Product Control System Using RFID Tag Information and Data Mining

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Abstract. In this paper, we suggest a method that applies RFID tag information and a data mining technology to a manufacturing execution system (MES) for efficient process control. The MES is an efficient process control method for many enterprises. But, the MES is not an analysis technique for process control. Therefore, we will supplement a data mining technology and RFID tag information to generate a more efficient process control system. In order to accomplish this, we designed and implemented an efficient product control system and adapted it to a TFT LCD production line using RFID tag information and data mining. As a result, the method proposed solved defects in parts and problems of personnel expenses.

Keywords: RFID, Data Mining, MES, LCD line.

1 Introduction

Information systems in the modern process and manufacturing sector bridge several layers, from the boardroom to the shop floor. At one end of this spectrum the ubiquitous ERP systems exist that have become essential to today's IT-enabled enterprises. At the opposite end of the spectrum, sensors, actuators and other field devices are found that are equally vital for ensuring perfect process control. Between these extremes a diverse range of systems with varying degrees of interconnection, fineness and cohesion exist[1].

Information systems span a wide range of data, processing power and time scales. The objectives and abilities of each of these systems are different, yet there is a clear need for them to operate in sync with each other. Any disconnect among them leads to inefficient operations, higher costs and lower quality, which ultimately translates into lower profits. Therefore, it is vital that there should be tight integration and perfect communication between all systems.

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A clear need exists for a set of systems that seamlessly bridge this gap. The manufacturing execution system (MES) fills this need. The MES controls the operations that enable realization of the plans, close the execution gap by providing links among shop floor instrumentation, control hardware, planning and control systems, process engineering, production execution, the sales force and customers.

The MES has multiple advantages. Nevertheless, there is no function regarding analysis techniques concerning the manufacturing process in the MES. Therefore, we designed and implemented the MES for the manufacturing process of TFT LCDs. Also, as reported in this manuscript, we investigated and analyzed the defects of LCDs that are produced in the manufacturing process using a data mining technology.

2 Manufacturing Execution System

A Manufacturing Execution System (MES) is a system that companies can use to measure and control production activities with the aim of increasing productivity and improving quality. The ISA has defined standards regarding the structuring of MES and its integration in a larger company-wide IT architecture. MES fits in between ERP and process automation level. MES gets production order and those are scheduled by ERP and that is also not in detail. Material requirement planning does the scheduling at the ERP level. MES collects the production order and does a detail scheduling for a small period.

The industry wants to know how to reduce the manufacturing cycle time, improve the quality, lower the cost and get more profit. Since MES can provide real time monitor and integrate with ERP and other information system, the potential utility will appear after the enterprise used MES. MES collected the manufacturing data, and managers can make the strategic decision by it and carry out the decision. It is information presented on-line to the production operator and to the desk of manufacturing management. Under MES implementation, integration with your accounting system, order entry system, inventory system, scheduling system and others become easy. These all become plug and play pieces because the data is sharable.

While the ERP focus is in areas such as finance, HR, etc., new investments focused on improving and optimizing production and logistic resources. An Advanced Planning and Scheduling (APS) system uses advanced programming techniques to improve/optimize production planning and scheduling, to allow the company to achieve pre-defined objectives, such as improvements on delivery performance without raising inventory levels, or maximize plant throughput [2]. Tao et al. [3] proposed an implementation process model for integrating the extensible Markup Language (XML) into an enterprise application, which also meets the inter-organizational data exchange standard of RosettaNet. Farahvash and Boucher [4] introduced an architecture that integrated shop floor agents for scheduling, cell control, transportation, and material management.

3 Design of MES for TFT LCD's Process Control

3.1 System Architecture Design

Product inspection is handled in real-time, because the RFID [5] concept is applied to the MES. If the LCD Panel or AD Board arrives in the examination line, the RFID tag will be printed. Information for parts is also provided because the information is linked with the ERP or SCM. However, because the product is selected from the database in this study, the RFID TAG LABEL is printed.

The system architecture (Fig. 1) was based on the MES component principle. Quality management process management, labor management, data collection and acquisition, dispatching production units and document control of the MES function were modeled.

