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(54) **Title**: A SENSOR MANAGEMENT SYSTEM

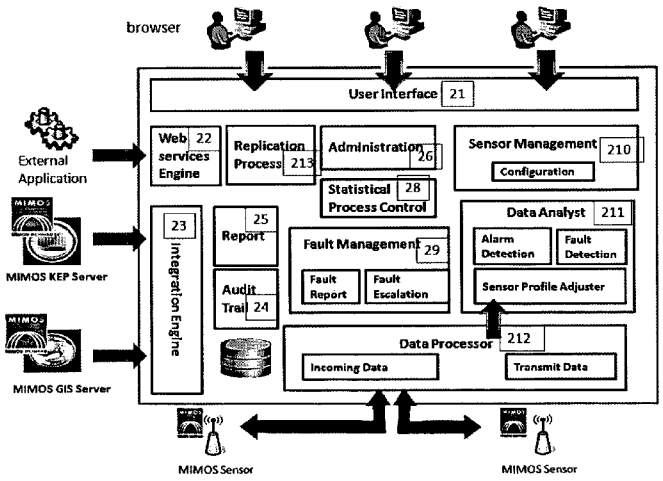

Figure 2

(57) **Abstract**: A web-based management system adapted for managing and displaying sensor data is provided for use such that necessary action based on trend and flow of the sensor data can be planned, said system including a user interface module (21) so as to establish interaction between a user and the system wherein said user interface being incorporated with AJAX (Asynchronous JavaScript and XML) features, a plurality of engine modules (22,23) being operatively integrated with one or more external applications and the user through user interface whereby data/information from one or more external applications is received by said engine modules (22,23) and a statistical process control module (28) adapted to display received data/information and additionally displaying one or more previously recorded data.

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A SENSOR MANAGEMENT SYSTEM

FIELD OF INVENTION

The present invention relates to a sensor management system deployed in an agricultural environment. In particular, the invention is concerned about a web based sensor management system for managing and displaying all the sensors data in agricultural industry.

BACKGROUND OF INVENTION

In modern agricultural industries/scenario, accuracy and perfection is essential. Accurate record keeping, gathering of accurate data, automated mapping, and precision agricultural techniques have all become crucial factors for improving overall agricultural system. The accurate application of herbicides, pesticides and fertilizers is an essential component of modern precision agricultural methodologies. With the development of computer science and web technology the scientist and researchers are in a hunt of fulfilling the requirement as to whether such applications are performed by aerial or terrestrial techniques, advanced tools that provide highly accurate navigation and guidance information for operators.

Moreover, even though these limited precision agricultural methodologies have become popular with the commercialization of GPS systems and Web systems/technologies, to date such methodologies have not included the use of AJAX (Asynchronous JavaScript and XML) in user interface in a precision agriculture management system.

Thus there is a need to provide for a web based sensor management system for managing and displaying all the sensors data on agricultural industry sent in by sensors and plan necessary action based on the trend and flow of the sensor data.

SUMMARY OF INVENTION

Accordingly there is provided a web-based management system adapted for managing and displaying sensor data such that necessary action based on trend and flow of the sensor data can be planned, said system including a user interface module so as to establish interaction between the user and the system wherein said user interface being incorporated with AJAX (Asynchronous JavaScript and XML) features, a plurality of engine modules being operatively integrated with one or more external applications and the users through user interface whereby data/information from one or more external applications is received by said engine modules and a statistical process control module adapted to display received data/information and additionally displaying one or more previously recorded data.

The present invention consists of several novel features and a combination of parts hereinafter fully described and illustrated in the accompanying description and drawings, it being understood that various changes in the details may be made without departing from the scope of the invention or sacrificing any of the advantages of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will be fully understood from the detailed description given herein below and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, wherein:

Figure 1 illustrates the overall flow diagram of the precision agriculture management system of the present invention.

Figure 2 illustrates an architectural diagram of the precision agriculture management system of the present invention.

Figure 3 illustrates incoming process flow and data analyst flow of the precision agriculture management system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention relates to a Precision Agriculture Management System (PAMS) solution using web technology whereby all the accessibility to PAMS is through (Hypertext Transfer Protocol) HTTP connection on agriculture type of system. PAMS is highly configurable and able to incorporate commercial sensor or in house developed sensors. PAMS is also able to be implemented on different operating system. Database in PAMS is also easily configurable in the properties on which database it can be used. Web services module (22) in PAMS can be configurable whereby the services offered to the external applications can easily be enabled or disabled.

