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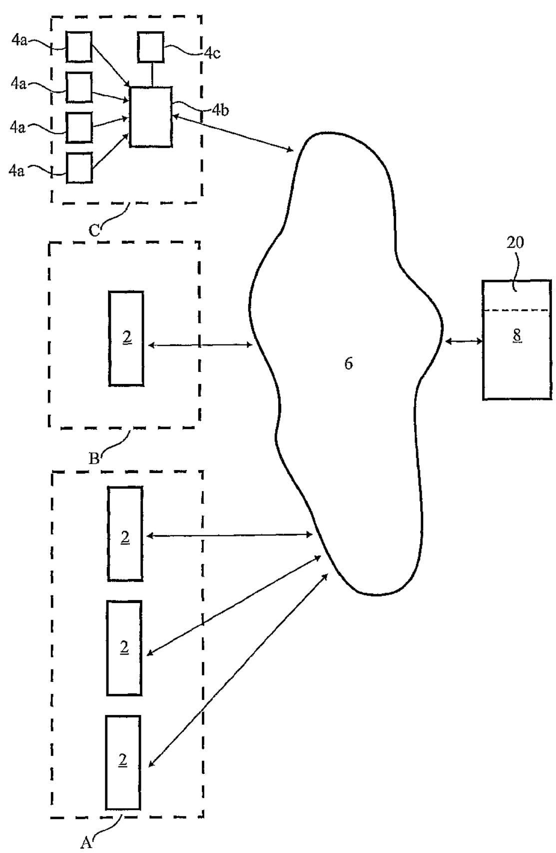
(54) Title: DISTRIBUTED ANALYSIS SYSTEM



(57) Abstract: A distributed analysis system comprises at least one analysis instrument (2; 4) for generating sample data from a sample at a local site (A; B; C) ; a storage means (8) holding a calibration library (20) at a site remote of the local site (A; B; C) ; and a data processor being integral with or separate from (4b) the analysis instrument (2;4) and which is adapted to determine a trait of the sample using a calibration model selected from the library (20) and the sample data. The data processor is sited at the local site (A; B, -C) and is connectable to the storage means (8) via a telecommunications link (6) , said data processor being further adapted to temporarily retain the selected calibration model received via the telecommunications link (6).

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Distributed Analysis System

Description

The present invention relates to a distributed analysis system and to a method for analysing materials employing said system. In particular the system and method relate to the optical analysis of materials to determine characteristics thereof.

Analysis instruments, such as optical, typically Near Infra Red (NIR), spectrophotometers, are employed in a wide variety of industries to analyse various material samples in order to make one or both of a quantitative or qualitative determination of various characteristics thereof, such as concentrations of constituents of the material and physical properties. In agricultural and food industries, for example, the oil, protein and moisture content of grain and other crops; the fat content of meat; the fat, protein, lactose and urea content of milk; the quality of grain and of wine and other vinicultural products; may all be determined using NIR analysis. Indeed, it is also known to apply similar NIR analysis in the medical, pharmaceutical, chemical and petro-chemical industries.

Such an optical analysis of samples is a so called 'indirect' determination because the optical measurements are only an indirect indication of the characteristic being determined. Results are typically obtained in a matter of minutes in contrast to the conventional 'direct', often chemical, analysis methods which may take hours or days to perform and which are often carried out at central laboratories remote from the site where the sample was taken.

