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A Study on Digital Visual Management for Providing Right Transparency against Emergencies

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Abstract

In the era of digital innovation, this paper discusses a new framework of visual management (digital visual management). With comparing with conventional visual management, this paper clarifies the improved functions of the framework from the perspective of the four capabilities; 1) visibility, 2) temporal capability, 3) problem-solving capability, and 4) geographical capability. For developing a system by this framework, this paper also indicates two approaches; a) the approach from the innovation of a visual tool as an interface with human, and b) the approach from the design of new data network. In addition, in the application stage of the framework, this paper discusses two troubles, 'the waste of visualization' and 'the omission of visualization', hidden in the established digital visual network system.

Keywords: Visual Management; Digitalization; Lean; Emergency Monitoring; Performance Measurement

1. Introduction

The installation of digital technologies in the world spotlights drastic increases in manufacturing industries over the past few years. The promotion of visualizations to increase the transparency of production activities is recognized as one of the key effects of this technological innovation, according to recent experts' opinions. However, in lean management, the purpose of which is to strengthen the nature of value chains, many organizations have executed visual management to help make people understand and quickly solve abnormal conditions hidden in operation systems. Relevant research must reveal differences between these two tendencies, the good and bad impacts of this change to visual management, and a specification of visual management with digital technologies, etc. In order to address to these recognized problems, this study aims to develop a new framework of visual management with digital technologies.

The research procedure mainly consists of the following three steps: 1) Reviewing conventional visual management, 2) Developing a new framework of visual management with digital technologies, and 3) Discussing conventional and new visual management. In the first step, the reason for the installation of visual management is reconsidered. The investigation sources for the step are publications by Mr. Taichi Ono, who proposed the concept and tools of visual management through the development of the Toyota Production System (TPS) (Spear 1999), the origin of lean management. In the second step, a new framework of visual management with digital technologies is imaged. This step carefully analyses the relevant materials from forums, lectures, and publications during one recent year. This work has been repeated to improve the quality of the developed framework every time new materials are collected. In addition, the observation results of digital innovation cases and interviews with practitioners are reflected in this framework. In the third step, conventional and new visual management are summarized, and the interactions between the two are discussed. They are systematically organized based on the results of the above two steps.

2. Conventional Visual Management

Academic researchers first met visual management in TPS. Mr. Taichi Ono (1988) advocated the system continued to think original production system that fit the climate of Japan that the small quantity of diversified products is requested, and thought that the final objective of this system was to not stop production even if any variety of product was flowed. From the era of Adam Smith, the job for making one product has been executed with dividing into plural processes for realizing high productivity in mass production system like Ford's automobile manufacturing system. However, each process can freely demonstrates each ability by this division. As the result, the relation between processes is divided, and a flow of production is stopped. In order to relieve structural problem like this, he made an effort to bring physically each processes as close as possible from the approach by layout improvement, and to assign some processes to one operator (multi-process handling).

In addition, he considered 'the absolute elimination of the wastes' the basis of TPS for reducing factors to stop a flow of production in daily operations. Visual management was the methodology to embody this basis. 'Kanban' and 'Andon', which are respective methods of 'just-in-time' and 'automation with a human touch', the two pillars of TPS, involves representative tools of visual management. 'Andon' informs abnormal conditions of each process. 'Kanban' performs information transmission between processes. That is to say, the whole of production activities are viewed as the system that expresses by production resources and the relationship between them, and comprehensive monitoring of their conditions is considered as the role of visual management. He also compared this viewpoint to excellent baseball team. Each member always plays nice and the cooperation between members is amazing. Visual management has important role to become the autonomic nerve to realize such ideal situation in the production system that mainly composed of the machines without saying anything. The above discussion summarizes Figure. 1.

Furthermore, TPS utilizes the tools to visualize the needed information in each process such as defective products, the actual progress of work in comparison to daily production plans, the arrangement of goods and tools, inventory, circulation of Kanban, and standard work procedures except the above two tools.

