Expert Systems with Applications 42 (2015) 1613–1625

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Review

Modeling of tacit knowledge in industry: Simulations on the variables of industrial processes

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A R T I C L E I N F O

Article history:
Available online 6 October 2014

Keywords:
Tacit knowledge
Expert system
Bayesian networks
Knowledge elicitation techniques

A B S T R A C T

The paper presents the application of a Technical Mapping and tacit knowledge elicitation in industry in order to promote the modeling of tacit knowledge to explicit and represent it in the form of production rules for use in manufacturing processes. The technique was applied with the involved people in the lithographic process in a Metallurgical Company located in southern Brazil. Knowledge of two production coordinators were modeled. For the process of knowledge acquisition and mapping of attributes and values to feed the knowledge base of an expert system, were used quality tools such as Brainstorming, Pareto Chart and Ishikawa Diagram associated with knowledge elicitation techniques such as unstructured interview, rating chips, observation technique, limitation of information and protocol analysis. Quality tools and techniques of knowledge elicitation were systematized to promote process mapping and the elicitation of tacit knowledge, with the aim of representing knowledge by means of production rules. We constructed two knowledge bases with the same methods of production, one in a non-probabilistic expert system (knowledge-based system) and the other in a probabilistic expert system (Bayesian networks) in order to perform comparisons and simulations of the results found. Expert systems perform systematic analysis from the answers given by those involved in lithographic labels process while the defect is identified in order to support the user in diagnosing the root cause of the failure process. From simulations of changes in process variables was possible to prove the hypothesis of the use of probabilistic expert system as industrial support tool in preventing the occurrence of defects in the process and result in a productivity gain.

1. Introduction

According to Bertalanffy (1973), physiological limitations and paradigms, which determine human capacity, limit the perception of reality in overall phenomena. From this observation, one is faced with the need for employing computing tools so that they can assist in understanding those phenomena. In this study, the phenomenon is applied in such (a) way(s) that the root cause(s) of the defect(s) may be diagnosed during the assemblage of Metal Aerosol Packaging in a Metallurgical Company, its application being intended for industrial processes in general.

The state of the art about how is made knowledge acquisition Wright (1987), Hoffman (1987), Liou (1990), Cooke (1994), Hoffman, Shadbolt, Mike, and Klein (1995), Cairo (1998), Tang, Jifeng, and MacLachlan (2008), Kim (2014), Schreiber et al. (2000), Alwis and Hartmann (2008), Pitchforth and Kerrie (2013), Oguz and Sengun (2011), Lemos (2012), Kim, Song, and Jones (2011) and Kim (2014) pursued during the preparation of this study, has shown that there is not a methodology to mapping and elicitation for the of tacit knowledge acquisition in industry, but rather the use of knowledge elicitation techniques used in isolation, without a logical sequence and objective oriented to analysis and problem solving. The methodology has been created based on a systemic approach, which is used in the observation process of complex phenomena in the industry. Concepts of Artificial Intelligence (AI) specifically expert systems (ES), have been used in the research to support the value of tacit knowledge in problem solving inside industries, as a way of disseminating it in internal processes, as well as promoting the organizational learning.

Rezende (2003) says that the main goal of AI is to enable the computer to perform human functions; so, the incorporation of knowledge proves to be essential for the success of any Intelligent

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http://dx.doi.org/10.1016/j.eswa.2014.09.023
0957-4174/

System. This statement contemplates the proposed study, which consists in mapping the type of collective tacit knowledge relevant to the solution of the phenomenon observed, thus generating a knowledge management system.

According to Alwis and Hartmann (2008) and Lemos and Luiz (2012) the transference process of knowledge from tacit to explicit within innovation management in organizations is a competitive advantage once explicit knowledge is already used in the organization; thus, it can be copied by competitors. On the other hand, tacit knowledge is new and, as such, the company will be able to remain for some time with a competitive advantage on its side.

As scientific methodology to structure the sequence of activities used for eliciting tacit knowledge, a technique called systemography has been used. It allows its users to approach, understand and interpret the phenomenon in a systematic way. During the application of the sequence of activities, some quality tools were implemented such as Brainstorming, Pareto Charts and the Ishikawa Diagram. These are tools often used to solve problems in industrial processes.