Since the optical analysis is an indirect determination then a link must be established between the optical measurement and the characteristic or property of interest (hereinafter referred to as 'trait'). As is known in the art, the trait can be represented in an equation summing products of weighting coefficients and values from the derivative of the optical absorbance or transmission spectrum that is acquired by the analysis instrument. Typically, a first order derivative of an absorbance spectrum is used but higher order derivatives may also or alternatively be used. The undifferentiated absorbance (or in some cases transmission) spectrum and any or all derivatives thereof will be referred to jointly or severally as the context demands, as a 'sample spectrum' or more generally as 'sample data'. In order to measure the desired trait of an unknown sample then spectra need to be collected from a multiplicity of known sample materials similar to the unknown sample. The trait(s), be it a physical characteristic or a constituent concentration, to be determined are known in the known samples. Using the collected sample spectra obtained from the known samples and from the knowledge of the associated trait then the weighting coefficients of the equations relating the known trait to the collected spectra are determined by multiple regression, by partial least squares regression or by other statistical techniques including those employing artificial neural nets. This process of determining the values of the weighting coefficients is commonly known as 'calibration'. After the calibration coefficients have been determined the unknown sample can be analysed using the analysis instrument (or a one intended to be substantially identical in performance so that the same calibration coefficients may be applied) together with the calibration coefficient that have been derived from the known sample materials. Typically, in known instruments instead of measuring the spectral response at selected specific wavelengths which are known or are presumed to correlate with the trait, the sample spectra are collected at wavelengths distributed throughout the spectral region appropriate to the trait (most commonly the NIR spectral region) and coefficients and equations relating the trait to spectral measurements throughout that spectral region are developed. Calibration coefficients are required for each trait to be determined and for each type of sample material and are often collected in 'calibration libraries' for access and use by a data processor which is programmed to carry out the determination of the desired trait. Such calibration libraries may additionally or alternatively include the complete calibration equations, including the calibration coefficients, for use by the data processor. The term 'calibration model' is used to refer either jointly or severally to the calibration coefficients and the calibration equations associated with a particular trait, as demanded by the context in which it is employed herein. It is to be understood that similar methodology may be applied to other types of sample data that is generated using other indirect measurement modalities employed by other types of analysis instrument.

An analysis system which employs an NIR spectrophotometer is known from for example, US 6,751,576 of Hall et al. and from US 2003/0122080 of Burling-Claridge et al. (the contents of both of which are incorporated herein by reference), in which the data processor is located at a site that is remote of the analysis instrument and in which system a communication link is provided to permit data transfer between the analysis instrument and the data processor.

This known distributed analysis system is also provided with storage means which is also located at a site remote of the analysis instrument, typically collocated with the dataprocessor, and which retains a calibration library for access by and use in the data processor. The data processor is adapted to select an appropriate calibration model from the library in dependence on data received from a particular remote analysis instrument over the link and to then apply the so selected model to sample data which is also provided over the link. Using the same telecommunications link the trait determined as a result of the application of the selected calibration model is then provided back to the local site, preferably to an output device in the vicinity of the analysis instrument that generated the sample data. In this manner the library of calibration models can be maintained centrally which facilitates their upgrading, for example as new known samples are added or as statistical analysis methodology is developed. Moreover, as development of a calibration library is costly and time consuming then by holding the library centrally and remote of the user of an analysis instrument a greater control is afforded over the access to and use of the models of the library.

However, sample data such as an optical spectrum, even if compressed, represents a relatively large amount of data that must be transmitted over the telecommunications link. Measures must be taken to ensure that the link remains stable over the relatively long time required to transmit said data and to ensure that the so transmitted data is accurately represented at the central processor. Furthermore the analysis results to be transmitted over the often publicly accessible telecommunication link are sensitive information which, if mis-appropriated, may be used to the commercial disadvantage of the intended recipient.

Throughout this specification the word "comprise", or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated element, integer or step, or group of elements, integers or steps, but not the exclusion of any other element, integer or step, or group of elements, integers or steps.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is not to be taken as an admission that any or all of these matters form part of the prior art base or were common general knowledge in the field relevant to the present invention as it existed before the priority date of each claim of this application.

According to a first aspect of the present invention there is provided a distributed analysis system comprising:

a plurality of analysis instruments located at a local site for generating sample data from a sample at the local site;

a storage means at a site remote of the local site, the storage means holding a library of calibration models; and

a data processor adapted to determine a trait of the sample using a calibration model selected from the library and the sample data, the data processor being sited at the local site in operable connection with the plurality of analysis instruments to receive sample data therefrom and being connectable to the storage means via a telecommunications link, said data processor being adapted to temporarily retain the selected calibration model received via the telecommunications link.