On the other hand, how to provide production information to a process is stated with taking their information system as an example in TPS. That is to say,

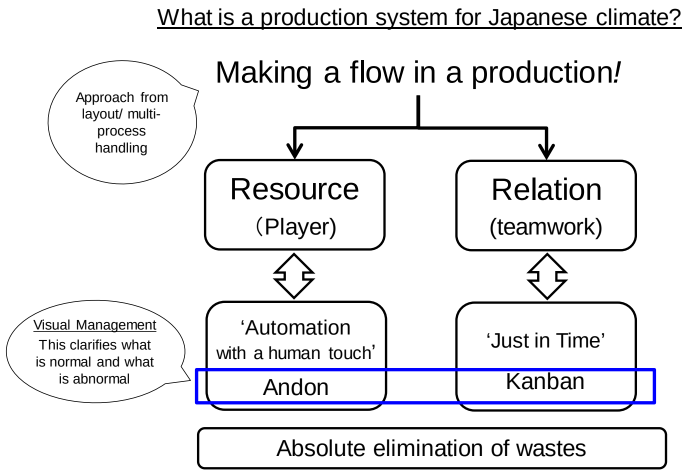

Figure 1 Visual management in TPS

'Too much information induces them to produce ahead and can also cause a mix-up in sequence. Items might not be produced when needed, or too many might be made, some with defects. Eventually, it becomes impossible to make a simple change in the production schedule (Ono 1988).*'*

The paper calls this phenomena 'the waste of visualization' that leads activities of Muri, Mura, and Muda (Katayama 2017). That is say, extra visualization and over-providing of information cause misunderstanding and misjudgement, and waste time and money.

After meeting visual management in TPS, there were many publications on management of manufacturing operations. The observant explorations of excellent visual management tools resulted in the newest concepts, such as visual factory (Greif 1991) and visual communication (Mestre 1999), which include many classified tools, such as visual indicator, visual signal, visual workplace, visual devices, visual guarantees, and visual standards (Galsworth 1997). These advances in the manufacturing industry have positively been applied to the practical operations in different fields, while the systematic transfer of visual management tools has developed on the academic side (Murata 2010a, 2010b, 2016). In recent publications, the application fields include the construction industry (Tjell 2015, Tezel 2017a), health lean management (Verbano 2017), small- and medium-sized enterprises (SMEs) (Fonseca 2017), and a rising nation that tackles lean management (Laoha 2017).

Focusing on a visual management tool, the incessant analysis of its practical cases leads to a deeper understanding of the tool and realizes its improvements. Murata (2013) proposed the mathematical model to evaluate the tools' performance. Pató (2017) expanded the job description method, a fundamental tool for capturing operation transformation, in order to gain operational knowledge using both three-dimensional (3D) and two-dimensional (2D) techniques. Dashboards to visualize production planning and control are easier to use owing to the analysis of them by Brady (2017). Performance management, utilized for sharing the current and future production system conditions among worksite members, also develops through the system science that can be applied to borderless subjects of nature, society, cognition, and science itself (Flumerfelt 2017).

However, researchers should offer a deeper understanding of the system involving a visual management tool to industry members through academic theorizing beyond empirical investigations. Regarding theoretical studies on a visual management tool combined by empirical studies, Tezel (2016) and Bell (2013) reveal future research topics based on literature reviews. Tezel (2016) arranged themes for theory-focused research: function and roles of visual management, visual management as organizational affordance, visual management and organizational socio-materiality, theoretical discussions on the concepts of visual management, visual workplace and visual tools, visual management research, visual studies perspective, workforce perception of visual management, and visual management tools as boundary objects across different social groups. Bell (2013) picked up on the types of useful academic theories to systematize visual management theory, such as media richness, ethnographic study, organizational theory, knowledge management, and information science. Furthermore, regarding the advanced studies on the application of academic theories, Beynon (2017) challenges the exploration of a tool in the health care industry using affordance theory.

