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An Approach to the Acquisition of Expert Knowledge

Adam DUDEK, Justyna PATALAS-MALISZEWSKA

Abstract: This article presents the approach to the acquisition of expert knowledge and includes the following stages: (1) observation-verbal reporting, (2) obtainment of a record of the observation, (3) protocol analysis, (4) formal record of expert knowledge. The first part of the article discusses each element of our approach based on a real-time case study. Next, the structure and exemplar functionalities of the proposed information system for the acquisition of expert knowledge are presented. Our information system supporting the acquisition of expert knowledge, as presented here, is based on the example of service department workers but may be used in other areas where the procedures for performing any given activity are definable.

Keywords: acquisition of Expert knowledge; case study; Expert knowledge; information system

1 INTRODUCTION

Companies have a need to acquire the expert knowledge in forms which can be stored and retrieved later for use by new employees; however, expert knowledge is very difficult to acquire and describe formally. Moreover, knowledge acquisition techniques should be used as a support for extending human capabilities [20]. Therefore, an approach to the acquisition of expert knowledge should attempt to change expert knowledge into explicit knowledge.

Our approach to the acquisition of expert knowledge is based on the knowledge acquisition model of [2] and includes the following stages:

- Observation-verbal reporting,
- Obtainment of a record of the observation,
- Protocol analysis,
- Formal record of expert knowledge.

Observation can be used as a technique to distil tacit knowledge from human experts [18] and can be applied to such as visual and audio records of a task, as realised by experts. Protocol analysis is an analysis of the material collected during the observation. The qualitative nature, complexity and lack of order within the data are, however, difficulties [19] at this stage, when attempting to acquire the expert knowledge of a system. The formal record of expert knowledge can be understood as a solution for the structuring and codification of knowledge.

In this paper, special attention is paid, firstly to the presentation of the input/output diagram illustrating the acquisition of expert knowledge and then, to the overall structure of the system for the acquisition of expert knowledge.

Section 2, therefore, shows the research literature related to the approach to the acquisition of expert knowledge and presents the stages which are involved in the system. Section 3 presents the rules for each stage involved in this system. Section 4 presents the functionalities of the system for the acquisition of expert knowledge, based on the example of service department workers in a manufacturing company. Section 5 summarises the research results.

2 INPUT/OUTPUT DIAGRAM FOR THE ACQUISITION OF EXPERT KNOWLEDGE

According to [15], the following method for the acquisition of expert knowledge may be distinguished, namely, real-time teacher observations, analyses of problem solving procedures, training sessions, courses, demonstrations, auditing knowledge and hidden interviews. The advantage of the real-time teacher observations method over the other indicated methods is that using the techniques: voice and/or video recording techniques, you can gather material that contains full expert knowledge of the activity being observed. Using other methods to acquire expert knowledge may lead to obtaining knowledge from given points of view. The main problem in the acquisition of expert knowledge is its formal representations and transferring it into a computer-implementable format. So, the main functionality of our proposed system for the acquisition of expert knowledge should be the extraction of information from unstructured text records to structured information records.

According to the Review of Information Extraction [21], the traditional approach to the extraction of information is based on constructing lexical databases, such as WordNet [9]. The second idea is based on the concept of constructing a comprehensive reflection of the factual content of the text [3, 1]. Finally, an approach to the acquisition of common knowledge, which is based on stored and structured knowledge, was discussed.

In this paper, we will attempt to solve the problem of the acquisition of expert knowledge of each worker, in real-time, as well as examine how that acquired, expert knowledge-which is based on the example of the service department in a manufacturing company-may be converted. Cherguiaet al. (2019) [4] compared the related works that deal with tacit knowledge acquisition and converting and stated that an ontology should be used for formalisation of tacit knowledge acquired from individual actor in a workplace. In our approach we present the methods and the technologies created and used to convert the unstructured Polish text records received from expert (workers in the service department) into formal form.

For the purpose of formalising expert knowledge and its conversion the so-called finalised word dictionary (SSW) was compiled; this contains important concepts

related to the domain of tasks for which knowledge acquisition was conducted.

It was developed in co-operation with a specialist mechanic. The following groups of concepts can be distinguished; these are referred to as basic forms hereafter:

- the names of the tools used on-site, such as an Allen key, torque wrench,
- the names of sub-assemblies found in vehicle systems covered by the field of ontology, such as the brake disc, hub,
- the names of connecting and fixing elements, such as screws, pins,
- the names of consumables and lubricants, such as bearing grease, brake fluid,
- the names of simple actions, such as hammering, pushing, sliding, ejecting.

