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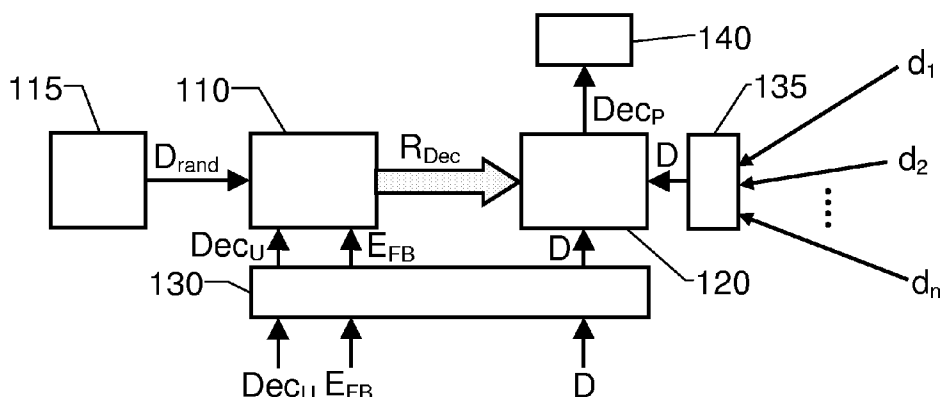
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(54) Title: DAIRY FARM DECISION SUPPORT SYSTEM



(57) Abstract: A dairy farm management support system includes an input interface (130), a rules engine (110), a decision engine (120) and an output interface (140) for presenting at least one proposed dairy farm decision to a human user. The rules engine (110) receives a first set of input parameters (D_{rand}), which reflect a decision basis for a particular type of dairy farm decisions. Via the input interface (130), the rules engine (110) also receives user generated input data (Dec_u), which represent a number of manual decisions in respect of the first set of input parameters (D_{rand}). In response to the first set of input parameters (D_{rand}) and the accompanying user-generated input data (Dec_u), the rules engine (110) generates a set of decision rules (R_{Dec}). Then, the decision engine (120) receives dairy farm data (D) reflecting animal parameters of the same type as the first set of input parameters (D_{rand}), applies the set of decision rules (R_{Dec}) to the dairy farm data (D) and derives at least one proposed dairy farm decision of the particular type, which is presented via the output interface (140).

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Dairy Farm Decision Support System

5 THE BACKGROUND OF THE INVENTION AND PRIOR ART

The present invention relates generally to support solutions intended to facilitate a dairy farmer's decision making in respect of his/her herd of livestock. More particularly the invention relates to a system according to claim 1 and a corresponding method according to claim 15. The invention also relates to a computer program product according to claim 28 and a computer readable medium according to claim 29.

Dairy farm management decision-making is generally a complex task, which is difficult to model mathematically with a satisfying degree of accuracy. Namely, in many situations, the rules underlying a particular decision are not well defined, or cannot be formulated in concrete terms by the farmer. Instead, these types of decisions may be highly influenced by the farmer's intuition, or tacit experience. For example, even if it normally is appropriate to inseminate a cow when she is approximately 60 days in milk, this is not a rigid rule. On the contrary, many other factors may have impact on an actual insemination decision for a particular animal. However, often the farmer himself/herself is not explicitly aware of exactly which these factors are, or how they influence the insemination decision. Therefore, it may be practically impossible to formulate a Boolean, or other mathematical model, for the decision process.

Moreover, even if such a model could be formulated it would typically only be applicable to a particular farm or region. Other

farms, regions or countries might require completely different models to satisfy the needs of the farmers who are active there.

The published European patent application 657 098 reveals an information system for automatically obtaining various data concerning animals in dairy farming, e.g. milk flow characteristics, reproductive status and/or health status. Here, parameter values are registered either automatically or manually. Based on the registered data expected future parameter values are determined, and an alarm is generated if the difference between the expected value and an actual value is greater than a permissible deviation. In case of such an alarm, the farmer can investigate a possible cause of the alarm, and determine appropriate measures.

U.S. Patent No. 6,405,672 discloses a similar system for monitoring the physical condition of a herd of livestock. Here, a number of animal-related parameters are automatically assessed for each animal individually. Based on historical data, future parameters are predicted, and if an error between a predicted value and a corresponding measured value falls outside of an automatically generated confidence interval, an alarm is produced indicating a potential unhealthy condition for the animal in question.

Although the above systems indeed may facilitate the farmer's supervision of his/her herd and its health status, none of the solutions is capable of providing assistance in the farm management decision process as such.

SUMMARY OF THE INVENTION

The object of the present invention is therefore to provide a solution, which alleviates the above problems and thus offers explicit decision support in the process of managing a dairy farm herd of livestock.

According to one aspect of the invention, the object is achieved

- by the system described initially, wherein the system includes a rules engine and a decision engine. The rules engine is adapted to receive a first set of input parameters reflecting a decision basis for a particular type of dairy farm decisions, receive user-generated input data representing a number of manual decisions in respect of the first set of input parameters, and generate a set of decision rules based on the first set of input parameters and the user-generated input data. The decision engine is adapted to receive dairy farm data reflecting animal parameters of the same type as the first set of input parameters, apply the set of decision rules to the dairy farm data, derive at least one proposed dairy farm decision of the particular type, and forward output data reflecting the at least one proposed dairy farm decision to the output interface for presentation to a human user.
- This system is advantageous because it is capable of modeling decision processes that cannot be explicitly formulated. Hence, also in very complex farm management decision making the system can provide valuable support to the farmer.
- According to one preferred embodiment of this aspect of the invention, the system includes a random data generator, which is adapted to produce the first set of input parameters. These parameters include a selection of parameter types, and for each parameter type a number of exemplary values are generated. The parameter types are selected based on the particular type of dairy farm decisions, and the exemplary values are distributed (e.g. according to a normal distribution) between a minimum value and a maximum value, which in turn, likewise are adapted to the particular type of dairy farm decisions. Thereby, appropriate training data is provided based on which the farmer can illustrate to the system how he/she wishes that decisions of a certain kind should be made. Consequently, the system becomes prepared for similar future decision making situations in which it can provide support.