As the summary of the above discussion, visual management originally aims to detect the abnormal statuses hidden in the internal of a supply chain. The difficulty regarding abnormal management is that the irregular occurrence of abnormal statues has to be discovered in cyclic production activity without daily minding them. The image of conventional visual management shows in Figure 2. In order to attain the above goal, the conventional approach installs a visual tool to objects, activities, and indicators that have a possible to happen anything unusual. Visualized attributes of these managed items involve for each step in the problem-solving such as understanding a present, pursing a cause, analysing an impact, and executing a countermeasure. A visual tool bases on diverse idea for plain view, and are independently established in a production system. The level of visual management is decided by the quality and quantity of installed visual tools.

Based on the above trend of academic studies and summaries, this paper proposes a new framework of visual management with digital technologies. The proposed framework provides the understanding of the difference between conventional visual management and digital visual management, and the future direction of digital visual management including an applicability, a limitation, and a specification etc.

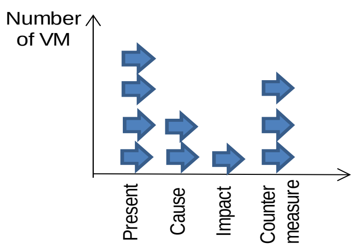

Figure 2 Image of conventional visual management

3. Digital Visual Management

3.1. Proposed Framework

Owing to new production paradigm transformation (Koren 2010), not only hand-made visual tools, but also advanced visual tools, have been continuously developed by information technology (IT), information communication technology (ICT), and the Internet of Things (IoT) (Sugawara 1994, Fitrianie 2007). Some industries already actively use new visual tools, such as building information modelling (BIM); mobile computing; virtual reality (VR); augmented reality (AR); mixed reality (MR); substitutional reality (SR); surface scans, including laser scanning; photogrammetry; and radio-frequency identification (RFID) (Steenkamp 2017, Tezel 2017b) and so on.

Figure 3 describes a new framework of visual management with digital technologies that are called 'digital visual management' in this paper. This shows the future image of problem-solving. New layer of data world is created in a supply chain, in addition to real world, owing to appearing advanced data- or virtual- visual tools such as a sensor, an analytical tool, a control tool, a display tool, and an internet etc. The proposed framework mainly detects the bad changes of managed objects including their trends with coming and going from real world to data world, and executes useful activities for perfect problem-solving with crossing geographical and temporal boundaries.

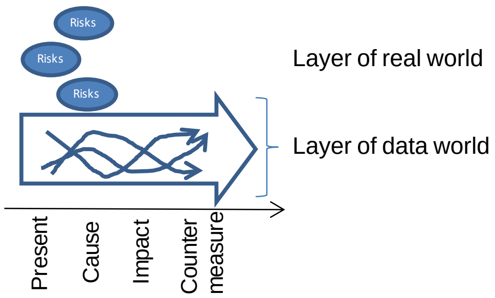

Figure 3 Image of digital visual management

As the social background of the development of digital visual management, industries become faced various risks with globalizing their activities. The risks are divided into internal risk and external risk. The former risks such as life of expendable supplies, mistaken operation, contamination, strike, and violation of rules has been managed conventionally. However the impact of customer complaint and environmental destruction occurred from the result become large than before with the expansion of social responsibility of industries. The latter risks such as an epidemic, natural disaster and cyberterrorist were born anew in the present age. Their destructive power has the possibility to bring a fire in a factory and to stop industry infrastructure. Based on the above social background, as the extension from the conventional visual management, the following four functions are added to digital visual management; 1) Monitoring the risks of both internal and external of a supply chain and their impact. 2) Automating the announcement of not only an abnormal situation but also its solution 3)

Strengthening the function of a prediction 4) Connecting data with crossing geographical and temporal boundaries. Digital visual management indicates both inductive and deductive directions for designing new systems as the following sections.