According to a second aspect of the present invention there is provided a method of analysing a material sample at a local site comprising:

generating sample data using an analysis instrument located at the local site and comprising a plurality of sensors;

selecting a calibration model from a library of calibration models held at a site remote of the local site; and

employing the selected calibration model in a data processor at the local site connected with the plurality of sensors to determine a desired trait of the sample material using the generated sample data; the determination of the desired trait being performed at the local site and in that the selected calibration model being transmitted via a telecommunications link from the remote site to be retained temporarily at the local site for access by the data processor.As mentioned above, it is envisaged that the present invention is usefully applicable to many different types of analysis instrument which are employed in the indirect determination of material traits. However, the present invention has a particularly useful application with respect to NIR spectrophotometric analysis instruments and therefore in the following exemplary description references will be made to the instrument as a NIR spectrophotometer, especially in the context of the analysis of agricultural and food products.

Advantages associated with the system and the method according to the present invention will become apparent from a consideration of the following description of an exemplary embodiment thereof and made with reference to the drawings of the accompanying figures, of which:

Fig.1 shows a schematic representation of a distributed analysis system according to the present invention; and

Fig.2 shows a flow chart illustrating the method according to the present invention.

Considering now the distributed analysis system of Fig.1, as illustrated NIR spectrographic instruments 2,4 are provided at a plurality of separated local sites A,B,C, which may be any geographical locations in the world having access to the necessary telecommunications link, here the internet 6. Of course other telecommunications links, such as conventional telephone lines or wireless transceivers, that are capable of transmitting data between geographically separated sites may substitute for the internet

In order to exemplify, at least partially, the versatility of the distributed analysis system according to the present invention, then the example of Fig. 1 is illustrated with site A having a plurality (here 3) of individual instruments 2, each being separately connectable to the internet 6; site B having only a single instrument 2 identical to those of site A; and site C having an instrument 4 comprising a network of a plurality of separate sensor units 4a, each for generating sample data and all connected to a single data processor 4b which is provided with a connection to an output device 4c such as a display or a printer and a connection to the telecommunications link 6. It will be appreciated that the instrumenst 2,4 may be configured in a variety of different way to provide the functionality described herein and still remain within the scope of the invention as claimed. Thus the data processor 4b may for exaple comprise a server at the local site connected to a central data processor in the vicinity of the sensors 4a or the output device 4b.

A central storage means 8 is also provided as part of the distributed analysis system and is located at a site that is geographically removed from the local sites A,B,C. The central storage means 8 is configured for bi-directional communication with the analysis instruments 2,4 across the telecommunications link 6. The storage means 8 is, in this embodiment, a computer that is used to store and manipulate a centralised calibration library. The storage means 8 may, of course, comprise multiple computers, perhaps performing different functions (as discussed below) such as a communications function, a library update function and a calibration model selection function. However, such a combination will in practice be configured to behave as a single entity.

Considering now Fig.2 where a flow process is shown illustrating a method of analysing sample materials to determine a trait thereof by using the system illustrated in Fig. 1. It will be appreciated that all steps need not be performed in the sequence illustrated but rather the flow process is only generally illustrative of the steps to be undertaken and here also in connection with the embodiment of the system according to Fig. 1.

Firstly, at 10, the separate sensor units 4a or those integral within the analysis instrument 2 acquire sample data to be used in determining the trait. In the present embodiment the instruments 2,4 are NIR spectrophgraphic instruments so that the sample data refered to here will be a sample spectrum, recorded in a conventional manner. This sample data is, as shown at 12, passed to the data processor 4b or that data processor (not shown) intergral within the analysis instrument 2 where it is stored, either permenantly or temporarily.

In the present exemplary embodiment an information gathering step, 14 is then performed. It will be apparent from what is disclosed below that the information gathering step 14 may, in some embodiments, be omitted, for example where only one analysis instrument is employed to determine only one trait or a fixed, known set of traits.