According to another preferred embodiment of this aspect of the

invention, the rules engine includes an artificial neural network, which is adapted to be trained based on the first set of input parameters and the user-generated input data. After adequate training, the resulting trained artificial neural network represents the set of decision rules to be applied by the rules engine, which thus likewise is an artificial neural network. Alternatively, the rules engine includes a processing unit, which is adapted to generate the set of decision rules based on linear correlation computations between the first set of input parameters and the user-generated input data. The results of these correlation computations reflect the set of decision rules, which are applied by the rules engine. Both these strategies are desirable in that they are highly flexible and can be used to support decisions over a wide range of dairy farm scenarios.

According to yet another preferred embodiment of this aspect of the invention, the system includes a data collection unit. This unit is adapted to receive a number of signals registered by at least one animal-related sensor means, and as a result produce at least a sub-set of the dairy farm data. Hence, large amounts of data may be collected automatically to provide a solid decision basis.

According to still another preferred embodiment of this aspect of the invention, the input interface is adapted to receive manually entered animal parameters, and forward these parameters to the decision engine to represent at least a sub-set of the dairy farm data. Thereby, the decision basis may either be supplemented manually, or the entire decision basis may be entered manually.

According to a further preferred embodiment of this aspect of the invention, the input interface is adapted to receive manually entered effect data reflecting the outcome of one or more actual farm management decisions made in agreement with the at least one proposed dairy farm decision. The input interface is here also adapted to forward the effect data to the rules engine, so that the set of decision rules represent an improved support qua

lity. Specifically, the rules engine is adapted to modify the set of decision rules based on the effect data and the farm data, such that at least one effect of an actual farm management decision made in agreement with any future proposed dairy farm decision generated based on the modified decision rules is expected to attain an effect, which is superior to the effect of a corresponding actual farm management decision made in agreement with a proposed dairy farm decision resulting from the unmodified decision rules.

10 According to other preferred embodiments of this aspect of the invention, the proposed dairy farm decisions relate to inseminations, dry-cow states, determining individual animal energy demands, ketosis testing and/or mastitis testing.

15 In the case of insemination decision support the dairy farm data includes a first input parameter reflecting an animal identity. Additionally, the dairy farm data here includes parameters, which for each animal identity reflect a respective number of days in milk, a peak milk yield in a latest lactation, a conception rate of any previous lactations (i.e. the average number of inseminations required for the previous conceptions), a heat-detection status, a time period since a last heat date, a number of lactation periods, a body condition scoring, whether the animal has been selected for culling, and/or an activity status. The output data produced by the decision engine includes a first output parameter indicating the animal identity, and a second output parameter reflecting whether the animal having this identity should be inseminated within a particular time period.

30 In the case of decision support in respect of dry-cow states the dairy farm data includes a first input parameter reflecting an animal identity, and one or more parameters, which for each animal identity reflect a body condition scoring, a number of days in milk, a number of lactation periods, whether the animal has been selected for culling, expected calving data, mastitis event data of any previous lactation, ketosis event data of any previous

lactation. The output data produced by the decision engine includes a first output parameter indicating the animal identity, and a second output parameter reflecting whether the animal having this identity should initiate a dry-off period within a particular time period or a dry-off treatment should be initiated within a particular time period.

In the case the decision support relates to determination of individual animal energy demands, the dairy farm data includes a first input parameter reflecting an animal identity, and one or more of parameters, which for each animal identity reflect a number of days in milk, a breeding status, a body condition scoring, a body-condition-scoring trend, a latest milk yield, a milk-yield trend, a number of lactation periods and a fat and protein concentration of the milk produced by the animal. The output data produced by the decision engine includes a first output parameter indicating the animal identity, and a second output parameter reflecting whether the animal with this identity within a particular time period is expected to have an unaltered, an increased or a decreased energy demand.

In the case the decision support relates to ketosis testing, the dairy farm data includes a first input parameter reflecting an animal identity, and one or more of parameters, which for each animal identity reflect a beta-hydroxybutyrate value, a number of days in milk, a body condition scoring, a body-condition-scoring trend (positive or negative), a latest milk yield and a milk-yield trend (positive or negative). The output data produced by the decision engine includes a first output parameter indicating the animal identity, and a second output parameter reflecting whether the animal with this identity should be tested for ketosis within a particular time period.

In the case the decision support relates to mastitis testing, the dairy farm data includes a first input parameter reflecting an animal identity, and one or more of parameters, which for each animal identity reflect a status of a low-activity alarm, a milk con

ductivity, a relative milk yield, a somatic cell count and a number of days in milk. The output data produced by the decision engine includes a first output parameter indicating the animal identity, and a second output parameter reflecting whether the animal
5 with this identity should be tested for mastitis within a particular time period.

According to another aspect of the invention the object is achieved by the method described initially, involving the steps of receiving a first set of input parameters reflecting a decision
10 basis for a particular type of dairy farm decisions; receiving user-generated input data representing a number of manual decisions in respect of the first set of input parameters; generating a set of decision rules based on the first set of input parameters and the user-generated input data; receiving dairy farm data
15 reflecting animal parameters of the same type as the first set of input parameters; applying the set of decision rules to the dairy farm data; deriving at least one proposed dairy farm decision of the particular type; and presenting output data reflecting the at least one proposed dairy farm decision on said format.

20 The advantages of this method, as well as the preferred embodiments thereof, are apparent from the discussion hereinabove with reference to the proposed system.

According to a further aspect of the invention the object is achieved by a computer program product, which is directly
25 loadable into the internal memory of a computer, and includes software for controlling the above proposed method when said program is run on a computer.

According to another aspect of the invention the object is achieved by a computer readable medium, having a program
30 recorded thereon, where the program is to control a computer to perform the above-proposed method.

Further advantages, advantageous features and applications of the present invention will be apparent from the following des

cription and the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is now to be explained more closely by means of preferred embodiments, which are disclosed as
5 examples, and with reference to the attached drawings.

- Figure 1 shows a block diagram over a system according to one embodiment of the invention;
- Figure 2 illustrates, by means of a first flow diagram, a general method of controlling a computer apparatus according to the invention when producing a set of
10 decision rules; and
- Figure 3 illustrates, by means of a second flow diagram, a general method of controlling a computer apparatus according to the invention when applying the
15 decision rules to derive proposed decisions.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

We refer initially to figure 1, which shows a block diagram over a system for dairy farm management support according to one embodiment of the invention. The system includes an input interface 130, an output interface 140, a rules engine 110 and a decision engine 120.
20

According to one preferred embodiment of the invention, the system also includes a random data generator 115. This unit is adapted to produce a first set of input parameters D_{rand} representing training data for a particular type of dairy farm decisions. The parameters D_{rand} include a selection of parameter types, and for each parameter type the random data generator 115 produces a number of exemplary values.
25

30 The parameter types are selected to be relevant for the parti

cular type of dairy farm decisions, i.e. the parameter types reflect factors that are important to consider when making the decision in question. The parameter types may either be proposed automatically by the system, or they may be selected manually by the farmer/user. In any case, the system is preferably adapted to allow the farmer/user to modify the parameter types at any stage of the process.