The PAMS is designed to display and manage sensors deployed on agriculture environment. The system consists of multiple components that interlink with each other internally. Any component that requires database storage will be sharing the same database which is deployed along with the PAMS installation. From Figure 2, PAMS shows that it's able to receive the sensor data from sensor through the data processor (212). After the sensor data is received, the sensor data will then be sent to data analyst module (211) in order to apply the correction factor, screening for alarm data or potential fault data and stored in the database.

PAMS is able to display these sensor data to user on a web environment through a web browser through HTTP connection. With this architecture in place, user will no longer require dedicated software to access system to manage and to view data unlike typical telecommunication network system. PAMS utilizes the AJAX (Asynchronous JavaScript and XML) technology to provide a similar user experience as conventional

client software environment. This will also help to increase the system performance comparing with the conventional web page.

PAMS is flexible to add any sensor type and display the sensor reading on the PAMS User Interface (21). For example, PAMS is currently preloaded with Nitrate, Potassium, Phosphorus, Moisture, and temperature and battery sensor type. There is also a proviso of interfacing PAMS with sunlight sensor or environmental sensor such that these two sensors can easily be included through the configuration and restart the system. All these changes required no source code changes on PAMS. The system is capable of working with multiple databases and can be installed on any operating system for ease of deployment to customer with various technologies.

In order to locate the exact location of the sensor topology on plantation, the system of the present invention comprises a visual display feature called a device map. In the device map, the system will display the exact location of a sensor and also highlight the exact location of the router(s). Once user clicks on the sensor in the device map, user can be directly linked to the sensor data on the grid table listing. It will be able to help user on reducing navigation time spent on locating the right sensor(s).

In said device map, PAMS is able to display the sensor information like hardware version or firmware version once the users mouse over on the sensor. The latest sensor data on device map can be viewed if the corresponding sensor tab is clicked. With the device map in place, it is possible for the user to locate the exact sensor node that is having problems from PAMS' Fault Report. In the PAMS Fault Report, user can

display the location of the sensor if they click on the "Show on Device Map" button. This will definitely help to reduce time to locate the exact location of the sensor if there is a lot of sensor on a bay.

The system is based on Service-oriented architecture (SOA) and is easily extendable with the use of web services. Users can extend PAMS features in their own application by leveraging PAMS' web services. For example, PAMS is able to display the total alarm count on a certain bay or nodes; total number of sensor node on PAMS etc. External application will be able to invoke the web services with the Web Services Description Language (WSDL) file given. Thus, there is proviso of providing sensor data to any potential mobile device like Jen-II.

For all these web services, there is a screen offering an option for user to enable or disable the web services for external access. With this management screen, PAMS will have better control on the integration process with external devices. This is also to enable PAMS to have the capability to restrict the access to certain sensitive data.

The system of the present invention displays the network relationship between sensor(s) and router(s). This allows the user to manage the relationship easily between the sensor and router. The system will be able to setup the multiple sensor(s) connecting to a router and display the visual relationship on device map. This is helpful when certain information specific to the identification of the router or the sensor is insufficient to establish the relationship between the router and sensor; the system is able to match these sensor and router.

PAMS has incorporated Statistical Process Control (SPC) chart in order to display the pattern of the sensor data received by PAMS. SPC is an effective method of monitoring a process through the use of control charts. By collecting data from samples at various points within the process, variations in the process that may affect the quality of the end product or service can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. PAMS uses the 3σ formula to calculate Upper Control Limit (UCL) and Lower Control Limit (LCL) on all the sensor data. This is the first SPC of its kind to be designed in an agriculture environment.

The system displays the sensor data reading in a tabular format as well as through charting technology to provide more comprehensive information related to trends of the sensor over time. The visual chart is scrollable between each data points. The next 30 data points can be seen by clicking the button on the chart to display those data.

Another embodiment of the present invention describes an alarm management in PAMS which is rules based controlled. Each sensor data sent to the system will be filtered and screened for any potential error or suspicious condition. If the sensor data doesn't fulfill the conditions pre-set on the table by user, it will be classified as the alarm data and will be highlighted to user in the system.

For example, battery data sent by sensor will be monitored by referring to the value set in a Threshold Table. If the battery reading range is not within the range set in the

table, the system will alert the user. This rules-based system is generic and is also able to support other sensor type such as moisture, nitrate or even sunlight sensor.