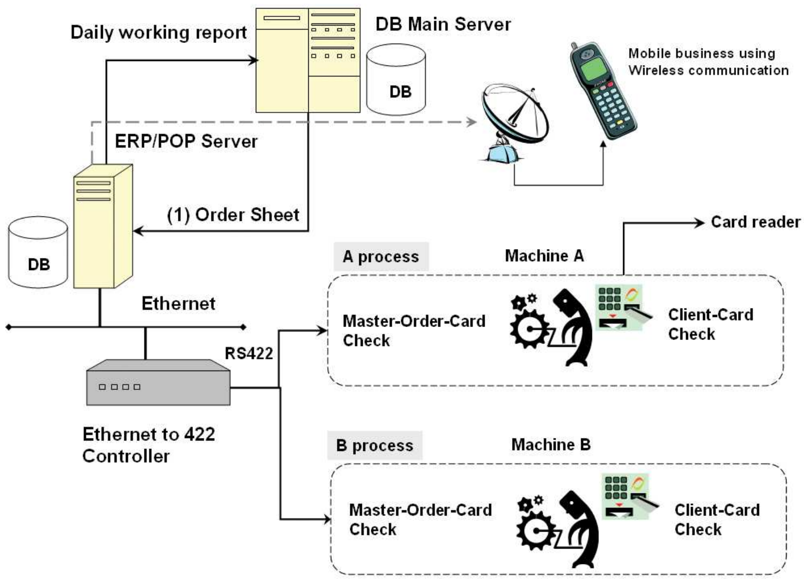

Fig. 1. Architecture of system for the parts

3.2 Data Flow Diagram of the System

The data flow diagram of the part inspection system using RFID in an electronic device manufacturing process, in which parts are produced or arrived at the subcontractors, the part information is inputted, the tag is attached by using an RFID printer, and it is moved to the inspection conveyor is depicted in Fig. 2. An inspector reads the tag information using a RFID reader, and outputs the information for the product concerned on the monitor. An LCD

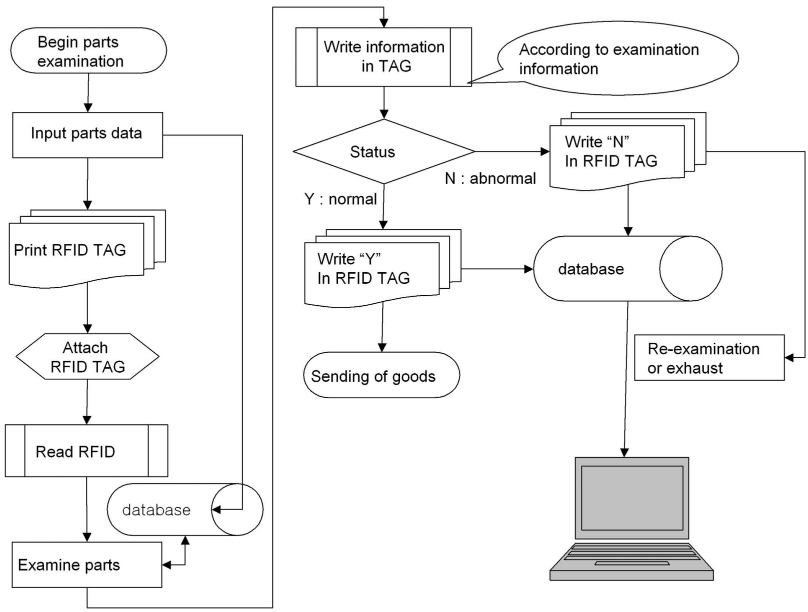

Fig. 2. Data flow diagram

electronic component is conveyed to an appropriate box or a pallet after judgment is made regarding whether to send the part to a shipment conveyor line, re-inspect it, or send it to disposition on the conveyor line due to inferior quality, when tag information is read through the final RFID reader. The system stores inspection data on various parts in the database, and permits them to shown on the monitor of a subcontractor, or an office manager, through the EDI/WEB. The system is configured to link with the existing SCM, and the ERP DB.

The diagram in Fig. 3 illustrates a detailed explanation of processes. When an electronic component arrives at the inspection line via the conveyor belt, the RFID reader automatically reads the appropriate information from the tag and judges whether or not it is a panel inspection or a board inspection.