Such interaction is accomplished via the input and output interfaces 130 and 140 respectively. The input interface 130 is adapted to receive user-generated input data Dec_U , and may thus be represented by a keyboard, a touch screen, a pointer device (e.g. a so-called computer mouse) or a voice recognition interface, or arbitrary combination thereof. The output interface 140 is adapted to present automatically generated output data Dec_P to a human user. Consequently, this interface preferably includes a computer display. However, a printer and/or an acoustic interface are equally well conceivable.

The exemplary values for each parameter type of the parameters in D_{rand} are selected such that the values are distributed between a minimum value and a maximum value. The minimum and maximum values respectively, in turn, are representative for the particular type of dairy farm decisions for which support is desired. In order to attain a good data quality, it is further preferable if the values are distributed according to a normal, or Gaussian, distribution. However, in many cases, other types of distributions may be more appropriate.

The rules engine 110 is adapted to receive a first set of input parameters D_{rand} , preferably from the random data generator 115. However, according to the invention, any other type of data source is conceivable, e.g. a storage medium, a remote resource accessible via a computer network, or manual entry. The first set of input parameters D_{rand} constitute a decision basis for a particular type of dairy farm decisions, e.g. with respect to insemination timing. The below table exemplifies the first set of input

parameters D_{rand} being applicable to insemination decisions. For each set of parameter values, the rightmost column shows examples of manual (i.e. human made) decisions by a particular farmer/user. Hence, this column represents user-generated input data Dec_U .

D_{rand}							Dec_U
<u>DIM</u>	<u>Peak Yield</u>	<u>Av.# Ins./ conception.</u>	<u>Heat</u>	<u>Last Heat</u>	<u>Lactation</u>	<u>BCS</u>	<u>Insem.</u>
26	50	2,0	Yes	—	2	3,0	No
60	40	2,5	Yes	21	3	3,5	Yes
120	60	3,0	Yes	23	1	2,0	Yes
70	20	1,5	Yes	22	6	3,3	No
80	40	2,0	Yes	20	4	2,3	Yes
100	50	1,0	Yes	21	5	3,2	No
⋮							
200	55	4,4	No	23	3	3,1	Yes

In the above table, the first parameter indicates the number of days in milk (DIM) for the animal, the second parameter indicates the peak yield of milk (here in liters), the third parameter shows the average number of inseminations that have been required for the animal's previous pregnancies, the fourth parameter indicates whether the animal is in heat presently, the fifth parameter designates the number of days since the latest heat, the sixth parameter specifies the number of previous lactations and the seventh parameter represents a body condition scoring (BCS) for the animal, which is either manually assigned, or automatically assessed, e.g. according to imaging system described in the pub

lished international patent application WO 2004/012146.

According to the proposed invention, the rules engine 110 receives the first set of input parameters D_{rand} along with the user-generated input data Dec_U , which represent the farmer's manual
5 decisions in respect of these first parameters D_{rand} , i.e. in case of insemination decisions, whether a particular cow should be inseminated within a particular time period or not. Based on the first set of input parameters D_{rand} and the user-generated input data Dec_U , the rules engine 110 generates a set of decision rules
10 R_{Dec} .

These rules R_{Dec} , in turn, are fed to the decision engine 120. Thereby, the decision engine 120 becomes adapted to generate future decision proposals in line with the decision strategies reflected by the user-generated input data Dec_U (i.e. the exemp-
15 lifying decisions entered by the farmer in connection with the first set of input parameters D_{rand}).

When operating the system in a decision-support mode after the above-described training mode, the system receives dairy farm data D , which reflect animal parameters of the same type as the
20 first set of input parameters D_{rand} . Thus, if the system has been trained in respect of insemination by means of the above first set of input parameters D_{rand} , the dairy farm data D comprises parameters that for each animal indicate a respective number of days in milk, a peak yield of milk, an average number of inseminations
25 previously required, whether the animal is in heat, a number of days since the latest heat, a number of previous lactations and a body condition scoring.

The decision engine 120 applies the set of decision rules R_{Dec} to the dairy farm data D and derives at least one proposed dairy
30 farm decision of the particular type, e.g. whether the individual members of a group of cows should be inseminated within a particular time period or not. The decision engine 120 then forwards the at least one proposed dairy farm decision in the form of

output data Dec_P to the output interface 140 for presentation to the farmer/user.

Continuing with the insemination example, the system may produce the following table in response to a farmer's/user's inquiry regarding which animals in his/her herd of livestock that should be inseminated today.

<u>Animal ID</u>	<u>DIM</u>	<u>Peak Yield</u>	<u>Av.# Ins./ conception.</u>	<u>Heat</u>	<u>Last Heat</u>	<u>Lactation</u>	<u>BCS</u>
1234	70	50	2,0	Yes	—	1	3,0
2345	60	40	1,5	Yes	21	3	3,5
3456	120	60	3,0	Yes	23	1	2,0

Hence, the output data Dec_P here includes a first output parameter reflecting the animal identity and a selection of input parameters that were used to reach the conclusion that insemination is recommended. However, animals that should not be inseminated are not listed here. Of course, the output data Dec_P may equally well be organized such that instead all animal identities in the herd are included, and the second output parameter reflects whether a particular animal should be inseminated or not.

According to one preferred embodiment of the invention, the rules engine 110 and the decision engine 120 include a respective artificial neural network. This artificial neural network is first trained (or programmed) in the rules engine 110 based on the first set of input parameters D_{rand} and the user-generated input data Dec_U , such that the resulting trained artificial neural network represents the set of decision rules R_{Dec} . Thereafter, the trained artificial neural network (i.e. the set of decision rules R_{Dec}) is copied into the decision engine 120.

According to another preferred embodiment of the invention, the rules engine 110 and the decision engine 120 instead include a

respective processing unit. The processing unit in the rules engine 110 is adapted to generate the set of decision rules R_{Dec} based on linear correlation computations between the first set of input parameters D_{rand} and the user-generated input data Dec_U .

