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Applying RFID Hand-Held Device for Factory Equipment Diagnosis

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***Abstract*—This paper proposes a new Hand-held Device application that incorporates an RFID with monitoring system with a fuzzy-rule-based inference into a Hand-held Device. The designed process follows: firstly, the machine status is displayed in the monitoring system, and when the machine has some problems, PDA users are informed; then, the PDA users can obtain information from the tags by PDA reader and use the fuzzy rules to infer the reasons of breakdown and which part of this machine should be repaired. By means of that the breakdown machine can be repaired immediately when PDA users are informed. After repairing the machine, the new rule is transmitted to other PDA users and central database by replication. This paper shows that applying RFID hand-held device in factory equipment diagnosis can make a big increase on work efficiency.**

***Keywords*—RFID, Equipment Diagnosis, Fuzzy Rules, PDA**

I. INTRODUCTION

Effective information collection is essential for successful diagnosis of the highly automated manufacturing and maintenance facilities. Radio Frequency Identification (RFID) systems have been widely used in these facilities for control and diagnostics for thousands of machines, vehicles and products. This paper proposes an application that uses RFID systems, networks, fuzzy-rule database with a hand-held device which communicates with operators. Fast networks, RFID systems and powerful monitoring systems allow the analysis of data at central monitoring computers and may save extensive information about the operations. Therefore, Engineers will be able to receive detailed information and maintain any equipment in the facility with their PDAs by using fuzzy-rule inference database and RFID system.

Radio Frequency Identification (RFID) is a technology for automated identification of objects and people. Human beings are able to identify objects in a variety of situation or environment, for example, a bleary-eyed person can easily pick out a cup of coffee on a cluttered breakfast table in the morning. However, a computer vision performs such tasks poorly. RFID may be viewed as a means of explicitly labeling object to facilitate the "perception" by computing devices.

A typical RFID system includes some components: an antenna or coil, a transceiver (with decoder) and a transponder (RF tag) electronically programmed with unique information. Radio signals are transmitted by an antenna in order to activate the tag such that data can be read and written to it (Domdouzis et al., 2007).

In general, modern RFID systems include three major components (Srivastava, 2008).

(1) Tags: they are composed of a microchip for storage and computation, and a coupling element, such as an antenna coil for communication.

(2) Readers: an RFID reader is a device that interrogates an RFID tag. The reader has an antenna that emits radio waves; and the tag responds by sending back its data.

(3) Database: The RFID reader contains a networking element such as wired Ethernet or wireless Ethernet that connects a single RFID-read event to a central server. The central server runs a database application, with functions that include matching, tracking, and storage.

The fuzzy set theory, introduced by Zadeh is an efficient technique to deal with ambiguous and vague problems. Its ability to handle problems with uncertainties lead to its wide applications in engineering control systems (Chatterjee et al., 2008). Fuzzy logic is basically a multi-valued logic that allows intermediate values to be defined between conventional evaluations like yes or no, true or false, black or white, etc. Notions like rather warm or pretty cold can be formulated mathematically and algorithmically processed by computers (AAAI, 2008). Through this way, an attempt is made to apply a more human-like thinking in the programming of computers. Fuzzy logic systems address the imprecision of the input and output variables by defining fuzzy numbers and fuzzy sets that can be expressed in linguistic variables (xs4all, 2008). They use linguistic IF-THEN- constructions that have the general form "IF A THEN B" where A and B are propositions containing linguistic variables. A is called the premise and B is the consequence of the rule. The use of linguistic variables and fuzzy IF-THEN- rules exploits the tolerance for imprecision and uncertainty. In this respect, fuzzy logic mimics the crucial ability of the human mind to summarize data and focus on decision-relevant information. In general, composite fuzzy production rule is classified into several rule types (Gao et al., 2003). The rule type of "AND" connection is used to describe the antecedent proposition. The certainty factor value is designed to reflect the way the experts think (Addison et al., 2002; Qu et al., 2003; Ting et al., 2008).