The objective of this research is to build the methodology, which aims to transform collective tacit knowledge into explicit by using knowledge elicitation techniques, associated to quality tools structured by systemography, represent it in a symbolic language and production rules, and model it in two expert systems which can assist the investigation of defect causes during the metal packaging production process. The production rules, which have been created, were stored in the knowledge's foundation in two different types of expert systems: probabilistic and non-probabilistic, to be utilized by different users. The first one mentioned will be used at the operational level and the second one at the tactical level of the organization. The expert system tools used were EXPERT SINTA and NETICA. The methodology is named MACTAK – Methodology for Acquisition of Tacit Knowledge.

2. Theoretical foundation

This section presents issues related to the study's development, such as: systemography (systemic approach to observation of complex phenomena), quality tools, elicitation knowledge techniques, tacit knowledge, Artificial Intelligence and expert system.

2.1. Systemic approach for observing industry complex phenomena

According to Neto and Fontana (2008), the modeling systems come from a general matrix. In other words, modeling is conceiving, for an object, a model which allows one to know, understand, and interpret it, as well as to assist in the anticipation of its behavior. According to Bertalanffy (1973) the General System Theory aims to develop theory and support the understanding of complex phenomena, through the elaboration of conceptual models which may represent real situations.

It is possible to conceptualize systemography as a mapping method and reorganization process. It has a systemic approach which seeks to discipline common sense and the institution through a logical process and a formal analysis of the problem, studying it as a whole and being careful with the interfacing between its parts. The chief role of systemography is to identify, map and detail the analysis of a process in order to attain an effective understanding of the problem; it studies the set of elements and relations between them Kintschner and Filho (2004), Kintschner (2005), Fontana and Neto (2006), Leite and Bornia (2006) and Neto and Leite (2009).

According to Leite et al. (2009), based on General Systems Theory, Le Moigne and Bártoli (1996) developed systemography in order to assist the process of object modeling in a complex system. The systemic approach can be applied using the systemography method, according to five steps, as shown in Fig. 1.

(1) Identify the phenomenon.
(2) Develop the general model which is able to encompass the observer's reality and the intentions.
(3) Observe reality through isomorphism. Reality is associated to the features the general system has.
(4) Develop models from reality.
(5) Act upon reality.

These steps observe the reality of industrial processes, in order to map, elicit and make the tacit knowledge of those involved in industrial processes explicit.

2.2. Quality control tools

This section will discuss some quality tools surveyed to assist in the process of knowledge acquisition.

The choice of quality tools applied in the MACTAK methodology occurred because of the analysis of research conducted by Kume (1993), Pinto, Carvalho, and Ho (2006) Amer, Wan Zaiyana, Khairul, Zuraida, and Norazan (2012) and Silva, Delai, de Castro, and Omett (2013).

In search of Pinto et al. (2006) a study of the survey type on the 1000 largest companies in Brazil, which have one of the following programs was conducted: ISO 9001:2000, Six Sigma or TQM. Survey result showed that the tool quality of cause and effect diagram is used in a ratio of 81.70% to 87.1% of the companies, and that the quality tool Pareto Chart is used in a ratio of 71.0% to 76.1% of the companies. Kume (1993) states the combined use of quality tool, Brainstorming to diagram cause and effect can be an interesting combination in problem analysis process. Amer et al. (2012) points out in its research of 150 groups, the quality tool Brainstorming helps individuals to improve the socializing and as a result, improves performance in the troubleshooting process. In research conducted by Silva et al. (2013) about quality tools to promote a lean production system, the same set 10 steps for analysis and troubleshooting. In the analysis phase of the case the authors suggest the use of Pareto Chart, cause–effect diagram and Brainstorming as being useful to aid in the improvement process.

2.2.1. Brainstorming

According to Brassard (1985), Oliveira (1995) and Aguiar (2002), Brainstorming is a tool which aids in the discovery of problem causes, taking into consideration people's knowledge of the subject related to the study. It is intended to generate ideas/suggestions that may provide meaningful advances in problem solving.

2.2.2. Pareto Chart

According to Brocka and Maria (1994), Brassard (1994), Ramos (2000) and Gomes (2006), the Pareto Chart is used when it is necessary to analyze problems in a systematic way, as well as when there is a large number of problems and limited resources to solve them. The graph, when designed correctly, indicates the most problematic areas following an order of priority. Such priorities may recur in as much as 70% to 80% of the problem in its entirety.

2.2.3. Ishikawa Diagram (fishbone)

The result of a process can be attributed to a several factors, and a cause–effect relation may be found among these factors. It is possible to determine the structure or relation of multiple cause–effect by observing the process systematically. It is difficult to solve complex problems without considering such structure, which consists in a chain of causes and effects, and a cause–effect diagram is a