Fig. 4 shows the main screen of the parts inspection system. The screen is on standby in the state depicted in Fig. 4. The left hand side of the screen configuration automatically indicates the details of the electronic component concerned. On the right hand side, the current date, time, inspector's name and ID, and inspection line are displayed. In the center of the display, which is the core of the program, the inspection items are automatically displayed in line with the electronic component concerned. Therefore, the appropriate inspection items can be easily understood by non-skilled personnel. The main screen of the parts checking system (Fig. 4) is implemented by the MES.

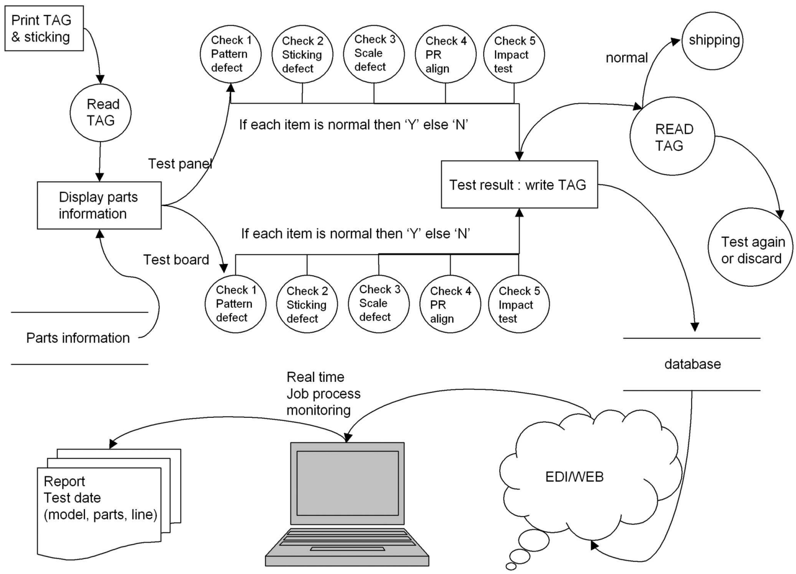

Fig. 3. Data flow diagram for the detail processing

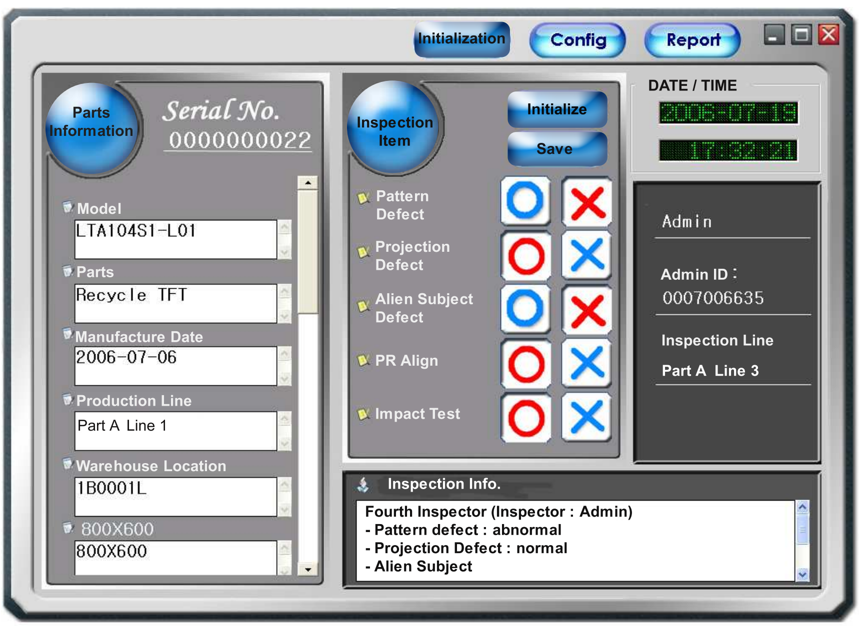

Fig. 4. Main screen for parts inspection

4 Data Mining for Efficient Production Control

In this chapter, we will explain neural networks and C 4.5 algorithms. Also, we apply these algorithms in the manufacturing process for TFT LCDs and suggest methods by which to locate defective parts. The method proposed may contribute to improve the efficiency of the manufacturing process for TFT LCDs. A neural network algorithm is a technology used in estimate modeling. Neural network algorithms are very efficient; however, this type of algorithm has shortcomings that can not explain the estimate sequence. Therefore, we used C4.5 algorithms and supplemented the shortcomings of the neural network algorithm. The C4.5 algorithm appropriately explains the sequence.