3.2. Approach from the innovation of a visual tool as an interface with human

For one direction, the approach from the innovation of a visual tool as an interface with human and aims to expand the power of expression of existing tools such as posters, signs, and warnings. That is to say, this approach digitalizes hand-made visual tools. The approach contributes to the improvement of visualization quality to overcome limitations of perception, such as blindness due to inattention and change blindness, which occurs even if installing conventional visual tools.

A conventional tool also has a possible to become the trigger of the development of the system. After digitalizing conventional tool, it can has functions to access the result analysed in new data network discussed in detail below. Owing to the approach, visualized item provided by the digitalized tool are, on a real-time basis, customized and personalized.

Virtual world is also recognized as new visual world that can be perceived by human. For example, the materials such as visual guarantees and visual standards that cannot be seen while operating are digitalized, and the materials selected by operation conditions are provided in production through smart glasses and smart tablet without an effort to search and remember them.

3.3. Approach from the design of new data network

For the other direction, the approach from the design of new data network aims to build high connectivity between all managed objects for perfect problem-solving that crosses geographical and temporal boundaries. The image illustrated Figure 4 evaluates that a risk occurs in a supply chain when the accumulation of group data of each process exceeds threshold r. The database equipped in a process i includes j kinds of physical data. These are obtained from the sensor system which real-time monitors the states in operation of resources like human, machines, and materials. The formulation of the above scheme shows from Equation (1) to (4).

This system includes both the horizontal network that manages physical data paralleling with operation networks, and the vertical data network that links with the decision of management level.

For the first network, all resources utilized in a process aim at the common goal which makes a value. However, they have different attributes and behave diverse with being influenced from relevant resources respectively. The network has an ideal to monitor steadily all of them as new vein of the problem-solving, in order to detect quickly an abnormal of each resource, and the impact of other resource or a process caused by an abnormal of a resource.

The second network relates to the measurement of production performance from the perspective of management level. In order to realize the network, the systematization of performance indicators is needed. Murata (2009) proposed the database structure to accumulate key performance indicators (KPIs), and key activity indicators (KAIs) and the analysis methodology of the relationship by the improved Data Envelopment Analysis (DEA).

