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論文題目	A New Methodology for Evaluation of the Worker Performance in the Manufacturing Process
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論文の内容の要旨

The production environment has a lot of revolutions in recent decades, with most companies taking part in mass customization production. The style of products, quality requirements from customers, materials, and even the machines involved in manufacturing are evolving quickly and orders are decreasing in size. In this situation, the employee is the important factor that determines the productivity and quality of product in a production process. This is why the selection of the right workers for operating tasks in an assembly line is always an important question, especially today because many tasks are becoming increasingly complex, as they must deal with the development of technologies, materials, and machines in the manufacturing process. If a task is more complex, the worker needs more skill and time to finish it. For all of the main purposes of the manufacturing enterprise, such as planning and scheduling, operators training or line balancing, the main requirement is almost always on predicting operator performance.

In a manufacturing process, the performance of the worker can be identified as their ability to accomplish a task based on the expectations of a standard. To determine how well a worker performs their job, various performance evaluation techniques can be used, such as the Synthetic Rating, Pace Rating method or the Westinghouse system. These methods have been applied recently to calculate operator performance ratings. The three traditional performance methods just apply effectively in the manufacturing process that the workstation is designed well. In these contexts, the manufacturing scheduling is completely based on machine capacity and the task characteristics remain consistent between customer's requirements. This makes it simple to set up standards to compare orders. Additionally, the impact of employee performance on production capacity is accounted for by very large orders. That is, workers have adequate time to meet the target performance, so production managers are not concerned with calculating operator skill level and task complexity to predict whether a worker's performance capacity is best suited to a specific task.

Further, in this conventional context, operator skills are learned and improved through comprehensive, industry standard training, and skill are enhanced gradually through precise, continuous repetitions of work processes. However, in the new manufacturing environment, the worker's performance results from the interaction between the skill levels of workers and the fluctuation of the characteristics of tasks.

The new and changing environment of the manufacturing industry, however, means that the usual ways of allocating workers tasks are less effective at forecasting workers' performance requirements. Moreover, such outdated approaches also lack success in driving workers to gain and master the new skills required to enhance quality and productivity. In addition, managers base their decisions only on their previous experience without the support of a systematic knowledge base. They merely observe the operation of workers and evaluate their performance based on subjective judgments. The accuracy of these judgments will mainly be dependent on the amount of experience the manager possesses.

My research proposal aims to propose a new methodology for the prediction of worker performance in manufacturing that is capable of effectively handling multiple factors of both a quantitative and qualitative nature that involve uncertainty and imprecision. Firstly, a methodology for evaluating worker skill levels is devised with the combination of the Delphi method, the principal component analysis and the ordinal logistic regression. Secondly, this research presents a method that combines the Analytic hierarchy process and Proportional 2-tuple linguistic representation model to evaluate the level of complexity of tasks in the manufacturing process. With regard to how the worker skill level and the complexity level of a task is evaluated, this research will pay closer attention to analysis of the relationship between task complexity and worker skill level, to clearly understand the interaction between them in order to predict the performance of workers. The newly developed methodology will be illustrated with a case study in the clothing industry to demonstrate its practical applicability in industrial contexts.

Keywords: worker's performance, skill level of worker, task complexity, decision support technique, rule-based support system.

論文審査の結果の要旨

In the manufacturing process, the evaluation and selection of workers for operating tasks in an assembly line is a complex and important problem. Practically, the performance of worker is influenced by many factors associating with the task assigned, such as skills of worker, task complexity, material characteristics, etc. Most of such factors are qualitative in nature and could only be properly assessed

using subjective judgments by human supervisors, which are usually associated with uncertainty and imprecision. This makes conducting multiple factor evaluation of the performance of worker in manufacturing process still a significant challenge. The principal objective of this research is therefore to propose a new methodology for prediction of worker performance in manufacturing that is capable of effectively handling multiple factors of both a quantitative and qualitative nature with uncertainty and imprecision. To this end, this dissertation has addressed the following specific problems: (1) identifying the skill level of workers, (2) assessment of task complexity, and (3) prediction of worker performance given task complexity and worker's skill level. The solutions to these problems were eventually integrated into the development of the new methodology for prediction of the worker performance in the manufacturing process. The main contributions of the dissertation are summarized as follows.

Firstly, a new method for identification of the skill level of workers is proposed. Based on principal component analysis and ordinal logistic regression, probabilities of the skill levels of a given worker is first calculated and then the skill level that has the highest predicted probability is assigned to the worker. Secondly, an integrated model based on Analytical Hierarchy Process (AHP) and linguistic evaluation analysis is developed for assessment of task complexity. In particular, the main factors contributing to the task complexity are first determined and prioritized by using the Delphi method and AHP, respectively, and then a proportional 2-tuple linguistic representation model is applied for assessing the complexity level of tasks. Thirdly, a rule-based system for prediction of the worker performance based on the skill level of worker and task complexity is developed using the decision tree method, which will support production managers in their decision making for task assignment in an assembly line. Finally, the proposed methodology is tested with a case study in the clothing industry to illustrate its practical applicability.

This dissertation has made significant contributions both theoretically and practically in the area of manufacturing management. The research work presented in this dissertation has resulted in 2 journal papers (1 published and 1 under review), and 3 refereed conference papers.

In summary, Ms. LE Song Thanh Quynh has completed all the requirements in the doctoral program of the School of Knowledge Science, JAIST and finished the examination on February 4, 2020, all committee members approved awarding her a doctoral degree in Knowledge Science.