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II. Overview of the System

In general, when the junior engineers start to learn how to repair the failure equipment and which part causes this failure, they always follow the senior engineers. They could only ask the senior engineers when some problems happened in the equipment. In addition, the senior engineers usually repair the failure equipment according to their own experience or few error messages, but they could not perpetually remember all the failure conditions. Therefore, important information and knowledge about the failure equipment may not be recorded efficiently. To solve these problems, this study designs an RFID hand-held device application to help the engineers to repair and infer the failure equipment.

First, the administrator can monitor the area status by central monitoring system. The performance of each area or equipment are collected through the monitoring system such that the administrator perceive the detail information about each equipment, such as the output range between mean value +1 or +2 standard deviation and mean value -1 or -2 standard deviation in the monitoring system and the three dimension analysis chart, to prevent the equipment from failure. When they find the unusual status, they can send the warning message to the engineers by this monitoring system. Therefore, the engineers can receive the warning message by cell phone or PDA. If they are not in the wireless environment, they still receive the message by cell phones due to the General Packet Radio Service (GPRS). If they are in the wireless environment, they can receive the message by the PDA. Secondly, the engineers can use the cell phone or PDA to examine which equipment has some problems. When they find the failure equipment, they send out the message to the administrator to indicate the found of the failure equipment and no need of redundant message. Thirdly, the historical status for all parts can read through the RFID tag to infer which part causes this failure. If historical status shows the possibility of all parts, systems can calculate the probability of each part that has problem. As a result, they can know the failure reason and repair the equipment by the RFID hand-held device immediately. Therefore, engineers do not need to remember all the failure conditions, but would be able to examine and repair the failure equipment quickly. Forth, with the proposed system, engineers can analyze the status by the XY-Plot chart, Area chart, Radar chart and Bar chart in the PDA application. In addition, if they find the new condition, they can add the new fuzzy rule in the database and then synchronize the database by communications between the PC and PDA. Finally, when engineering finish examining, they can send out the message to the administrator indicating that they finish examining.

III. Implementation of Fuzzy Rule

First, this study defines the membership function. The ANELVA SiGe UHVCME equipment is considered in the following sample. There are four parameters, including base pressure, typical process pressure, temperature, and heating rate, in the ANELVA equipment. Each parameter can sub-divided into three areas such as low area, medium area and high area. For simplicity, triangular membership function is adopted to present it.

The following formulas are each parameter's member function and output function.

$$\text{Base Pressure: } bpmf(x) = \begin{cases} (40-x)/40, & 0 \le x \le 40 \\ (x-20)/30, & 20 \le x \le 50 \\ (80-x)/30, & 50 \le x \le 80 \\ (x-60)/40, & 60 \le x \le 100 \end{cases} \quad (1)$$

$$\text{Typical Process Pressure: } tppmf(x) = \begin{cases} (70-x)/70, & 0 \le x \le 70 \\ (x-40)/60, & 40 \le x \le 100 \\ (160-x)/60, & 0 \le x \le 160 \\ (x-130)/70, & 0 \le x \le 200 \end{cases} \quad (2)$$

$$\text{Temperature: } tmf(x) = \begin{cases} (450-x)/50, & 400 \le x \le 450 \\ (x-430)/70, & 430 \le x \le 500 \\ (570-x)/70, & 500 \le x \le 570 \\ (x-550)/50, & 550 \le x \le 600 \end{cases} \quad (3)$$

$$\text{Heating Rate: } hrmf(x) = \begin{cases} (120-x)/120, & 0 \le x \le 120 \\ (x-70)/80, & 70 \le x \le 150 \\ (230-x)/80, & 150 \le x \le 230 \\ (x-180)/120, & 0 \le x \le 300 \end{cases} \quad (4)$$

$$\text{Output: } otmf(x) = \begin{cases} (40-x)/40, & 0 \le x \le 40 \\ (x-20)/30, & 20 \le x \le 50 \\ (80-x)/30, & 50 \le x \le 80 \\ (x-60)/40, & 60 \le x \le 100 \end{cases} \quad (5)$$

Then, fuzzy rules are generated based on expert's experience in the database. Engineering can download the fuzzy rule database into the PDA to help to find the possible reasons and calculate the probability of each part that causes this failure. After examining the equipment, we add the new fuzzy rules in the database and synchronize it.