5 Analogously, the thus produced set of decision rules R_{Dec} is transferred to the processing unit in the decision engine 120, where the rules R_{Dec} are applied to dairy farm data D to derive at least one proposed dairy farm decision.

10 Preferably, the system also includes a data collection unit 135, which is connected to, by wire or wirelessly (e.g. by means of radio-, optical- or ultrasonic transmission resources), a number of animal-related sensor means, (not shown) i.e. sensors located on/in the animals, or at implements interrelating with the animals, such as milking apparatuses. Thereby, the data collection
15 unit 135, may receive a number of signals $d_1, d_2, \dots, d_n$ registered by these sensor means, and based thereon produce at least a sub-set of the dairy farm data D . It is also desirable that the input interface 130 is adapted to receive manually entered animal parameters, and forward these parameters to the
20 decision engine 120 to represent at least a sub-set of the dairy farm data D . Namely, thereby, the farmer/user can supplement and/or correct/modify any automatically registered data.

Specifically, according to one preferred embodiment of the invention, the input interface 130 is further adapted to receive
25 manually entered effect data E_{FB} , which reflects the outcome of at least one actual farm management decision made in agreement with the at least one proposed dairy farm decision. This data E_{FB} are forwarded to the rules engine 110, which in turn, is adapted to modify its decision rules R_{Dec} based on the effect
30 data E_{FB} and the corresponding farm data D (i.e. the data linked to effect data E_{FB}). The decision rules R_{Dec} are modified such that at least one effect of an actual farm management decision made in agreement with any future proposed dairy farm decision generated based on the modified decision rules R_{Dec} is expected
35 to be improved, i.e. attain an effect superior to the effect of a

corresponding actual farm management decision made in agreement with a proposed dairy farm decision generated based on the unmodified decision rules R_{Dec} . Naturally, the modified decision rules R_{Dec} are also forwarded to the decision engine 120, so that the updated decision rules R_{Dec} gain influence over decision proposals in respect of future dairy farm data D.

Instead of, or as a complement to, the above, the proposed dairy farm decision may relate to a dry-cow state. In this case, the dairy farm data D includes a first input parameter reflecting an animal identity, and for each identity, parameters indicating one or more of the following: a body condition scoring, a number of days in milk, a lactation period number, whether the animal has been selected for culling, expected calving data for the animal, mastitis event data of any previous lactation for the animal and ketosis event data of any previous lactation for the animal. Here, the output data Dec_P preferably includes a first output parameter reflecting the animal identity, and a second output parameter reflecting whether the animal having this identity, within a particular time period, should initiate a dry-off period or a dry-off treatment should be initiated.

According to another embodiment of the invention, the proposed dairy farm decision relates to determination of individual animal energy demands. To this aim, the dairy farm data D includes a first input parameter reflecting an animal identity, and for each identity, parameters indicating one or more of the following: a number of days in milk, a breeding status (i.e. whether the animal is pregnant or not), a body condition scoring, a body-condition-scoring trend (positive or negative), a latest milk yield, a milk-yield trend (positive or negative), a lactation period number, and a fat and protein concentration of the milk produced by the animal. In this case, the output data Dec_P preferably includes a first output parameter reflecting the animal identity, and a second output parameter reflecting whether the animal with this identity is expected to have an unaltered, an increased or a de

creased energy demand within a particular time period, say a following week.

According to another embodiment of the invention, the proposed dairy farm decision relates to whether one or more animals should be subjected to ketosis testing. Here, the dairy farm data D includes a first input parameter reflecting an animal identity, and for each identity, parameters indicating one or more of the following: a beta-hydroxybutyrate (BBH) value, a number of days in milk, a body condition scoring, body-condition-scoring trend (positive or negative), a latest milk yield and a milk-yield trend (positive or negative). Preferably, the output data Dec_P specifies a first output parameter reflecting the animal identity, and a second output parameter reflecting whether the animal with this identity should be tested for ketosis within a particular time period, e.g. today.

According to yet another embodiment of the invention, the proposed dairy farm decision relates to whether one or more animals should be subjected to mastitis testing. To this aim, the dairy farm data D includes a first input parameter reflecting an animal identity, and for each identity, parameters indicating one or more of the following: a status of a low-activity alarm (i.e. essentially whether a Registered activity level falls below a threshold level, which may depend on the animal's present movement space), a milk conductivity, a relative milk yield, a somatic cell count (SCC) and a number of days in milk. Preferably, the output data Dec_P specifies a first output parameter reflecting the animal identity, and a second output parameter reflecting whether the animal with this identity should be tested for mastitis within a particular time period, e.g. during the present week.

To sum up, we will now describe the general method of controlling a computer apparatus for generating the set of decision rules according to the invention with reference to the flow diagram in figure 2.

An initial step 210 generates a first set of input parameters, preferably by a random algorithm, to constitute a decision basis for a particular type of dairy farm decisions. Then, a step 220 presents the first set of input parameters to a user, for instance in the form of a query set on a computer display. Subsequently, a step 230 receives user-generated input data in respect of the first set of input parameters, i.e. a number of manual decisions made on the basis of the circumstances defined by these parameters. Finally, a step 240 generates a set of decision rules based on the first set of input parameters and the user-generated input data. The set of decision rules here extrapolates a number of generic decision principles from the manual decisions of the step 230, such that these principles can be applied to future decision scenarios.

Turning now to the flow diagram in figure 3, we will describe the general method of controlling a computer apparatus for deriving dairy-farm-decision proposals. A first step 310 receives dairy farm data reflecting animal parameters of the same type as the first set of input parameters received in the step 210 above. A subsequent step 320 applies the set of decision rules generated in the step 240 to the dairy farm data, and derives at least one proposed dairy farm decision of the particular type mentioned above. A final step 330 then presents output data reflecting said at least one decision on a format, which is comprehensive to a human, e.g. visually on a graphical display and/or acoustically via a loudspeaker.