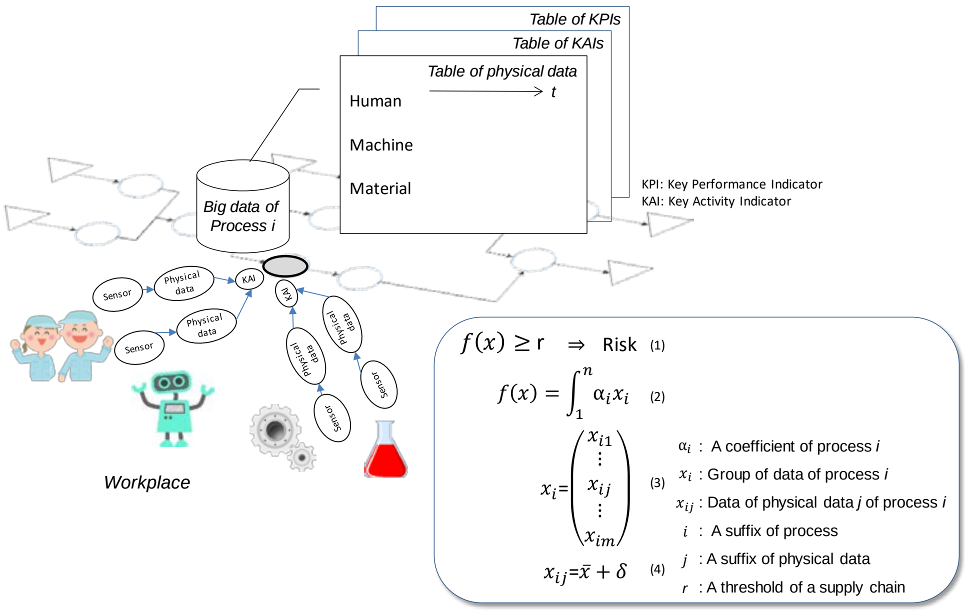

Figure 4 Image of digital visual management of data-oriented

4. Comparison between Two Visual Management

Table 1 illustrates the summary of the above discussion. The appearance of digital technology steadily contributes to extend the application range of visual management by an improvement of four capabilities; 1) a visibility by an improvement of the power of expression with interface innovation and various sensor technologies, 2) temporal capability by large-data-accumulation and analysis, 3) problem-solving capability by the automation of information processing like artificial intelligence (AI) and machine learning (ML), and 4) geographical capability by a fast Internet connection.

However the clarified difference between two visual management do not mean that all visual management is digitalized in the future. Probably, items that cannot be visualized by digital technologies continue to be existed in the future too. Such items concerning a communication, a team-building, and an information-sharing had better be visualized by hand-made tools. Also, conventional visual management will be needed because of the cost to invest digital tools and the restrictions on their installation such as a plant of explosion-proof specification.

Also, once the system of digital visual management is established, it is considered hard to frequently improve full specification of the system. However the system may have two latent troubles that are ‘the waste of visualization’ and ‘the omission of visualization’.

Table 1 Conventional visual management and digital visual management

Attribute	Conventional visual management	Digital visual management
Clarified item by visual tools	*Clarifying what is normal and what is abnormal* (Ono 1988)	Clarifying the internal and external risks that threaten the survival of a company
Visualized item	Visualizing vital objects, activities, and indicators	Visualizing all objects, activities, and indicators
Idea source of visual tools	Diverse idea-driven visual tools for a plain view	Data- or virtual- visual tools, such as a sensor, an analytical tool, a control tool, and a display with coming and going from real world to data world
Establishment of visual tools	Distributed in a production system	High connectivity among all managed objects for perfect problem-solving with crossing geographical and temporal boundaries

For the first trouble, future visual management also must monitor not only the internal risks in a factory, but also the influence of risks from outside the factory, in order to achieve its responsibility as social infrastructure in the view of recent serious events such as economic crisis, natural disasters, and terrorist activities. This radical increase of visualization requests indicates a need to carefully consider the priority of visualization including the timing to appropriately deliver information in Section 2.

For the second trouble, as the application range of established digital visual network becomes larger and wider, the maintenance capability of the details of the network structure will decline. Also, the network may have the possibility that the phenomena that cannot be obtained from the network will be not perceived by human all the time. The improvement of the network's mobility from this perspective is always required because the movement of a supply chain is always changed. Needless to say, there is no doubt that hand-made visual tools which have high mobility is useful for the situation.

5. Concluding Remarks

The main finding of this paper is a new framework of visual management with digital technologies (digital visual management). With comparing with conventional visual management, the functions of the proposed framework are extended from the perspective of the four capabilities; 1) a visibility, 2) temporal capability, 3) problem-solving capability, and 4) geographical capability.

For designing and applying the framework, this paper also indicates two approaches for designing a new system; a) the approach from the innovation of a visual tool as an interface with human and b) the approach from the design of new data network. In addition, this paper discusses two latent troubles, 'the waste of visualization' and 'the omission of visualization', hidden in the established digital visual network system.

With recent innovation in advanced technologies as a start, this study rethought visual management and proposed a new framework of the scheme by digital technologies. The outcomes of the paper are useful when practitioners, such as production managers and system engineers, embody a concept of digital innovation in order to improve the transparency of the activities managed by them. In addition, past studies on visual management have mainly been formed with many analyses of best practices in the field of a lean management. In response to such academic trends, relevant publications have insisted that visual management must be studied more theoretically and systematically. This paper gives an opportunity to overcome those problems.

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