IV. Application Design

This study designs a hand-held device application, which incorporates a fuzzy-rule-base inference with RFID with monitoring system in hand-held device for the semiconductor manufacturing equipment. The entire system was written in Visual Basic language and ran under the WINDOWS XP platform.

If some problems happen in one of the area during checking, the proposed system shows the different colors (red) on the screen as shown in Figure 1. Then engineers are informed to examine all the equipments in this area when some problems happened. When the engineers finish repairing the equipment, the proposed system receive the responded message from the engineers indicating that they finish repairing.

Figure 1. Area status screen in PC

If engineers want to see the detail of the area, they can enter this screen shown in Figure 2 (Thin film status screen). By means of that, they can realize the performance of equipment in the scatter chart. The proposed system keeps track of all the performance of equipment immediately. The proposed system also presents the output range between mean values +1 or +2 standard deviation and mean values -1 or -2 standard deviation in the monitoring system shown in Figure 3.

Figure 2. Thin film status screen in PC

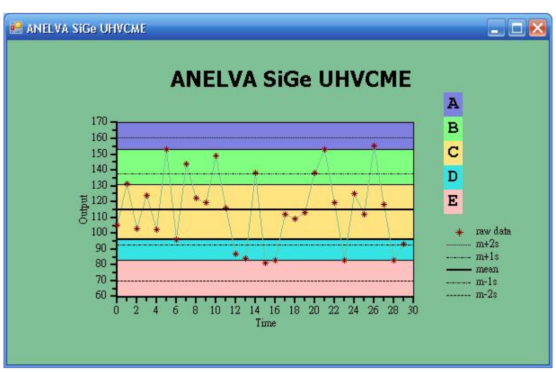

Figure 3. The detail history status of ANELVA XY-Plot

The designed system reads the historical status of all parts by RFID reader to infer which part might have some problems. It can further monitor the progress by the progress bar at the bottom of the read status screen (Figure 4).

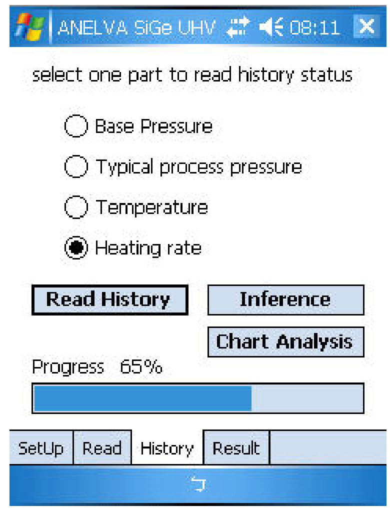

Figure 4. Read status screen in PDA

The engineers can enter the chart analysis screen to select chart types, such as XY-Plot chart, Area chart, Radar chart and Bar chart, and to select equipment part as shown in Figure 5. They are history status of all parts which were read by RFID hand-held device.

The engineers can also examine the equipment by the probability as shown in Figure 6 such that they can repair the failure equipment with more accuracy. This design can significantly enhance the work efficiency. If they find the reason that differs from the suggestion after repairing it, they can select a correct reason from the possible reason and save it into the system. Accordingly, they can add a new rule selected from our database and synchronize to all the databases. When other equipments have similar status in other FAB, the engineers can use the new rule table to examine the equipment and to infer their equipment breakdown.