The system further comprises an escalation flow where problems and resolution can be documented. Users can use this system to indicate a corrective action or escalate the problem to his supervisor if the problem is beyond his capability to resolve. PAMS has both built-in Short Message Service (SMS) and email capability. During the escalation process, PAMS is able to inform the user quickly through the use of SMS with transmitter engine running on back end. Additionally, the user is also able to send an email notification to his superior.

The PAMS comprises of an audit trail feature for data modification monitoring process. All the changes in the data can be tracked in the database such as INSERT, DELETE or UPDATE operation throughout the entire system. Eventually, this entire modification event will be stored and recorded on a different table and shown to user.

PAMS can be deployed as a local system (LPAMS) on a plantation or as a global system (RPAMS) managing other Local PAMS (LPAMS). Local PAMS has the scope of controlling of a local plantation. Remote PAMS can interface with multiple local PAMS to provide a remote user with on current site information of all plantations base on adjustable update cycle. Currently the replication time is set to every 30 minutes. The main objective for this setup is to enable to user in LPAMS to easily access the system irrespective of the internet connectivity or performance. These two deployments are identical and there are no differences in terms of UI or database schema.

To maintain data consistency between LPAMS and RPAMS, replication process is required. PAMS' replication is unique as we are controlling the data consistency using 4 extra table columns which is rplFlag, rplCount, localId, lpamsId. These table columns are to improve the replication process, identifying the data priorities, indicate the original data identification (id) locally and to highlight which source the data is coming from. PAMS' replication is considered passive replication, each single request is processed on a single replica and then its state (rplFlag) is transferred to the other replicas.

PAMS allows users to fine tune any sensor type or a specific sensor to account for sensor hardware variation through time and temperature with the implementation of sophisticated user interface and formula parser. User can easily enter a formula to correct the sensor data base on drift correction, temperature compensation and parts per million (ppm) conversion on the same screen without conflicting each other.

Figure 1 shows an overall flow diagram of the system of the present invention. The various modules and features of the system of the present invention will now be described with reference to the figures.

Referring to figure 2, user interface module or UI (21) is the main user interface and layout for the PAMS user to see. User will be able to interact with the system through this component. The user interface (21) is only viewed through the web browser like Internet Explorer or Mozilla Firefox. In order to make the user interface (21) more interactive, the AJAX (Asynchronous JavaScript and XML) features have been

incorporated in PAMS. Web service engine module (22) enables PAMS to integrate with any external application. With this, the engine module (22) will have common WSDL (Web Services Description Language) for user to enquiry any sensor data. PAMS' web services can be enabled or disabled as per configured depending on usage. PAMS Web Services Client is the sample application that utilizes the web services features in PAMS. The system further comprises integration engine module (23) shown in figure 2, which is used to integrate other application servers internally. PAMS will accept parameters from these two applications and display the chart on their system accordingly. For any integration, it requires these parameters to be passed to PAMS; home URL, user id, bay id, and alarm type or action value. In figure 2 an audit trail module (24) makes a duplicate copy of the original copy as a backup copy without the user knowing it when the user wants to change the data in the PAMS system. The system utilizes the database Trigger features. Once the Relational Database Management System (RDMS) detects any potential changes on data, it will then duplicate a copy of the original data to another table. Thus, each table in PAMS will have a duplicate table with [table_name] _audit naming convention. A reporting module (25) of the PAMS comprises of a data report to display all the incoming sensor data. The SPC Chart is included in the data report to display the pattern or the trend of the sensor data. On top of these, the battery reading chart is also there. The report module (25) also includes an alarm report and a data report.

An administrative module (26) changes the user information which is related to PAMS such as mobile number (for alert notification), supervisor name and ID.

Statistical processing module or SPC (28) displays a data grid and the user is able to display the trend of the data point as specified by him. The processing module (28) is designed such that 30 previous data point will be displayed when a user clicks on a single sensor data display on the PAMS grid listing. On the back end, the system will capture the data point's information such as sensor type (Nitrate, Phosphorus, Potassium, moisture, temperature or battery reading) and date.

After that, PAMS calculates the σ (sigma) value of that data point using this formula:

$$\sigma = \sqrt{[\Sigma (X - \text{meanValue6})2]/ n-1}$$

$$3\sigma = 3 * \sqrt{[\Sigma (X - \text{mean Value}) 2]/ n-1}$$

Upper Control Limit = mean Value + 3σ

Lower Control Limit = mean Value - 3σ

mean Value = average value of data point selected by the user

n = number of sample we are collecting, which is 30.