All of the process steps, as well as any sub-sequence of steps, described with reference to the figures 2 and 3 above may be controlled by means of a programmed computer apparatus. Moreover, although the embodiments of the invention described above with reference to the drawings comprise computer apparatus and processes performed in computer apparatus, the invention thus also extends to computer programs, particularly computer programs on or in a carrier, adapted for putting the invention into practice. The program may be in the form of

source code, object code, a code intermediate source and object code such as in partially compiled form, or in any other form suitable for use in the implementation of the process according to the invention. The program may either be a part of an
5 operating system, or be a separate application. The carrier may be any entity or device capable of carrying the program. For example, the carrier may comprise a storage medium, such as a Flash memory, a ROM (Read Only Memory), for example a DVD (Digital Video/Versatile Disk), a CD (Compact Disc) or a semi-
10 conductor ROM, an EPROM (Erasable Programmable Read-Only Memory), an EEPROM (Electrically Erasable Programmable Read-Only Memory), or a magnetic recording medium, for example a floppy disc or hard disc. Further, the carrier may be a transmissible carrier such as an electrical or optical signal which
15 may be conveyed via electrical or optical cable or by radio or by other means. When the program is embodied in a signal which may be conveyed directly by a cable or other device or means, the carrier may be constituted by such cable or device or means. Alternatively, the carrier may be an integrated circuit in
20 which the program is embedded, the integrated circuit being adapted for performing, or for use in the performance of, the relevant processes.

The term "comprises/comprising" when used in this specification is taken to specify the presence of stated features, integers,
25 steps or components. However, the term does not preclude the presence or addition of one or more additional features, integers, steps or components or groups thereof.

The invention is not restricted to the described embodiments in the figures, but may be varied freely within the scope of the
30 claims.

Claims

1. A dairy farm management support system comprising:
an input interface (130) adapted to receive user-generated
input data (Dec_U), and
5 an output interface (140) adapted to present automatically
generated output data (Dec_P) to a human user
characterized in that the system further comprises:
a rules engine (110) adapted to
receive a first set of input parameters (D_{rand}) reflec-
10 ting a decision basis for a particular type of dairy farm de-
cisions,
receive user-generated input data (Dec_U) represen-
ting a number of manual decisions in respect of the first set
of input parameters (D_{rand}), and
15 generate a set of decision rules (R_{Dec}) based on the
first set of input parameters (D_{rand}) and the user-generated
input data (Dec_U), and
a decision engine (120) adapted to
receive dairy farm data (D) reflecting animal parame-
20 ters of the same type as the first set of input parameters
(D_{rand}),
apply the set of decision rules (R_{Dec}) to the dairy farm
data (D),
derive at least one proposed dairy farm decision of
25 the particular type, and
forward output data (Dec_P) reflecting the at least one
proposed dairy farm decision to the output interface (140).
2. The system according to claim 1, characterized in that it
comprises a random data generator (115) adapted to produce
30 the first set of input parameters (D_{rand}), such that these parame-
ters (D_{rand}) comprise a selection of parameter types and a num-
ber of exemplary values are generated for each parameter type,
the parameter types being selected based on the particular type
of dairy farm decisions, and the exemplary values being distri-
35 buted between a minimum value and a maximum value which are

adapted to the particular type of dairy farm decisions.

3. The system according to claim 2, characterized in that the exemplary values are distributed according to a normal distribution.

5 4. The system according to any one of the preceding claims, characterized in that the rules engine (110) comprises an artificial neural network adapted to
be trained based on the first set of input parameters (D_{rand}) and the user-generated input data (Dec_U), and
10 generate the set of decision rules (R_{Dec}) in the form of a resulting trained artificial neural network.

5. The system according to any one of the claims 1 to 4, characterized in that the rules engine (110) comprises a processing unit adapted to generate the set of decision rules (R_{Dec}) based on linear correlation computations between the first set of input parameters (D_{rand}) and the user-generated input data (Dec_U).
15

6. The system according to any one of the preceding claims, characterized in that it comprises a data collection unit (135) adapted to
20 receive a number of signals (d_1, d_2, d_n) registered by at least one animal-related sensor means, and
produce at least a sub-set of the dairy farm data (D) based on the signals (d_1, d_2, d_n).

7. The system according to any one of the preceding claims, characterized in that the input interface (130) is adapted to receive manually entered animal parameters, and forward these parameters to the decision engine (120) to represent at least a sub-set of the dairy farm data (D).
25

8. The system according to any one of the preceding claims, characterized in that the input interface (130) is adapted to
30

receive manually entered effect data (E_{FB}) reflecting at least one outcome of at least one actual farm management decision made in agreement with the at least one proposed dairy farm decision, and

5 forward the effect data (E_{FB}) to the rules engine (110).

9. The system according to claim 8, characterized in that the rules engine (110) is adapted to modify the set of decision rules (R_{Dec}) based on the effect data (E_{FB}) and the farm data (D) such that at least one effect of an actual farm management decision made in agreement with any future proposed dairy farm decision generated based on the modified decision rules (R_{Dec}) is
10 expected to attain an effect which is superior to the effect of a corresponding actual farm management decision made in agreement with a proposed dairy farm decision generated based on
15 the unmodified decision rules (R_{Dec}).

10. The system according to any one of the preceding claims, characterized in that the at least one proposed dairy farm decision relates to insemination, and the dairy farm data (D) comprises a first input parameter reflecting an animal identity,
20 and at least one of

a second input parameter reflecting a number of days in milk for the animal having said identity,
a third input parameter reflecting a peak milk yield in a latest lactation for the animal having said identity,
25 a fourth input parameter reflecting a conception rate of any previous lactation for the animal having said identity,
a fifth input parameter reflecting a heat-detection status for the animal having said identity,
a sixth input parameter reflecting a time period since
30 a last heat date for the animal having said identity,
a seventh input parameter reflecting a lactation period number for the animal having said identity,
an eighth input parameter reflecting a body condition scoring for the animal having said identity,

a ninth input parameter reflecting whether the animal having said identity has been selected for culling, and
a tenth input parameter reflecting an activity status for the animal having said identity, and
5 the output data (Dec_P) comprises
a first output parameter reflecting the animal identity, and
a second output parameter reflecting whether the animal having said identity should be inseminated within a
10 particular time period.