4.1 Neural Network Algorithm

Neural network[6] technology uses a multilayered approach that approximates complex mathematical functions to process data. It consists of many processing elements or nodes that work in parallel. Nodes are connected to each other in layers, and layers are interconnected. These nodes are simple mathematical functions; the connections between these nodes, which weight the data transformation from each node and send the information to the next node or output layer, are how neural networks "think." As the complexity of the task increases, the network size increases, and the number of nodes increases rapidly.

To properly train a neural network, the developer feeds the model a variety of real-life examples, called training sets. The data sets normally contain input data and output data. The neural network creates connections and learns patterns based on these input and output data sets. Each pattern creates a unique configuration of network structure with a unique set of connection strengths or weights. A neural network adapts to changing inputs and learns trends from data. A set of examples of the data or images is presented to the neural network, which then weights the connections between nodes based on each training example. Each connection weight builds on previous decision nodes, propagating down to a final decision (Equ. 1).

- Signals passed from each input node are gathered and become a linear combination. That is, the hidden node, L, is expressed as follows if (x1, ..., xp) is the explanatory variable.
- Connection weights for each input are summed, resulting in a unique complex function each time the neural network is trained with a set of inputs and outputs. Successsively summed weights define the algorithm that the neural network uses to make a pattern-matching decision.

$$L = w_1 X_1 + ... + w_p X_p \tag{1}$$

After the neural network reaches a final decision, it compares its answer against an answer provided in the training set. If there is a match, within a predefined tolerance, the neural network stores these connection weights as successful. If the decision outcome is outside the tolerance, then the neural network cycles through the training set again. A neural network may cycle thousands of times to reach an acceptable tolerance.

Table 1 is used to determine the variable used to forecast the defect in TFT LCDs

Table 1. Factor for TFT LCDs quality decision

Input variable	Meaning of variable	Category
Variable 1	Pattern defect	Y/N
Variable 2	Output voltage	Y/N
Variable 3	Decide projection	Y/N
Variable 4	Terminal R	Y/N
Variable 5	Terminal Y	Y/N
Variable 6	PR Align	Y/N
Variable 7	Terminal W	Y/N
Variable 8	Impact test	YES/NO

4.2 C4.5 Algorithm

Statisticians developed a tree-structured classification of many members known as machine learning. Characteristics of the tree model are described as follows.

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If A, then B, Else C
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The decision tree C4.5 algorithm [7] used an entropy standard. Entropy is a concept used to measure randomness in thermodynamics. Suppose that data set, T, depends on Y and is divided into k. Then, the ratio (p1,, pk) of the category can be classified. Therefore, the entropy of T is defined in equation 2.

$$Entrop(T) = \sum_{i=1}^{k} p_i log\ p_i \tag{2}$$

The C4.5 model must find a separation variance that generates the lowest entropy in the entropy test. In this paper, we will determine factors concerning the defects of LCDs using C4.5 algorithms. The factors in Table 1 were used in an experimental design. The sequence of results is illustrated in Fig. 5.

4.3 Analysis of the Proposed Algorithm

Table 2 and Table 3 are results from the manufacturing process that apply to the neural network algorithm and the C4.5 algorithm, respectively. Table 2 and Table 3 present data on precision and recall.

