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Cognitive Automation Strategies

- Improving use-efficiency of carrier and content of information

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Abstract

The production paradigm of mass customization puts high demand on the production system and the people who works there. This is especially true for final assembly where the number of variants is the richest. To handle this variety, the operator needs the correct information accessible at the right time; the operator wants to know how and when to assemble what part. What is correct information includes the amount of information (content of information), how it is presented (carrier of information) and who is the receiver (specific operator). The strategy for Cognitive Automation will be more and more important for companies within this paradigm. This paper aims to show the use-efficiency of information, both carrier and content, in two industrial case studies. Furthermore how the cognitive automation strategy within a company is connected to the maturity of technology.

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1. Introduction

In a more and more complex production environment [1], companies have to find cognitive automation strategies to improve the information handling and to increase the usability of Information and Communication Technology (ICT)-tools. There is a need for high degree of flexibility [2, 3] and more dynamic decision making later in the production chain answering to a growing complexity [4]. Furthermore, the ICT-tools have to provide the operators with information (not decisions) [5] useful for them, not how a designer expects or assumes operators view or use information [6]. This puts high demand on the system to be sufficiently transparent and adaptable to the users' needs [7].

This article aims to describe how companies think when it comes to information and communication tools for operators' i.e. cognitive automation and how they can increase the use-efficiency in production systems. Two case studies will discuss the use of information carrier and content and how this could be improved to meet future needs. The cases handle different issues regarding ICT; the first case discusses how to improve the dynamics in the current information system and the other case discusses how tacit knowledge used for decisions could be transferred into the system to help novice operators

2. Information handling

The areas of information handling that will be brought up in this paper are; content of information, carriers of information and structure of information. All areas are important to consider when forming a cognitive automation strategy [8]. In order to find a flexibility from the structure of data handling in different systems to the way the data is transformed into information to the operator and then in the end is transformed into knowledge

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and know-how among the operator cognitive automation strategies will be more and more important issue within the information and organization structure, in line with [9] it is important to consider the relations between data-information and knowledge; Some associate information with data and others associate information with knowledge. But since none of them readily conflates data with knowledge, this suggests too loose a conceptualisation of the term 'information' [9] When to examine the implementation of technologies within organizations, it is found that 'technology' and 'organization' cannot be treated as entirely separate categories [10]. Following sections will give an explanation on how we interpret or define the areas of structure, carries and content of information and why they are important to consider. Figure 1 gives an overview of how the different information areas are connected.

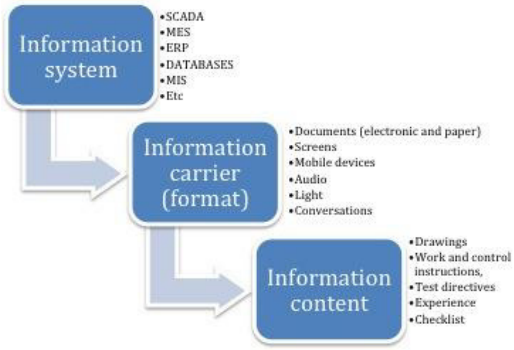

Fig. 1. The Overview of the information structure

The highest level is the information system or the structure of information, could also be called the back end system, the information carrier and the information content could be defined as the front-end system [11].

2.1. Structure of information

Structure of information could be defined as the systems used when data is extracted or produced into the content and carriers. Examples include databases, XML-files, cloud-based technology, ERP-systems, MES, SCADA, I/O-signals etc. This is important to know in order to distinguish if changes could be made in the system i.e. flexibility of the system. Static complexity in manufacturing systems is related to the system's structure and configuration. Products, processes and resources comprise the information, related to the system's structure, while their interactions affect its configuration[2], this is important to consider in order to create flexibility in a system and in order to easily access the content of information. Wand and Weber [12] describes two different views when looking at the structure of information; the external and internal view of looking at an information system.

External view: One treats the information system as a black box that delivers particular services to an organization, affects the lives of its users in particular ways, and evokes certain types of managerial concerns. Researchers who adopt this perspective would be interested in phenomena such as the processes stakeholders use to define their information requirements, the formal and informal power shifts that occur among users when an organization implements an information system, and the ways in which an organization might use an information system to obtain competitive advantage.

The internal view takes the requirements that an information system is intended to fulfil as given. It is concerned with the characteristics that information systems must have if they are to fulfil these requirements. Researchers who adopt this perspective would be interested in phenomena such as how well different screen interface might meet users' needs, how data and processes should be structured to provide the required system functionality and what types of hardware platform will meet required response time.