Finally, after considering the above, the SSW glossary includes about 200 basic forms, about 400 synonyms and about 11,000 flexible forms. The graphical form for this ontology with SSW is presented in Fig. 1.

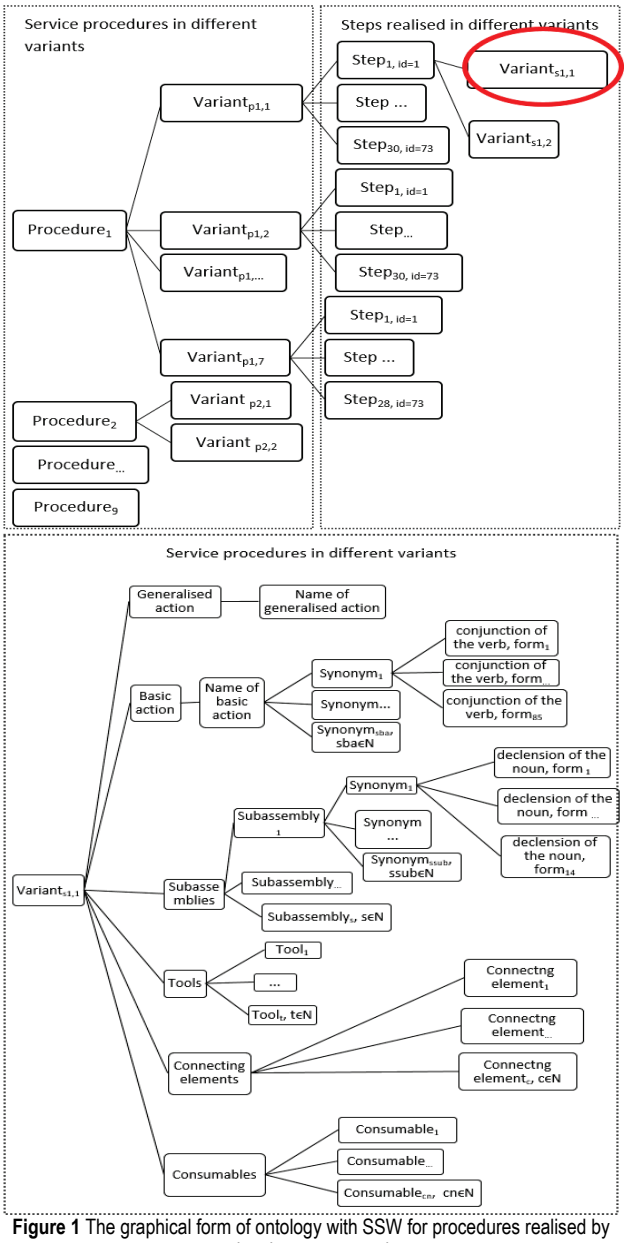

Figure 1 The graphical form of ontology with SSW for procedures realised by service department workers

Our formal approach to a representation of knowledge is based on the specific, conceptual model of explicit knowledge from the service department of a manufacturing company, described using the ontology (see Fig. 1). In Fig. 2, the input/output diagram for the acquisition of expert knowledge is presented.

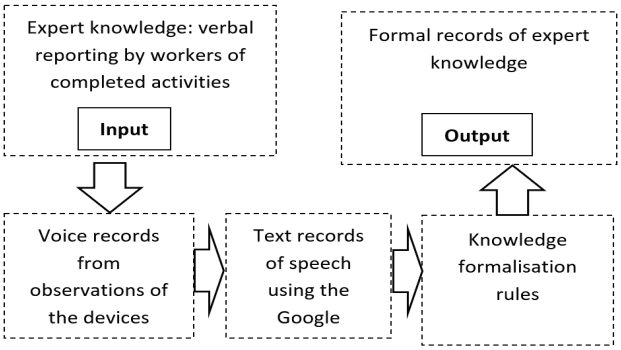

Figure 2 Input / output diagram for the acquisition of expert knowledge

3 THE STRUCTURE OF THE SYSTEM FOR THE ACQUISITION OF EXPERT KNOWLEDGE

The system for the acquisition of expert knowledge is based on the knowledge of experts in the service department of a manufacturing company, according to the diagram in Fig. 2. The following stages, therefore, are involved in the system:

(1) Observation - verbal reporting

Expert knowledge is acquired from devices such as smartphones, as used by experts (workers in the service department). This method for the acquisition of expert knowledge allows investment expenditure, for the storing of the knowledge of an enterprise, to come at minimum cost, since technical resources allowing voice recording are cheap and widely available.

(2) Obtaining records from observation

The records obtained from observing service workers are then converted from the verbal form to the written form using Automatic Speech Recognition technology (ASR).