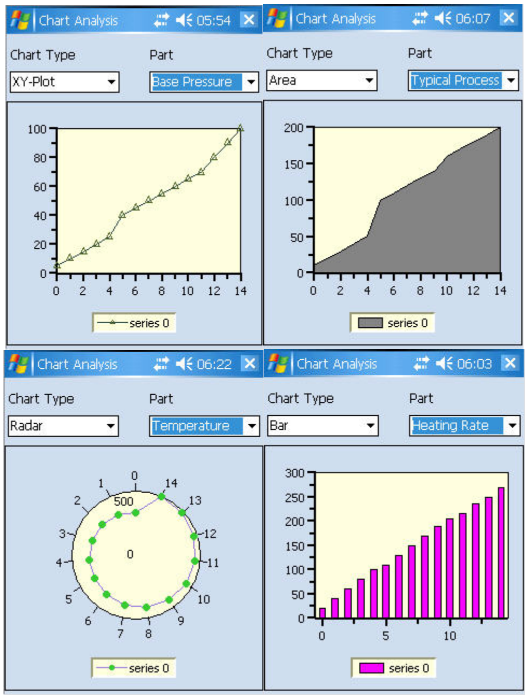

Figure 5. Status chart

Figure 6. ANELVA suggestion with probability

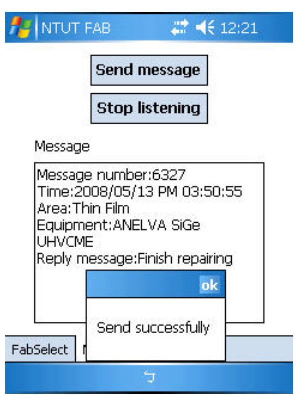

Figure 7. Message screen

The engineers can get a warning message and know the detail of the warning message such as equipment name, failure time and so forth as shown in Figure 7. After repairing it, they can also send the result message to the central monitoring PC to enable administrators to go a step further.

In addition to PDA, the proposed system also applies an RFID cell phone in the FAB. Sometimes the engineers are not in the FAB or they can not receive the wireless signal by the PDA, then the administrators can send the warning messages through the engineers' cell phone. The Figure 8 shows the interface of the message transmitting.

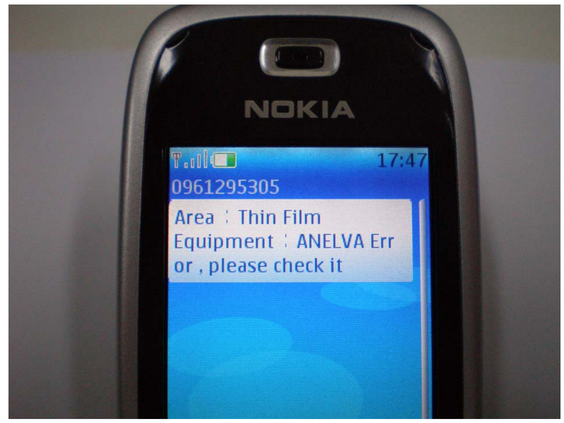

Figure 8. Receive message of cell phone

V. CONCLUSION

In tradition, the engineers must find the equipment with unusual status by themselves, or they are always informed too late when some problems happened in the equipment. Even though they find the unusual equipment quickly, junior engineers can hardly find the correct causes of failure without experiences in the equipments. For the senior engineers, when they have some experiences in fixing the equipments, they will not able to remember all the failure conditions and reasons. In contrast to traditional factory, this study proposes an RFID hand-held device application that helps solve many real-world demands in the factory. Engineers can be informed by the PDA or cell phone immediately when some problems happened in the equipment. In this application, engineers can realize the historical status of all parts in the failure equipment and infer which part causes this equipment failure immediately regardless their experience and the complicated failure conditions of equipments. By means of the proposed system, engineers are informed soon when some problems happened to the equipment as long as they carry their RFID hand-held devices. Consequently, applying a RFID hand-held device in factory equipment diagnosis can significantly enhance the of work efficiency.

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