2.2. Content of information

Content of information could be described as: the actual data or information that is to be conveyed to the recipient [13]. The recipient in this context is a human operator, but it could be a machine or a robot. The content can be multimodal. Meaning it can be presented in different modes such as text, pictures, movies and sound, vibrations etc. Each of these modes has their benefits and area of usage. Text has been the most common mode in work instructions, but pictures have become more commonly used.

2.3. Carrier of information

Carrier of information is the type of tool or technology that is used to present the information. Examples include computer screen, paper, phone, persons (tacit knowledge for example) etc. Carriers can be further divided into mobile, semi mobile or stationary [13]. The carrier could also indicate how accessible the information is. This basic definition where information transfer is divided into two parts; carrier (how) and content (what), has powerful potential when designing information systems. This is because the carrier and content can be decoupled when analysing the system. Every source of information can be referred to as an information carrier for example the product to be assembled, a work instruction or a light system signalling errors. Studies performed by Heat et al, [14] address the social and interactional organization of workplace activities, and the ways in which tools and technologies, ranging from paper documents through to complex multimedia systems, feature in day to day work and collaboration [15]. Empirical studies, done in final assembly environment, with complex products or tasks, shows that 90 % of final assembly tasks are still performed by humans [16] and the operators are not using any decision support but performing the tasks solely based on own experience.

3. Knowledge

Different levels of knowledge, regarding the possibility to codify, can be recognized in organizations' knowledge resources [17]. The easiest to transfer is structured knowledge, in for example databases and instruction books. Unstructured knowledge found in, for example, reports or discussions is possible to code and transfer into the information system but this is seldom done. The hardest knowledge transfer or collect is tacit knowledge, which is the most transparent and subjective form of knowledge [18]. Tacit knowledge is held in a non-verbal form, and therefore, the holder cannot provide a useful verbal explanation to another individual [18].

There are different opinions in how much of this tacit knowledge that could be transferred into structure and thereby become easy to share in the organisation. Haldin-Herrgard, means that tacit knowledge typically becomes embedded in, for example, routines and cultures, while the explicit knowledge, can be expressed in symbols and communicated to other individuals by use of these symbols [19]. In Case stud B there is a try to make the tacit knowledge more explicate, in line with Schults, new knowledge has uncertain relevance, an unknown potential to affect everyone and everything. The implications of new knowledge are discovered as new knowledge via explicit documentation or embedded in prototypes [20].

4. Industrial case studies

For each case the information the operators encounter was studied regarding content, carrier and structure. Observations and interviews were utilized to find potential issues with the information transfer to and from the operators.

The following sections describe one special issue at each company that could be improved if investigating and improving the cognitive automation.

Table 1. Summary of the case studies

Cases	Type of industry	Carrier of information	Content of information
Case A	Heating	Paper, Morning meeting	Pictures of machines, Text
Case B	Machining	Paper, Phone, Barcodes	Text, Blue-prints, Knowledge

In order to increase the user-efficiency of using the right information and to be able to increase the communication to and from the operators, improvements will be done in terms of prototypes [21].

4.1. Case A- Dynamic morning round

In Case A, the aim was to digitalize the preventative maintenance rounds and make the list of check-point more dynamic over time, this will save time and build in flexibility in the system.

In current morning rounds, paper is used in order to check the status of different machines and tools. In a current state, an excel file with a list of machines and checkpoints is printed every morning. The operators take the paper, goes the round and note with a pen if something is wrong, if it is urgent she calls the technician for help, otherwise they allocate the task on a morning meeting after the rounds. They also have to type in their notes in a maintenance system manually afterwards.

In order to improve the morning rounds an electronic application was developed. This Android based application demonstrates a dynamic list of **tasks** with **automatic** sorting in numbered order or importance, illustrated in fig. 2.

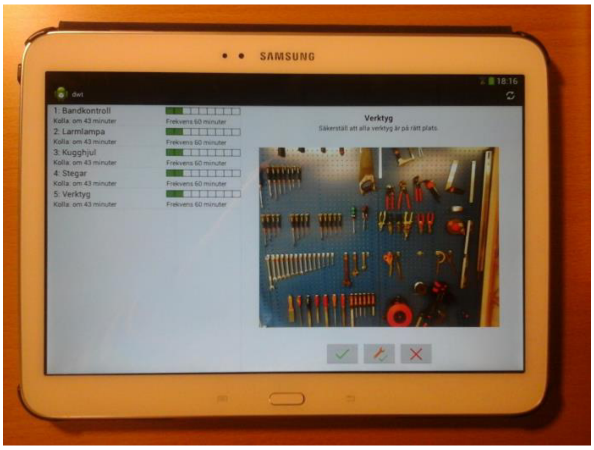

Fig. 2. The user interface of the application.