The information may be gathered either automatically or entered manually by a user and, in the broadest application, identifies both the type of material being analysed and the individual instrument performing the analysis. For sake of example only, in the further discussion of the method of Fig.2 it will be assumed that each instrument 2 and sensor 4a has associated with it a unique identifier, such as a Globally Unique Identifier (GUID)or a barcode identifier, that may be automatically read and provided as an electronic signal and that information concerning the sample being analysed is entered manually by a user using a user interface such as a touch screen, a keyboard, a pointing device or any combination thereof. This user input sample information may for example indicate the particular variety of grain being analysed and the trait or traits to be determined.

In the present example the unique identifiers and the user input information may all be transmitted, in a next step 16, via the Internet 6 to the central storage means 8 at a remote site.

In the present embodiment, the central storage means 8 retains not only a calibration library 20 but also a database that indexes the identities of the analysis instruments 2,4 and possibly the individual sensors 4a that comprise an analysis instrument 4, as are obtained by the storage means 8 from the electronic identifiers transmitted to it, with a group or groups of calibration models (including for example a group comprising the entire library 20) from within the library 20 that may be made available to the so identified entity. In a next step 18 a calibration model or models, if available from the indexed group, is selected in dependence of the user input, in particular a one identifying a trait to be determined. An encrypted representation of this selected calibration model or models is transmitted back, in the next step 22, to the relevant data processor at the appropriate site A,B,C. The appropriate site and data processor may be readily identified from the instrument ID in the associated indexed database.

As a futher example of the versatility of the distributed analysis system of the present invention, as illustrated in Fig. 1, the storage means 8 is configured to hold as a portion of the library 20 a plurality of calibration models, each usable in the determination of the same trait but which is constructed, in a known manner as described above, using different collections of known samples. Thus, for example, site A and site B are each populated with essentially the same analysis instrument 2 to perform essentially a determination of the same trait. However, each site A,B is owned by a different entity and the analysis instruments 2 may be considered as belonging to independent networks at site A and at site B. The owner of site A has provided additional known samples to augment or replace those used in the generation of a generally accessible group within the calibration library 20 and so has had created a specific group of calibration models within the library 20. The owner of site A wishes access to this specific group to be restricted to only those instruments that are indexed as belonging to site A, whilst the owner of site B can access the same storage means 8 but have made available only calibration models that are indexed as belonging to the generally accessible group.

The owner of site C operates a processing plant converting grain to flour and has sensors 4a located at different parts of the local site C to monitor the process in real time. In this example the data processor 4b receives electronic identifiers that identify each of the sensors 4a individually and has an electronic identifier to identify the site B. It is this site identifier which is transmitted at 16 to the storage means 8. The library 20 of the present embodiment comprises also calibration models which are solely accessible to site C that are employed in there in the determination of not only traits of the grain but also traits of intermediate process materials as well as the quality of the end product, here milled flour. It is envisaged that in a further version of this embodiment, site C is provided with an automated process control system that is co-operably linked to the system according to the present invention. It can be readily appreciated that the process control system may be configured to provide instructions to the data processor 4b that cause a particular one of the sensors 4a to generate sample data. The data processor 4b may then be configured to provide the determined traits to the process control system for use in monitoring and varying the operation of the processing plant.

It can be appreciated that the storage means 8 may be readily provided with appropriate computer coding and indexed database such that an operator (typically independent of the owners of the local sites A,B,C) of the central storage means 8 can provide a service that satisfies the requirement of all such different owners.

On receipt via the internet 6 of the encrypted transmission according to the step illustrated at 22 the data processor, at a next step 24, attempts to decrypt the received decrypted model. If decryption fails, for example because of a corrupted tranmsmission, a transmission break or the erroneous receipt of a calibration model not indended for the site, then at step 26 the information is re-transmitted to the storage means 8 via the telecommunications link (here the Internet 6) according to step 16 and the steps 18-22 are repeated.

According to step 24, once the received encrypted calibration models are successfully decrypted they are temporarily retained in the data processor which is caused to execute appropriate determination software to perform, in a generally known manner, a determination of the desired trait or traits from the sample data which was acquired at the step 10 and stored at the step 12.

