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Defect Cause Search Support System Using Ontology and Bayesian Network in Liquid Crystal Display Manufacturing Process

Kouki Hamamoto[a]*, Akira Kitamura[a], Satoshi Taguchi[b], Shingo Watanabe[b], Hiroki Matsuno[b]

[a]Department of Information and Electronics, Graduate School of Engineering, Tottori University, 4-101, Koyama, Tottori, Tottori 680-8550, Japan
[b]Manufacturing Engineering Dept. Tottori Plant, Manufacturing Division. Japan Display Inc., 3-117-2, Minamiyoshikata, Tottori, Tottori 680-8575, Japan

Abstract

   This paper describes a new defect cause search support system by combining Bayesian network and ontology to use the inherent production theory and the operation knowledge in the manufacturing process. The internal parameters, that are not measured as the actual data but can be calculated by mathematical model based on the production theory, often cause the truth of defects. In this study, these parameters information is used for the probabilistic inference of the defect cause by Bayesian network. The ontology is used for data dimension reduction, because too many dimensions of data deteriorates the estimation accuracy. Moreover, the calculation method of the similarity degree between the concepts in the ontology is used to search the new information about the production theory and the operation knowledge. This system was applied to the actual defect analysis in the liquid crystal display manufacturing process. As the result, F-measure that means the accuracy in Bayesian network has increased by 0.4905 drastically and the analysis time can be shortened to about 1/3.

Nomenclature

D_i	Concepts to denote the new data accumulated in the production knowledge ontology ($i = 1...DN$)
R_{ij}	Partial concepts to denote the related defect appended to D_i ($i = 1...DN, j = 1...RN_i$)
DN	Number of D_i in the production knowledge ontology
RN_i	Number of R_{ij} appended to D_i ($i = 1...DN$)
c_1, c_2	Concepts in the defect ontology
LCS	A common parent concept that is the nearest to two concepts in ontology
d	Depth from the root to LCS in ontology
$\alpha_1 - \alpha_6$	Constants obtained by experiments in the theoretical formula
$x_1 - x_4$	Variables in the theoretical formula

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* Kouki Hamamoto. s112045@ike.tottori-u.ac.jp.

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1. Introduction

Usually, in the manufacturing process, the total quality management has been used for the defect cause analysis. However, in this method, the considerable effort is required to approach the true cause. Moreover, the fundamental production theory that expresses the ideal fact using mathematical equation and model and the operation knowledge which belongs to the engineers are underutilized.

Bayesian network is a method for quantitative analyzing the relation between multiple factors probabilistically and has been applied to analyze the complicated causations[1,2,3]. In the defect analysis for the manufacturing process, multiple factors that cause defect can be identified quickly and the probabilistic influence of them can be obtained by applying Bayesian network to the actual data measured in the manufacturing process. The feature of the defect analysis in the manufacturing process is there is the fundamental production theory in the background. However, in the actual data, although the expressive phenomenons are expressed, the inherent production truth and the fundamental production theory that can predict the true cause of the defect aren't expressed fully. In the defect analysis using Bayesian network, the cooperation of the production theory is effective but it has not been attempted in the previous studies.

On the other hand, it has been studied to systematize concepts such as the manufacturing process, the product part and so on by ontology[4,5,6]. However, there are few cases that these methods are actually applied in the manufacturing field.

Therefore, in this paper, a new defect cause search support system is proposed by combining Bayesian network and ontology using the inherent production theory and the operation knowledge in the manufacturing process, in order to realize the efficient and high-accuracy cause analysis. By the way, in the cause analysis using the production data, the input data often becomes high dimension. In case such high-dimensional data is used for the input to Bayesian network, the estimation accuracy often deteriorates and the analysis efficiency decreases by complication of the Bayesian model. Therefore, the feature selection method for the input data is proposed by the ontology and the analysis in which the input data is limited to only the minimum number of actual data and the new data about the theory and the knowledge with high importance is realized by this method. In this paper, the outline of the proposed system and verification result of effectiveness in the manufacturing process are described. In this verification, this system is applied to the actual defect analysis in the liquid crystal display manufacturing process.

2. Outline of application process

The proposed system is applied to the defect analysis in the TFT array process in the liquid crystal display manufacturing process. Outline of this process is shown in Fig. 1. In this process, the each electrode and film are formed by
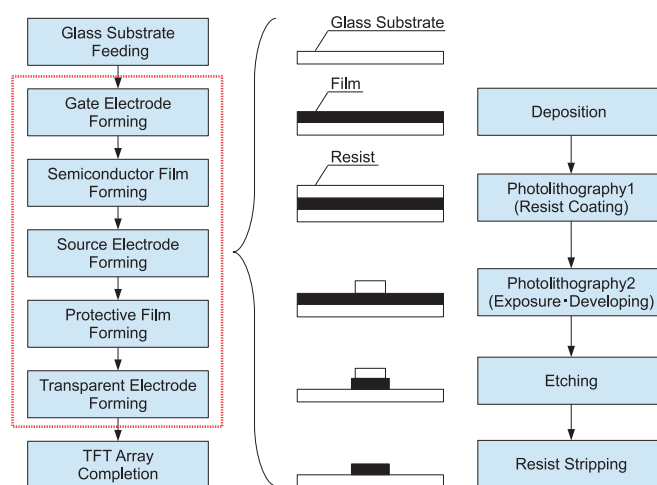

Fig. 1. Outline of TFT array manufacturing process