In the case of speech recognition in the English language, there are a number of ASR solutions available, each relatively highly efficient, namely, SonicFoundry [12], Microsoft [13], Google [8], IBM [10] or Cisco [5]. Unfortunately, in the case of the Polish language speech recognition, only works in the limited number of applications are prepared for speech recognition, notably SkryBot [16], the research project Sarmata [22] and MagicScribe+ [17] and the solution provided by Google, under the name Google Speech Api, which was ultimately chosen as the tool for converting the records obtained in our approach.

On the one hand, this is highly efficient and on the other hand we can use the Commercial API programming interface or use the Google Web Speech Api, free solution.

(3) Protocol analysis

Protocol Analysis methods are used to improve the data received from the knowledge elicitation process [6] and are methods in which we can define the records received via the systematic identification of specific characteristics.

In our approach, the use of the automatic speech recognition method (ASR) allows textual representation of

voice records received earlier, to be obtained. The written record of the completion of the service procedure, expressed in the form of a text document, is expressed in the Polish language, as spoken naturally. The Polish language is characterised by ambiguity and extensive flexography, which makes processing and understanding it more difficult to automate. However, it must be transformed into a form that allows it to be analysed further.

(4) formal record of expert knowledge

For the formal representation of the explicit knowledge of the service department, an ontology has been developed in which the correct course of service procedures is represented by sequences occurring in the corresponding sequence of steps. The service department presented in this paper is responsible for vehicle inspection and repair. Due to the complexity of the systems and the technical complexity of the vehicles, the field of ontology presented has been limited to one brake and suspension system. Each procedural variant is represented by a sequence of steps that may be repeated; the service procedure and each step in the procedure may be presented in a general form as:

$$P = \overline{V}_n^j \tag{1}$$

Where: P - service procedure, $\overline{V}_n^j$ - elemental variation with repetitions of the set of steps with n-elements, n - the total number of steps defined in the ontology, and $n \in N$, $1 < j < n$, $j \in N$.

$$K = \left(cz, \overline{V}_{ch}^q \right) \tag{2}$$

Where: K - a step in the procedure, cz - a generalised name of the activity, $\overline{V}_{ch}^q$ - elemental variation with repetitions of the set of characteristics of the K step with p-elements where ch = {p-supported subassemblies, l-connecting elements used, n-tools used, m-consumables used}.

The defined stages of the system for the acquisition of expert knowledge are implemented in the software solution.

4 FUNCTIONALITIES OF THE SYSTEM FOR THE ACQUISITION OF EXPERT KNOWLEDGE

Within Stage 1: observation-verbal reporting and within Stage 2: obtaining a record from the observation, we have the following function, as an example:

The software developed allows the voice records base and their textual representations to be managed. This representation can be obtained directly in the form of text or by processing a received recording. In the case of the first, the source of the acquired text is, for example, a smartphone device, along with the appropriate software. In the second case, the source for the voice recording is a Dictaphone which, by using the Google Speech Api, is then converted into a text record (see Fig. 3).

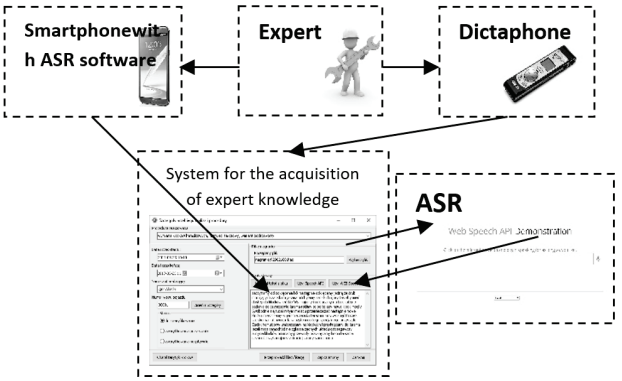

Figure 3 Obtaining a record from the observation

Within Stage 3, Protocol analysis, is the following function:

The application discussed allows the analysed record to be represented, using the ontology created with the SSW glossary. The elements of speech that do not have their forms in the SSW glossary (see Fig. 1) are written in black font, the remaining speech elements, depending on their affiliation to particular categories in the SSW glossary, such as activities, tools, etc., are colour-highlighted (see Fig. 4).