For example, the data processor 4b, say, of the analysis instruments 2,4 may be provided with a permenant data storage such as a hard disk and a temporary data storage such as an addressable volatile memory. Here the terms permenant and temporary are to be interpreted relative to one another in the context of the invention. The data processor is programmed to store the acquired sample data in the permenant memory and to hold the decrypted calibration model in the temporary memory. The determination software causes the data processor to retrieve the acquired sample data, here in the form of a sample spectrum in to a working memory and to access the calibration model.

Once the determination of the trait or traits is completed then, at step 28, the results are provided to a user, such as by displaying them at an output which may be intergral with (not shown) the analysis instrument 2 or a separate component 4c of the instrument 4. The results may also be retained in the permenant memory.

At this step 28 of the present embodiment the data processor, 4b say, determines wheter the received calibration model is to be removed from access by the data processor by erasing it from the addressable volatile memory.

It is envisaged that the data processor may be adapted to remove the calibration model dependent on other predetermined conditions being met. Thus for example, the data processor may be configured with a counter which may be an elapsed time counter or a usage counter, counting the number of times a determination has been performed according to the step 24, and adapted to remove the model at the earliest of reaching a predetermined count or when a software initiated 'shutdown' is performed to end an analysis session.

It is also envisaged that an update of the contents of the storage means 8, step 30, may be included in a method according to the present invention. This updating may, as illustrated, involve a modification of the calibration library 20 whereby the calibration models may be updated and new models added in order to expand the trait determination capabilities of the analysis system or may involve a replacement of the entire library. New users may be added to the indexed database or the access rights of existing users to the calibration models may be varied.

2006250020 29 Oct 2010

Claims

1. A distributed analysis system comprising:

a plurality of analysis instruments located at a local site for generating sample data from a sample at the local site;

a storage means at a site remote of the local site, the storage means holding a library of calibration models; and

a data processor adapted to determine a trait of the sample using a calibration model selected from the library and the sample data, the data processor being sited at the local site in operable connection with the plurality of analysis instruments to receive sample data therefrom and being connectable to the storage means via a telecommunications link, said data processor being adapted to temporarily retain the selected calibration model received via the telecommunications link.

2. A distributed analysis system as claimed in Claim 1, wherein the data processor is configured to transmit data to the storage means via the telecommunications link usable to select the calibration model.

3. A distributed analysis system as claimed in Claim 1 or Claim 2, wherein the data processor is adapted to temporarily retain the selected calibration model in an addressable volatile memory and to remove said model therefrom dependent on a predetermined condition being fulfilled.

4. A method of analysing a material sample at a local site comprising:

generating sample data using an analysis instrument located at the local site and comprising a plurality of sensors;

selecting a calibration model from a library of calibration models held at a site remote of the local site; and

employing the selected calibration model in a data processor at the local site connected with the plurality of sensors to determine a desired trait of the sample material using the generated sample data; the determination of the desired trait being performed at the local site and in that the selected calibration model being transmitted via a telecommunications link from the remote site to be retained temporarily at the local site for access by the data processor.

5. A method as claimed in Claim 4, wherein the method further comprises a step of transmitting data from the local site via the telecommunications link, said data being usable at the remote site in the selection of the calibration model from the library of calibration models.

6. A method as claimed in Claim 4 or Claim 5, wherein there is provided a step of removing the selected calibration model from access by the data processor up on fulfilment of a predetermined condition, selected to make access to the model by the data processor temporary.

7. A method as claimed in Claim 6, wherein the predetermined condition is the completion of a single determination of a desired trait.

8. A distributed analysis system substantially as hereinbefore described with reference to the accompanying drawings.

9. A method of analysing a material sample at a local site substantially as hereinbefore described with reference to the accompanying drawings.