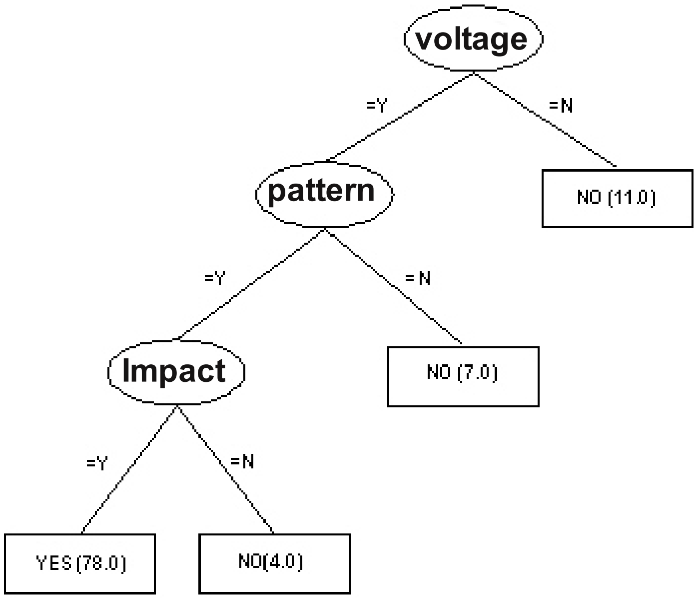

Fig. 5. Application of C4.5 algorithm to LCD line

Table 2. Experiment result of neural network algorithm

Precision	Recall	F-Measure	ROC Area	Class
0.98	0.987	0.985	0.946	YES
0.943	0.943	0.971	0.946	NO

Table 3. Experiment result of neural network algorithm

Precision	Recall	F-Measure	ROC Area	Class
0.97	0.985	0.977	0.983	YES
0.971	0.943	0.957	0.983	NO

The results of analysis are as follows.

- 11 items had a voltage defect in the whole parts production number.
- 7 items had both a pattern defect and a voltage defect in the whole parts production number.
- 4 items simultaneously had a pattern defect, a voltage defect and an impact defect in the whole parts production number.

Therefore, the incidence of voltage defects should be reduced. Also, we determined that a voltage defect causes a pattern defect. Finally, voltage defects in the manufacturing process should be managed specifically. We used RFID

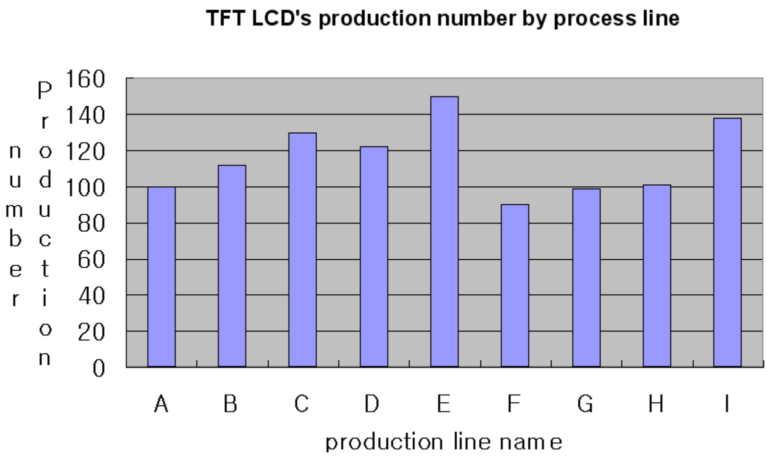

Fig. 6. Statistical analysis of the parts using RFID tag

technology and demonstrated that the process of producing TFT LCDs can generate monitoring in real time. Also, we produced real-time data information by chart to more easily confirm manufacturing information. Fig. 6 illustrates productivity according to each line of TFT LCD production.

5 Conclusions

In this paper, the system proposed was established to actualize an overall inspection system for electronic components or devices using RFID. This study developed a system to inspect electronic components and devices, specifically, LCDs Panels that are the core parts of an LCD monitor store inspection result data in the RFID TAG and the Reader/Writer. The existing system managed the inspection result data by manually attaching stickers containing inspection values. As a result of implementing the system developed in this research, the inspection time in the real parts inspection line was greatly reduced. The system developed consists in a way that the inspection data of multiple types of parts or devices can be displayed in real time to raise the efficiency of the concerned inspector or manager. This system is comprised of a MS-SQL SERVER or MySQL, which is a general purpose database, and can be linked with various ERPs and SCM. This system is forecast to provide many benefits to LCD panel and parts inspection companies. The MES is an excellent system for process control. However, the MES lacks an analysis function concerning information that occurs in process control. As a result, this approach was effective for closely examining the cause of necessary product defects in process control. We expect that the system proposed in this paper will be useful in various fields.

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