A task consists of signing off the state of a checkpoint. A name, a description and an image guides you to the checkpoint. A bar that fills up shows how important it is to check a specific task right now. Tasks are signed off with three different options. Ok, Ok after changes or Not Ok.

Checkpoints that are not ok will be omitted (greyed out) until fixed. Recently checked (OK) checkpoints will have an empty time bar and cannot be rechecked until next check period. Checkpoints are administrated with a web based server. The web server interface lets an administrator add, remove and change checkpoints. It is possible to see statistics and follow the state of a checkpoint in time. If a checkpoint is often broken, maybe it is a good idea to shorten the time period (update frequency). In a dynamic work environment the reason for something to be checked can disappear and sometimes focus shifts to something new. It is important to keep your checklists up to date otherwise the workers may lose faith in the importance of their work tasks.

So far this application has increased the operators' comments and transformation of tacit knowledge into the system, the communication between the operators and technicians goes faster, this result in more efficient morning meetings, because that have already allocated the tasks when doing the round. A longer field test and more integration in the companies back-end system is important to do if the company wants to gather and use information other than in the stand-alone system.

4.2. Case B-Learning from tacit decision knowledge

In case B, the aim is to reduce the decisions steps when sorting orders. Furthermore, by building in the tacit decision knowledge into the system, the novice operators will learn from experts even though they are not always at place. This will save time in terms of decreasing the information gathering time and increase the flexibility and knowledge among novice operators.

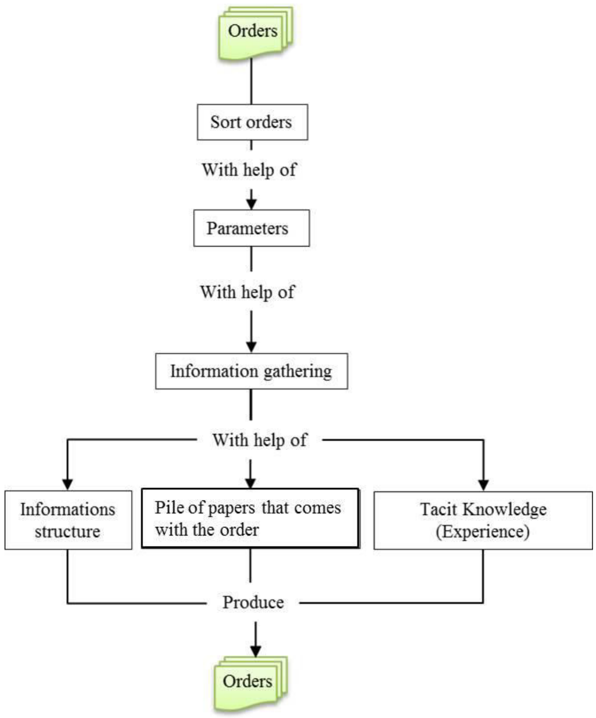

Fig. 3. The different steps the operator has to take in order to sort and produce the orders.

The sorting of orders is done by comparing the orders due to different parameters i.e. suitable for the night shift (batch sizes and cycle-time), machines (they have three different machines available) etc. This prioritization is mostly based on tacit knowledge. Novice has to gather more information in order to do the same prioritization; this could be done both in information systems and in the pile of papers the come with each order (the pile of paper consist of 15-20 papers concerning the order in terms of blue-prints, tolerances etc. for the product, each paper is used but not at all stations so this pile could be adapted and digitalized for each station in order to save paper and to increase flexibility)

An application will be built in order to sort the decisions and to help the novices to make the right decision, first based on the built-in tacit knowledge and then based on dynamic changes, in order for the novice to be able to use less and less information and more and more own knowledge in order to make the decisions

5. Discussion and conclusion

The problems described in the industrial cases show that it is not easy to understand the connection between all the information that actually exists in a production system. It is important to identify the underlying problem and classify the needed information. The company have to consider a lot of parameters when finding a strategy for cognitive automation. It is important that the company have a well-planned structure, standardized work-plan and a clear idea why they want to change the system or automate. The front-end -back-end problem i.e. to get connections and standards on how to connect the user interface with the information structure such as MES, ERP systems .If this issue could be solved (without just building another stand-alone system or cloud-based system) companies can increase both the user efficiency and become more competitive

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