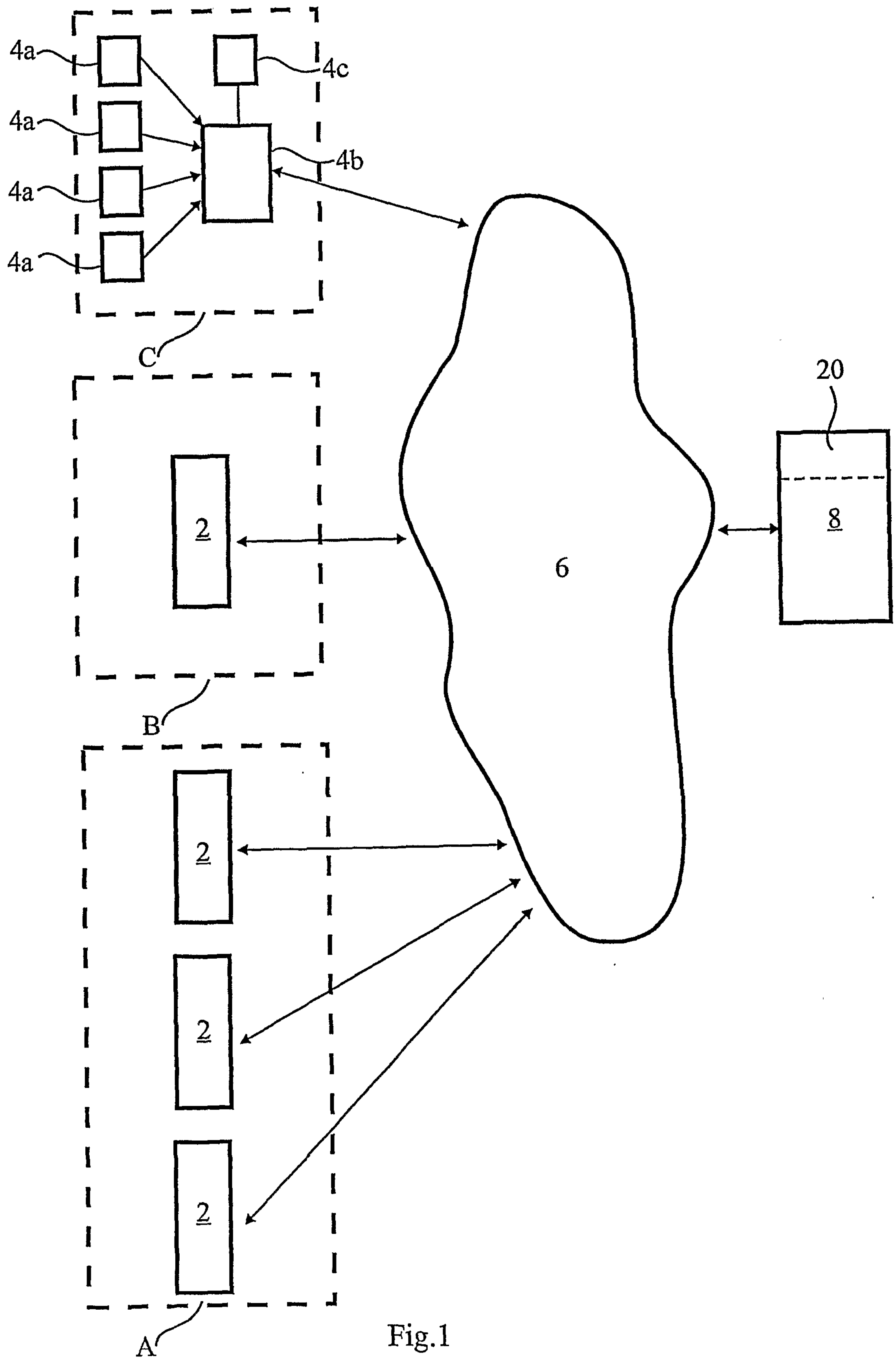

Fig.1

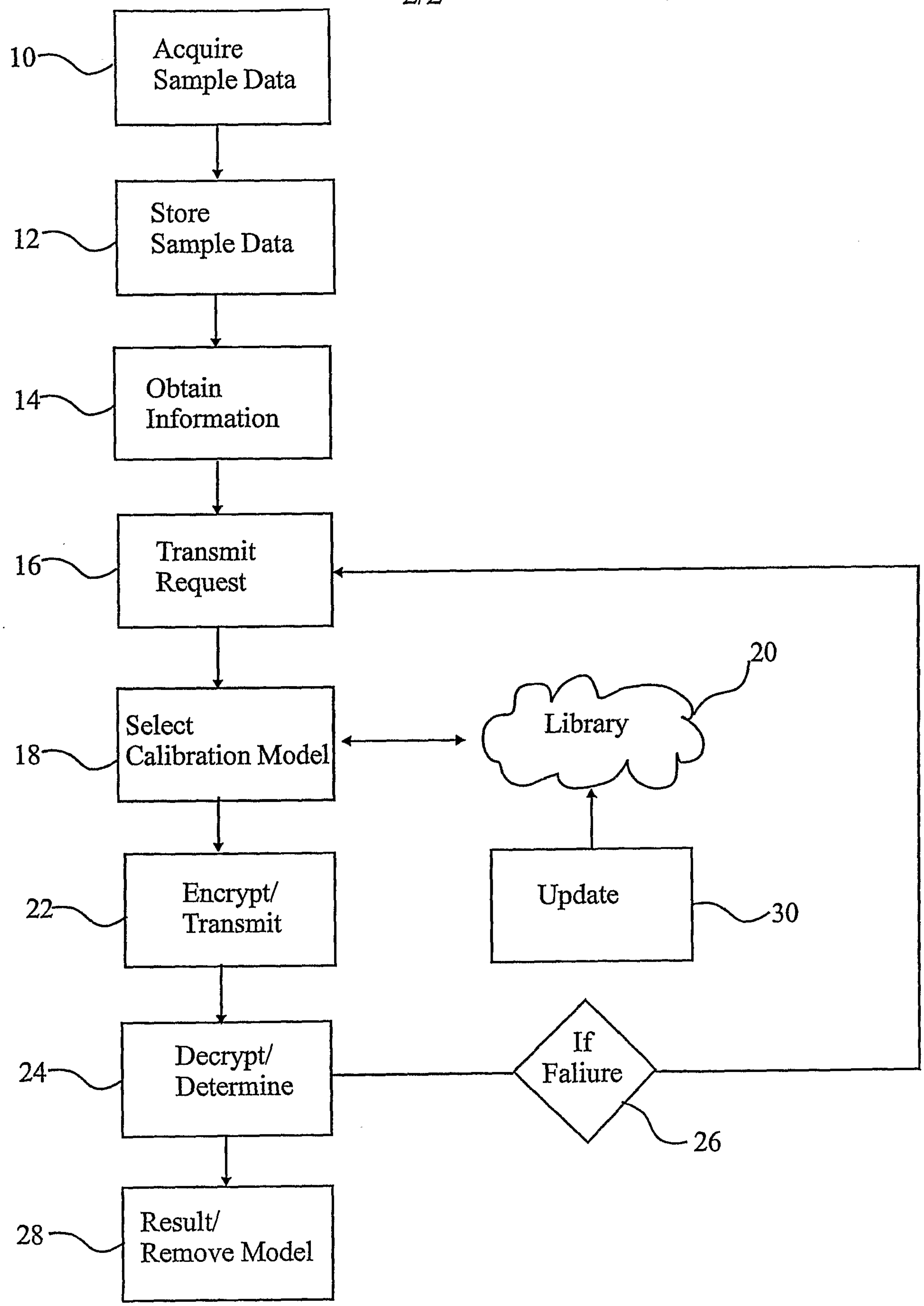
10
Acquire
Sample Data
12
Store
Sample Data
14
Obtain
Information
16
Transmit
Request
18
Select
Calibration Model
Library
20
22
Encrypt/
Transmit
Update
30
24
Decrypt/
Determine
If
Faliure
26
28
Result/
Remove Model

Fig.2