11. The system according to any one of the preceding claims, characterized in that the at least one proposed dairy farm decision relates to a dry-cow state, and the dairy farm data (D) comprises a first input parameter reflecting an animal identity,
15 and at least one of
a second input parameter reflecting a body condition scoring for the animal having said identity,
a third input parameter reflecting a number of days in milk for the animal having said identity,
20 a fourth input parameter reflecting a lactation period number for the animal having said identity,
a fifth input parameter reflecting whether the animal having said identity has been selected for culling,
a sixth input parameter reflecting expected calving
25 data,
a seventh input parameter reflecting mastitis event data of any previous lactation for the animal having said identity,
an eighth input parameter reflecting ketosis event data of any previous lactation for the animal having said identity, and
30 the output data (Dec_P) comprises
a first output parameter reflecting the animal identity, and
35 a second output parameter reflecting whether the

animal having said identity within a particular time period a dry-off period should be initiated or a dry-off treatment should be initiated.

12. The system according to any one of the preceding claims,
5 characterized in that the at least one proposed dairy farm decision relates to determining individual animal energy demands, and the dairy farm data (D) comprises a first input parameter reflecting an animal identity, and at least one of
- 10 a second input parameter reflecting a number of days in milk for the animal having said identity,
 - a third input parameter reflecting a breeding status for the animal having said identity
 - a fourth input parameter reflecting a body condition scoring for the animal having said identity,
 - 15 a fifth input parameter reflecting a body-condition-scoring trend for the animal having said identity,
 - a sixth input parameter reflecting a latest milk yield for the animal having said identity,
 - a seventh input parameter reflecting a milk-yield trend
20 for the animal having said identity,
 - an eighth input parameter reflecting a lactation period number for the animal having said identity, and
 - a ninth input parameter reflecting a fat and protein concentration of the milk produced by the animal having
25 said identity, and
- the output data (Dec_P) comprises
- a first output parameter reflecting the animal identity,
and
 - 30 a second output parameter reflecting whether the animal having said identity within a particular time period is expected to have an unaltered, an increased or a decreased energy demand.

13. The system according to any one of the preceding claims, characterized in that the at least one proposed dairy farm de

cision relates to ketosis testing, and the dairy farm data (D) comprises a first input parameter reflecting an animal identity, and at least one of

- 5 a second input parameter reflecting a beta-hydroxybutyrate value for the animal having said identity
 - a third input parameter reflecting a number of days in milk for the animal having said identity,
 - a fourth input parameter reflecting a body condition scoring for the animal having said identity,
 - 10 a fifth input parameter reflecting a body-condition-scoring trend for the animal having said identity,
 - a sixth input parameter reflecting a latest milk yield for the animal having said identity,
 - a seventh input parameter reflecting milk-yield trend
 - 15 for the animal having said identity, and
- the output data (Dec_P) comprises
- a first output parameter reflecting the animal identity,
 - and
 - 20 a second output parameter reflecting whether the animal having said identity should be tested for ketosis within a particular time period.

14. The system according to any one of the preceding claims, characterized in that the at least one proposed dairy farm decision relates to mastitis testing, and the dairy farm data (D)
- 25 comprises a first input parameter reflecting an animal identity, and at least one of
- a second input parameter reflecting a status of a low-activity alarm for the animal having said identity
 - a third input parameter reflecting milk conductivity for
 - 30 the animal having said identity,
 - a fourth input parameter reflecting a relative milk yield for the animal having said identity,
 - a fifth input parameter reflecting a somatic cell count for the animal having said identity,
 - 35 a sixth parameter reflecting a number of days in milk

for the animal having said identity, and
the output data (Dec_P) comprises
a first output parameter reflecting the animal identity,
and
5 a second output parameter reflecting whether the
animal having said identity should be tested for mastitis
within a particular time period.

15. A method of generating dairy farm management support,
comprising:
10 receiving user-generated input data (Dec_U), and
presenting automatically generated output data (Dec_P) on a
format perceivable by a human user, characterized by
receiving a first set of input parameters (D_{rand}) reflecting a
decision basis for a particular type of dairy farm decisions,
15 receiving user-generated input data (Dec_U) representing a
number of manual decisions in respect of the first set of input
parameters (D_{rand}),
generating a set of decision rules (R_{Dec}) based on the first
set of input parameters (D_{rand}) and the user-generated input data
20 (Dec_U),
receiving dairy farm data (D) reflecting animal parameters
of the same type as the first set of input parameters (D_{rand}),
applying the set of decision rules (R_{Dec}) to the dairy farm
data (D),
25 deriving at least one proposed dairy farm decision of the
particular type, and
presenting output data (Dec_P) reflecting the at least one
proposed dairy farm decision on said format.

16. The method according to claim 15, characterized by pro-
30 ducing the first set of input parameters (D_{rand}) according to a
random algorithm, such that the first set of input parameters
(D_{rand}) comprises a selection of parameter types and a number of
exemplary values for each parameter type, the parameter types
being selected based on the particular type of dairy farm de

cisions, and the exemplary values being distributed between a minimum value and a maximum value which are adapted to the particular type of dairy farm decisions.

5 17. The method according to claim 16, characterized by the exemplary values being distributed according to a normal distribution.

10 18. The method according to any one of the claims 15 to 17, characterized by implementing the set of decision rules (R_{Dec}) in the form of a trained artificial neural network having been trained based on the first set of input parameters (D_{rand}) and the user-generated input data (Dec_U).

15 19. The method according to any one of the claims 15 to 17, characterized by generating the set of decision rules (R_{Dec}) based on linear correlation computations between the first set of input parameters (D_{rand}) and the user-generated input data (Dec_U).

20 20. The method according to any one of the claims 15 to 19, characterized by
collecting a number of signals (d_1, d_2, d_n) registered by at least one animal-related sensor means, and
producing at least a sub-set of the dairy farm data (D) based on the signals (d_1, d_2, d_n).

21. The method according to any one of the claims 15 to 20, characterized by receiving manually entered animal parameters to represent at least a sub-set of the dairy farm data (D).