For example, when a data point of the sensor type of Nitrate is clicked by the user, for a date of 15th January 2008, the mean value (average reading of previous 30 reading), Upper Control Limit, Lower Control Limit is generated by the system.

A PAMS Statistical Process Control (SPC) chart (SPC) displays the sensor data. If user is interested to see the SPC Chart, a data point is clicked to show the PAMS SPC Chart. With this chart, the trend and pattern of the data points can be seen.

As illustrated in Figure 2, the system further comprises fault management module (29) and sensor management module (210). Fault management module (29) is adapted to display all the suspicious sensor data or the alarm data. User is able to perform a selection of choice on the top search menu. This is to enable the user to verify any possible problem on the sensor via the data sent in by the sensors. The sensor module (210) is adapted to configure and set the node information. User is able to configure the sensor tip, sensor code etc in here. A data processor module (212) includes a transmitter to transmit any command from PAMS back to sensor. A data analyst module (211) is one of the back end process module.

Figure 3 shows that when the data processor module (212) in PAMS receives the sensor data, it triggers the data analyst module (211) automatically. In this module, raw sensory data with a specific format and binary segments will be analysed by verifying that the data received is in compliance with the expected format. Once the data has been analysed, the sensor data will be checked for fault data contained within the sensor data string which was sent. The sensor data will be cross-checked to confirm if the variance between the previous sensor readings and current sensor readings is more than 20 %. The sensor type data is also checked at this stage for any invalid zero (0) value. It is also verified at this same stage that all other sensor type data readings are valid. Any sensor data that does not conform to these predetermined conditions will be deemed invalid and stored into an Alarm Table. Subsequently, alarm data

verification is conducted where the system cross-checks all sensor data with a preset Threshold Table to identify sensor alarm data. For example, user has set the sensor type A to only accept a variance of sensor data readings from 10% to 40%, but the sensor data that was received has a higher variance of more than 40% in its readings. The setting of acceptable variance can be done in the Threshold Table by the user based on his requirements. Thus, the system stores these invalid data into the Alarm Table. Once these processes are done, the valid sensor data that has been verified will be stored in the PAMS database and displayed to the user. The sensor data stored in the Alarm Table is also displayed to the user.

Replication process module (213) is adapted for replication process from LPAMS to RPAMS. This process happens every 30 minutes and the purpose is to make sure RPAMS will have the latest data on each LPAMS.

The sensor management system can be adapted to be applied for agricultural industries, telecommunications and industries which relate to sensor technology and the like.

CLAIMS

1. A web-based management system adapted for managing and displaying sensor data such that necessary action based on trend and flow of the sensor data can be planned, said system including:

a user interface module (21) so as to establish interaction between a user and the system wherein said user interface being incorporated with Asynchronous JavaScript and XML (AJAX) features;

a plurality of engine modules (22,23) being operatively integrated with one or more external applications and the user through user interface whereby data/information from one or more external applications is received by said engine modules (22,23); and

a statistical process control module (28) adapted to display received data/information and additionally displaying one or more previously recorded data.

2. The system as claimed in claim 1 wherein said engine modules comprise web service engine (22) and integration engine (23).

3. The system as claimed in claims 1 and 2 wherein said web service engine (22) is adapted to pull data from the system corresponding to the enquiry of the user for any particular sensor data.

4. The system as claimed in claims 1 and 2 wherein the integration engine (23) is adapted to be integrated to application servers internally such that parameters can be accepted by the system.

5. The system as claimed in claim 1 wherein said statistical process control module (28) is adapted to capture 30 previous data points when a particular sensor is clicked.

6. The system as claimed in claim 1 further comprises a means for visualization of sensor network and sensor.

7. The system as claimed in claim 6 wherein said means comprises device mapping feature so as to locate exact location of sensor topology.

8. The system as claimed in claim 6 further comprising an audit trail module (24) adapted to make duplicate copy of original copy as back up copy without any knowledge of the user, wherein said audit trail module (24) is further adapted to track changes on data in a database such as INSERT, DELETE OR UPDATE operation.

9. The system as claimed in claim 8 further comprising a report generating module (25) adapted to prepare data report to be displayed for all incoming sensor data.