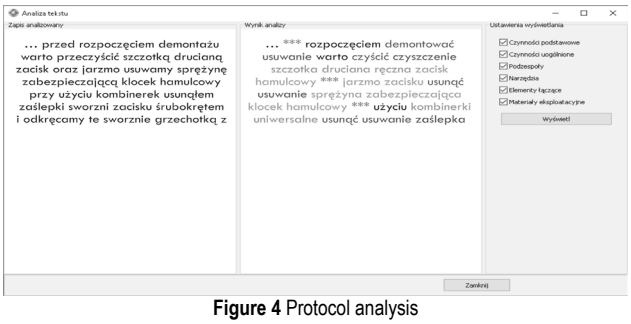

Figure 4 Protocol analysis

Within Stage 4, Formal record of expert knowledge, there is the following function:

In conclusion, it is possible to present the sequence of step characteristics, determined from the record analysed, by using the ontology with the SSW glossary. In line with the assumptions adopted in the ontology, a single characteristic is represented by the names of basic and generalised actions, in combination with at least one of the names of the subassembly, or the tool used, or the connecting elements (see Fig. 5).

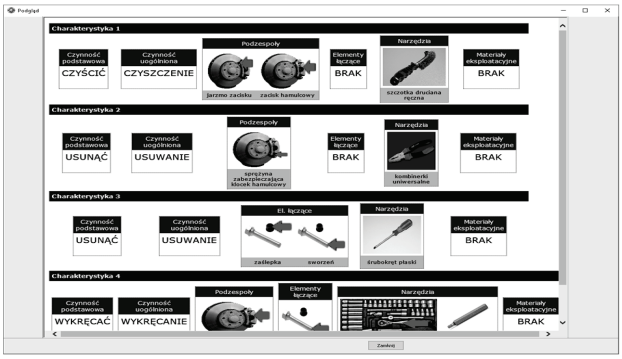

Figure 5 Formal record of expert knowledge

The application, developed in this way, also allows representation of determined step sequences by comparing

the voice records with the master step sequences of the service procedures, as described in the ontology.

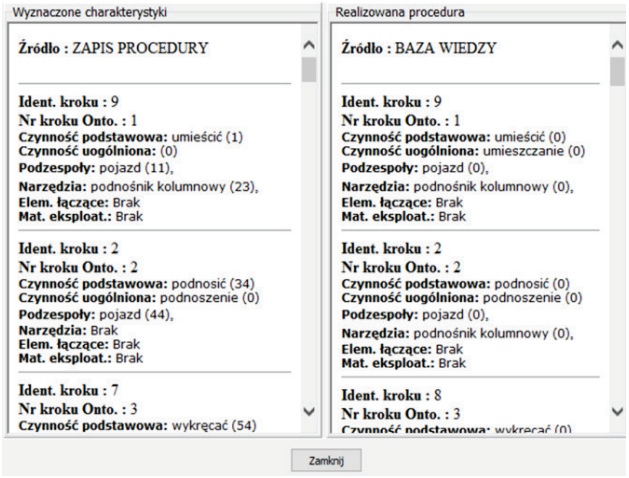

Figure 6 Formal record of expert knowledge, compared with the ontology

Our approach to the acquisition of expert knowledge, as presented here, is based on the example of service department workers but may be used in other areas where the procedures for performing any given activity are definable.

It is important that each procedure be presented as a sequence of linear steps without branches; an ontology with an SWW glossary can then be created for the master procedures; acquired, expert knowledge can then be structured and codified, according to our proposed rules.

The presented system allows the conversion of tacit knowledge based on the example of the service procedure in a production company and also acquiring new tacit knowledge in the area of implementation of a given procedure (so called service technician's know-how). The use of this system in the manufacturing company allows also to manage previously collected procedures as well as create new procedures by service technicians.

5 CONCLUSIONS

Methods for acquiring and converting expert knowledge are expected to significantly increase in number. In the learning process of a company, there is one critical moment where existing expert knowledge is insufficient for that company's development and new resources must be developed for acquiring the critical expert knowledge. Several limitations of the proposed system need to be kept in mind; in fact, these limitations might serve as starting points for further research.

Firstly, this system should be modified and made relevant to the profile of other experts as well as to their activities. Future research should extend our theoretical model to other expert knowledge.

Secondly, the present application focuses on defined services procedures in service departments.

Future research should extend this analysis to other relevant procedures in other departments within a company.

Finally, due to our approach, it will be necessary to formulate a different ontology and SWW glossary according to other, defined procedures.

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Contact information:

Adam DUDEK, PhD,
University of Applied Science in Nysa,
Institute of Technical Sciences,
Armii Krajowej 7, 48-300 Nysa, Poland
E-mail: adam.dudek@pwsz.nysa.pl

Justyna PATALAS-MALISZEWSKA, Prof., PhD, D.Sc.
(Corresponding author)
University of Zielona Góra,
Institute of Computer Science and Production Management,
prof. Z. Szafrana 4, 65-516 Zielona Góra, Poland
E-mail: j.patalas@iizp.uz.zgora.pl