25 22. The method according to any one of the claims 15 to 21, characterized by
receiving manually entered effect data (E_{FB}) reflecting at least one outcome of at least one actual farm management decision made in agreement with the at least one proposed dairy farm decision, and
30

- modifying the set of decision rules (R_{Dec}) based on the effect data (E_{FB}) and the farm data (D) such that at least one effect of an actual farm management decision made in agreement with any future proposed dairy farm decision generated based on the modified decision rules (R_{Dec}) is expected to attain an effect which is superior to the effect of a corresponding actual farm management decision made in agreement with a proposed dairy farm decision generated based on the unmodified decision rules (R_{Dec}).
23. The method according to any one of the claims 15 to 22, characterized by the at least one proposed dairy farm decision relating to insemination, and the dairy farm data (D) comprising a first input parameter reflecting an animal identity, and at least one of
- a second input parameter reflecting a number of days in milk for the animal having said identity,
 - a third input parameter reflecting a peak milk yield in a latest lactation for the animal having said identity,
 - a fourth input parameter reflecting a conception rate of any previous lactation for the animal having said identity,
 - a fifth input parameter reflecting a heat-detection status for the animal having said identity,
 - a sixth input parameter reflecting a time period since a last heat date for the animal having said identity,
 - a seventh input parameter reflecting a lactation period number for the animal having said identity,
 - an eighth input parameter reflecting a body condition scoring for the animal having said identity,
 - a ninth input parameter reflecting whether the animal having said identity has been selected for culling, and
 - a tenth input parameter reflecting an activity status for the animal having said identity, and
- the output data (Dec_P) comprises
- a first output parameter reflecting the animal identity,
- and

a second output parameter reflecting whether the animal having said identity should be inseminated within a particular time period.

24. The method according to any one of the claims 15 to 23,
5 characterized by the at least one proposed dairy farm decision relating to a dry-cow state, and the dairy farm data (D) comprising a first input parameter reflecting an animal identity, and at least one of
- 10 a second input parameter reflecting a body condition scoring for the animal having said identity,
 - a third input parameter reflecting a number of days in milk for the animal having said identity,
 - a fourth input parameter reflecting a lactation period number for the animal having said identity,
 - 15 a fifth input parameter reflecting whether the animal having said identity has been selected for culling,
 - a sixth input parameter reflecting expected calving data,
 - a seventh input parameter reflecting mastitis event data of any previous lactation for the animal having said identity,
 - 20 an eighth input parameter reflecting ketosis event data of any previous lactation for the animal having said identity, and
- 25 the output data (Dec_P) comprises
- a first output parameter reflecting the animal identity, and
 - a second output parameter reflecting whether for the animal having said identity within a particular time period a dry-off period should be initiated or a dry-off treatment should be initiated.
- 30

25. The method according to any one of the claims 15 to 24, characterized by the at least one proposed dairy farm decision relating to determining individual animal energy demands, and

the dairy farm data (D) comprising a first input parameter reflecting an animal identity, and at least one of

a second input parameter reflecting a number of days in milk for the animal having said identity,

5 a third input parameter reflecting a breeding status for the animal having said identity

a fourth input parameter reflecting a body condition scoring for the animal having said identity,

10 a fifth input parameter reflecting a body-condition-scoring trend for the animal having said identity,

a sixth input parameter reflecting a latest milk yield for the animal having said identity,

a seventh input parameter reflecting a milk-yield trend for the animal having said identity,

15 an eighth input parameter reflecting a lactation period number for the animal having said identity, and

a ninth input parameter reflecting a fat and protein concentration of the milk produced by the animal having said identity, and

20 the output data (Dec_P) comprises

a first output parameter reflecting the animal identity, and

25 a second output parameter reflecting whether the animal having said identity within a particular time period is expected to have an unaltered, an increased or a decreased energy demand.

26. The method according to any one of the preceding claims 15 to 25, characterized by the at least one proposed dairy farm decision relating to ketosis testing, and the dairy farm data (D) comprising a first input parameter reflecting an animal identity, and at least one of

30 a second input parameter reflecting a beta-hydroxybutyrate value for the animal having said identity

35 a third input parameter reflecting a number of days in milk for the animal having said identity,

- a fourth input parameter reflecting a body condition scoring for the animal having said identity,
a fifth input parameter reflecting a body-condition-scoring trend for the animal having said identity,
5 a sixth input parameter reflecting a latest milk yield for the animal having said identity,
a seventh input parameter reflecting milk-yield trend for the animal having said identity, and
the output data (Dec_P) comprises
10 a first output parameter reflecting the animal identity, and
a second output parameter reflecting whether the animal having said identity should be tested for ketosis within a particular time period.
- 15 27. The system according to any one of the claims 15 to 26, characterized by the at least one proposed dairy farm decision relating to mastitis testing, and the dairy farm data (D) comprising a first input parameter reflecting an animal identity, and at least one of
20 a second input parameter reflecting a status of a low-activity alarm for the animal having said identity
a third input parameter reflecting milk conductivity for the animal having said identity,
a fourth input parameter reflecting a relative milk yield
25 for the animal having said identity,
a fifth input parameter reflecting a somatic cell count for the animal having said identity,
a sixth parameter reflecting a number of days in milk for the animal having said identity, and
30 the output data (Dec_P) comprises
a first output parameter reflecting the animal identity, and
a second output parameter reflecting whether the
35 animal having said identity should be tested for mastitis within a particular time period.

28. A computer program product directly loadable into the internal memory of a computer, comprising software for controlling the steps of any of the claims 15 to 27 when said program is run on the computer.
- 5 29. A computer readable medium, having a program recorded thereon, where the program is to make a computer control the steps of any of the claims 15 to 27.