10. The system as claimed in claim 8 further comprising a plurality of management modules (29, 210), wherein management modules comprise a fault management module (29) which is adapted to display all suspicious sensor data and/or alarm data and a sensor management module (210) adapted to configure sensor tip, sensor code and the like.

11. The system as claimed in claim 10 further comprises an escalating means adapted to indicate corrective actions or escalate any problem, wherein said escalating means comprises a built-in-sms and / or email facility.

12. The system as claimed in claim 10 additionally comprises a sensor profile adjuster adapted to fine tune any sensor type or a particular sensor.

13. The system as claimed in claim 10, wherein a data analyst module (211) analyses and verifies sensor data to be in compliance with required format and cross-checks for Fault Data by comparing previous sensor data readings and current sensor data readings to be not more than 20% variance.

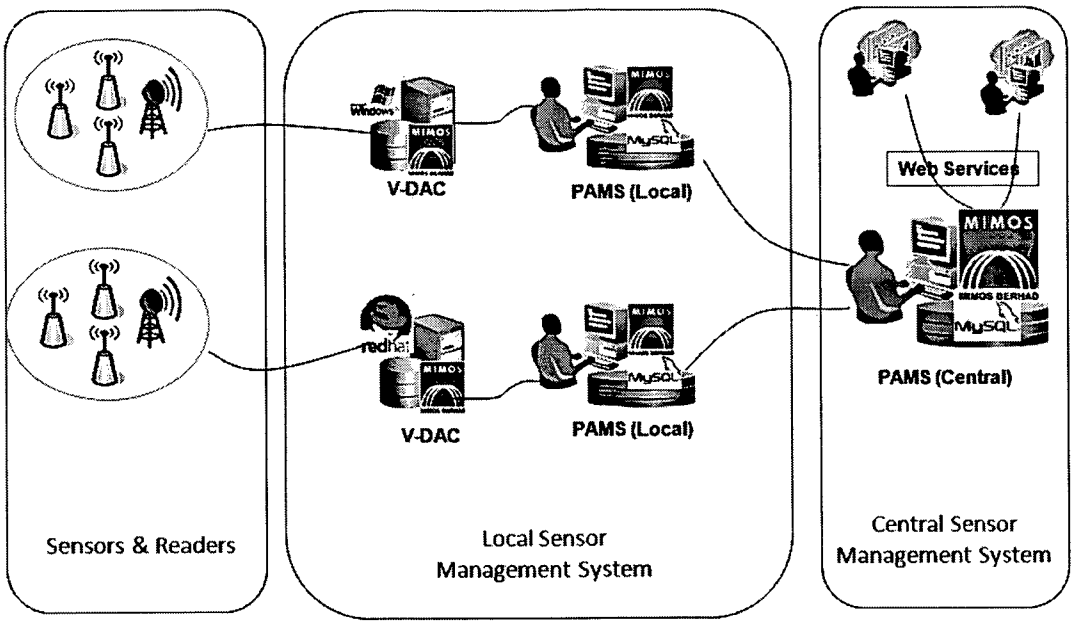

Figure 1

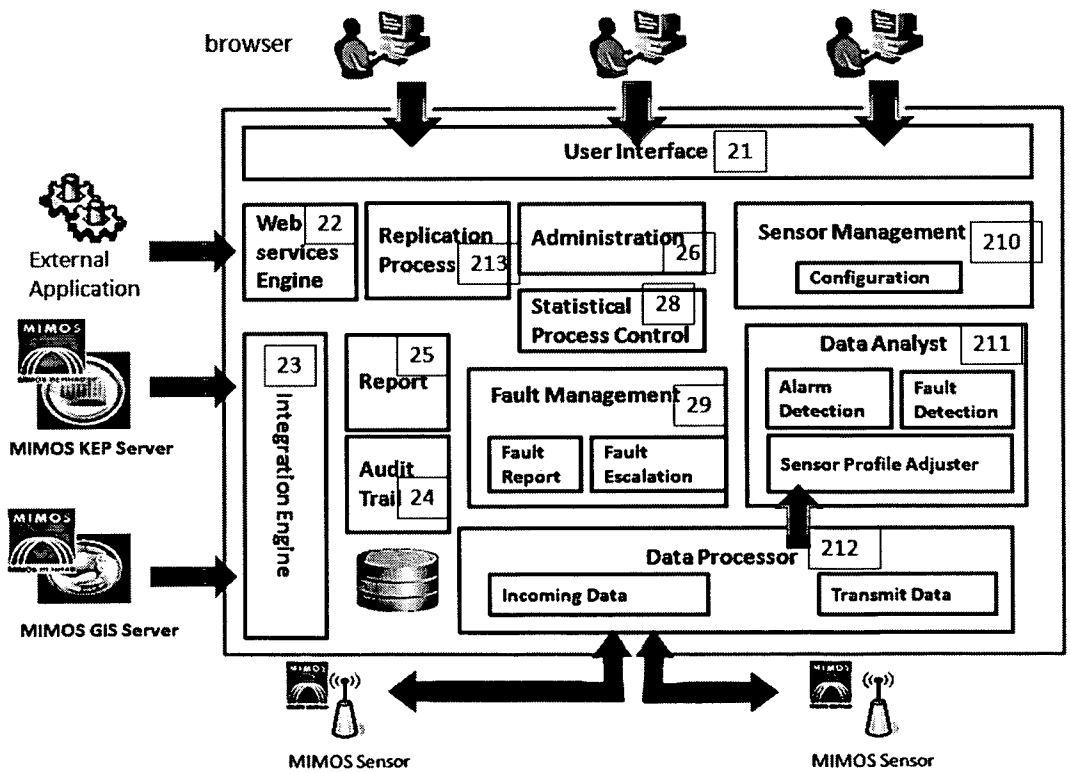

Figure 2

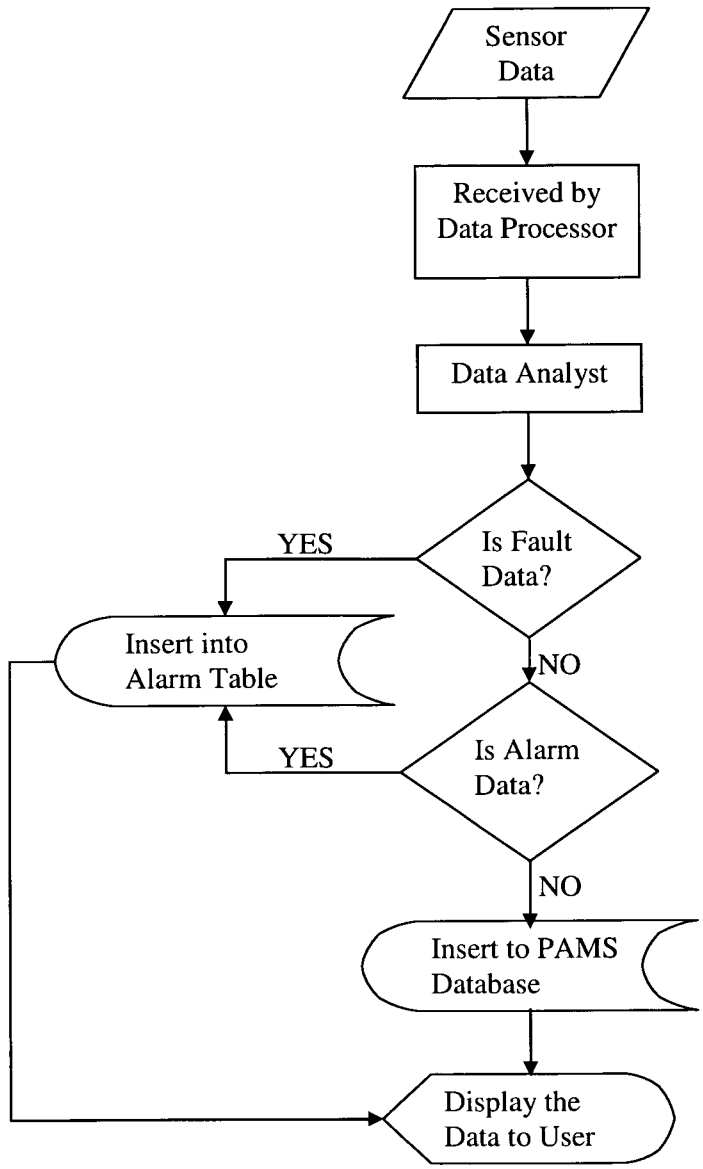
Sensor Data
Received by Data Processor
Data Analyst
Is Fault Data?
YES
NO
Insert into Alarm Table
Is Alarm Data?
YES
NO
Insert to PAMS Database
Display the Data to User

Figure 3