed and the international application includes the necessary components for an international filing date (see PCT Article 11 and MPEP 1810), a Notification of the International Application Number and of the International Filing Date (Form PCT/RO/105) will be issued in due course, subject to prescriptions concerning national security, and the date shown on this Acknowledgement Receipt will establish the international filing date of the application.



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APPLICATION NO.	ISSUE DATE	PATENT NO.	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/154,727	10/03/2023	11775831	22193-0137002	4440

20985 7590 09/13/2023
FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
MINNEAPOLIS, MN 55440-1022

ISSUE NOTIFICATION

The projected patent number and issue date are specified above. The patent will issue electronically. The electronically issued patent is the official patent grant pursuant to 35 U.S.C. § 153. The patent may be accessed on or after the issue date through Patent Center at <https://patentcenter.uspto.gov/>. The patent will be available in both the public and the private sides of Patent Center. Further assistance in electronically accessing the patent, or about Patent Center, is available by calling the Patent Electronic Business Center at 1-888-217-9197.

The USPTO is implementing electronic patent issuance with a transition period, during which period the USPTO will mail a ceremonial paper copy of the electronic patent grant to the correspondence address of record. Additional copies of the patent (i.e., certified and presentation copies) may be ordered for a fee from the USPTO's Certified Copy Center at <https://certifiedcopycenter.uspto.gov/index.html>. The Certified Copy Center may be reached at (800)972-6382.

Determination of Patent Term Adjustment under 35 U.S.C. 154 (b) (application filed on or after May 29, 2000)

The Patent Term Adjustment is 0 day(s). Any patent to issue from the above-identified application will include an indication of the adjustment on the front page.

If a Continued Prosecution Application (CPA) was filed in the above-identified application, the filing date that determines Patent Term Adjustment is the filing date of the most recent CPA.

Applicant will be able to obtain more detailed information by accessing the Patent Center (<https://patentcenter.uspto.gov>).

Any questions regarding the Patent Term Extension or Adjustment determination should be directed to the Office of Patent Legal Administration at (571)-272-7702. Questions relating to issue and publication fee payments should be directed to the Application Assistance Unit (AAU) of the Office of Patents Stakeholder Experience (OPSE), Stakeholder Support Division (SSD) at (571)-272-4200.

INVENTOR(s) (Please see PATENT CENTER site <https://patentcenter.uspto.gov> for additional inventors):

Jae-sun Seo, Tempe, AZ;
Minkyu Kim, Chandler, AZ;

APPLICANT(s) (Please see PATENT CENTER site <https://patentcenter.uspto.gov> for additional applicants):

The United States represents the largest, most dynamic marketplace in the world and is an unparalleled location for business investment, innovation, and commercialization of new technologies. The USA offers tremendous resources and advantages for those who invest and manufacture goods here. Through SelectUSA, our nation works to encourage and facilitate business investment. To learn more about why the USA is the best country in the world to develop technology, manufacture products, and grow your business, visit [SelectUSA.gov](https://selectusa.gov).



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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
18/154,727	01/13/2023	Jae-sun Seo	22193-0137002	4440
20985	7590	10/03/2023		
FISH & RICHARDSON P.C. (SD)			EXAMINER	
P.O. BOX 1022			GUO, XILIN	
MINNEAPOLIS, MN 55440-1022				
			ART UNIT	PAPER NUMBER
			2616	
			NOTIFICATION DATE	DELIVERY MODE
			10/03/2023	ELECTRONIC

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Notice of the Office communication was sent electronically on above-indicated "Notification Date" to the following e-mail address(es):

PATDOCTC@fr.com



UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
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APPLICATION NO.	ISSUE DATE	PATENT NO.
18/154,727	03-Oct-2023	11775831

FISH & RICHARDSON P.C. (SD)
P.O. BOX 1022
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EGRANT NOTIFICATION

Your electronic patent grant (eGrant) is now available, which can be accessed via Patent Center at <https://patentcenter.uspto.gov>

The electronic patent grant is the official patent grant under 35 U.S.C. 153. For more information, please visit <https://www.uspto.gov/electronicgrants>