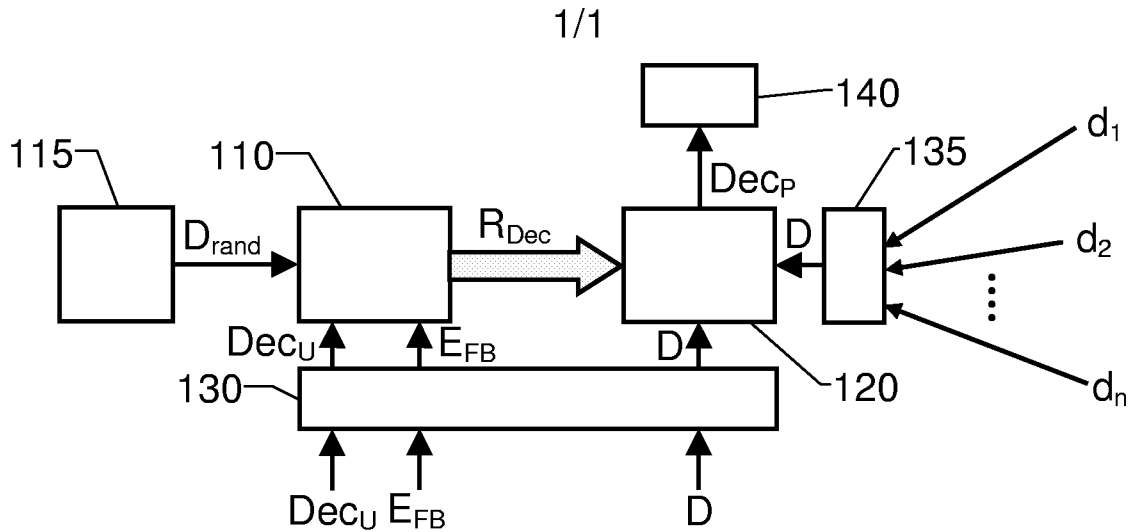


Fig. 1

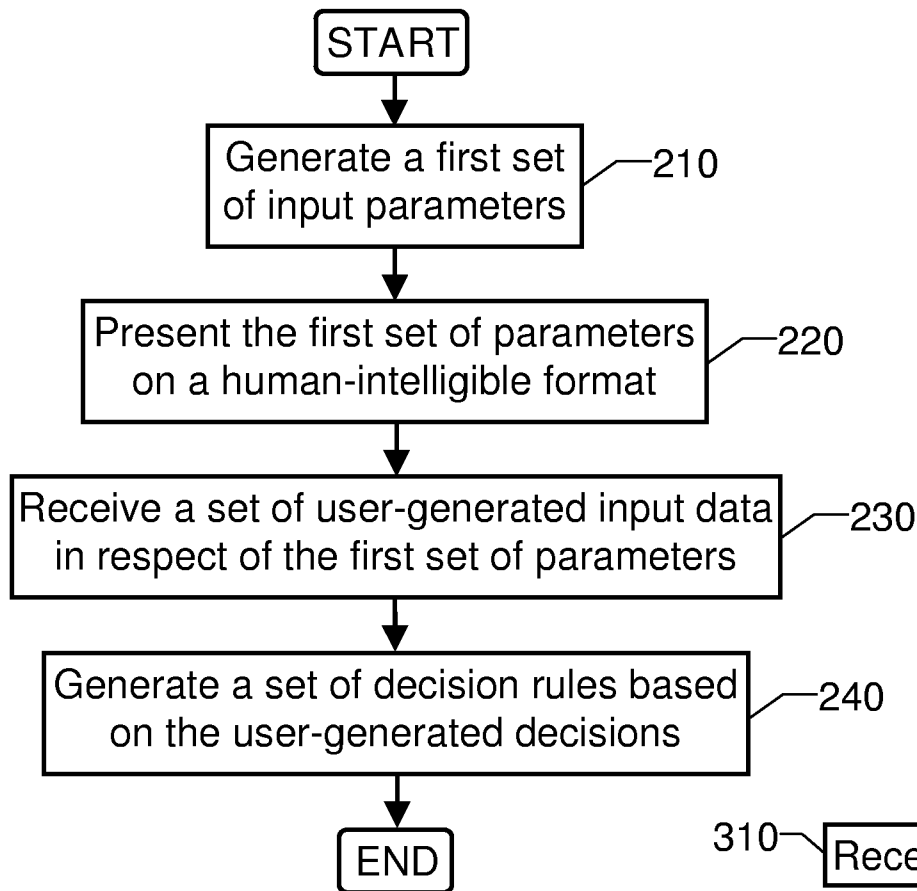


Fig. 2

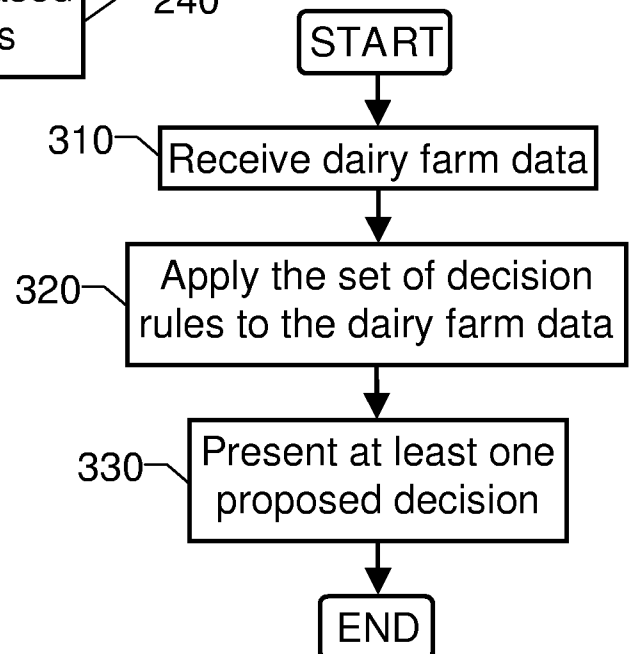


Fig. 3 Smaxtec Exhibit 1010

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2006/050343

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: G06F, G06N, G06Q

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-INTERNAL, WPI DATA, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HOGVEEN, H. et al: "Knowledge Representation Methods for Dairy Decision Support Systems". J Dairy Sci., 1994, Vol. 77, pages 3704-3715. See pag. 3705, 3708, 3709 --	1-29
A	US 20030078683 A1 (HARTMAN, E ET AL), 24 April 2003 (24.04.2003), paragraphs [0004]-[0006]; [0243] --	1-29
A	DELORENZO, M.A. et al: "Optimizing Model Insemination, Replacement, Seasonal Production, and Cash Flow". J Dairy Sci., 1992, Vol. 75, pages 885-896. See the whole document --	1-29

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search

28 December 2006

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE2006/050343

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 0189285 A2 (RENESSEN LLC), 29 November 2001 (29.11.2001), see the whole document -- -----	1-29

Form PCT/ISA/210 (continuation of second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2006050343

International patent classification (IPC)

G06Q 10/00 (2006.01)

G06F 19/00 (2006.01)

G06N 3/02 (2006.01)

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Paper copies can be ordered at a cost of 50 SEK per copy from PRV InterPat (telephone number 08-782 28 85).

Cited literature, if any, will be enclosed in paper form.

INTERNATIONAL SEARCH REPORT
Information on patent family members

25/11/2006

International application No.
PCT/SE2006/050343

US	20030078683	A1	24/04/2003	EP	1428153 A	16/06/2004
				US	7054847 B	30/05/2006
				US	20030033194 A	13/02/2003
				US	20030033587 A	13/02/2003
				WO	03021490 A	13/03/2003

WO	0189285	A2	29/11/2001	AU	6471401 A	03/12/2001
				EP	1290573 A	12/03/2003
