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Application of human error theories for the process improvement of Requirements Engineering

Milene Elizabeth Rigolin Ferreira Lopes, Carlos Henrique Quartucci Forster *

Technological Institute of Aeronautics (ITA), Praça Marechal Eduardo Gomes, 50 – Vila das Acácias, CEP 12.228-900 São José dos Campos – SP, Brazil

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ABSTRACT

Problems with the structuring and execution of the Requirements Engineering (RE) process can lead to project failure. As the involved activities are essentially human and subjective, the importance of the human factor must be considered. The possible correlation between human errors and the problems that may occur in the RE process is explored in this paper in order to propose a process improvement approach, which applies the theories of human error to build an expert system for automated diagnosis of problems. This approach starts by assessing the importance of individual types of human errors in different contexts using questionnaires to extract knowledge from RE practitioners. A method for managing the priorities of solutions to improve a given process is then proposed and a prototype application is implemented for evaluation with practitioners. The activities with RE practitioners also provide data that are used to construct and evaluate estimators of the presence of human errors and the affected phases of the RE process. Most of the volunteering participants agree that knowledge of error typologies may help to improve their processes to avoid problems.

1. Introduction

The purpose of this research is the tentative improvement of Requirements Engineering (RE) processes. Problems during the activities of the RE process, such as imprecise plans, loss of information and information recorded in ambiguous or incomplete form [8] can cause projects to fail, delay, have the products delivered with deficient quality and overrun the stipulated budgets. Some examples of problematic projects have been reported to us, including cases of a team trying to specify a system for about 2 years without being able to release a single version for production, teams reporting lack of access to final users, managers with disparate conflicting goals and lack of people with domain knowledge for a specific project.

As most of the activities of RE are essentially human and subjective and, therefore, susceptible to human error, the Human Error Theories (HETs) may assist the understanding of the problems in the process, and the adoption of controls and methods for their prevention and detection. By enhancing perception of the problems and pointing to the estimated appropriate solutions, our research may help to solve the aforementioned kinds of problems.

The supposed correlation between human error and problems in the RE process is analyzed in this work in an exploratory and quantitative manner, by proposing and evaluating forms of application of the HETs in RE. The principal proposed form of application considers the construction of an expert system to produce an ordering of human error types by importance for specific activities of RE. This order by importance is obtained at first in a global context and later refined for particular contexts of the adopted processes. The refinement of the importance of the error types is then used to select known solutions

* Corresponding author. Tel.: +55 12 3947 5981; fax: +55 12 3947 5989.
E-mail addresses: milenerigolin@gmail.com (M.E.R.F. Lopes), forster@ita.br (C.H.Q. Forster).

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that must be implemented according to their priorities so as to improve the process. Thus, the proposed method can be seen as a solution management device to allow the incremental improvement of an already adopted process.

The methodological approach employed in this paper is based on knowledge extraction from RE practitioners. Questionnaires were elaborated for RE practitioners to help to evaluate the importance of human errors and to identify particular types of error with greater importance for selected activities of RE. For this, two activities were selected as they suit well the intent of the investigation due to having a predominance of human intellectual work that is hard to automate. The types of human errors were obtained primarily from the theories, which include their classification, dynamics and detection, prevention and mitigation techniques.

With the information obtained from the questionnaires, we proposed and evaluated a method for solution management based on process diagnosis. For this, we assumed that the importance of these error types is dependent on the adopted process and that the improvement of the process may be guided towards the implementation of solutions related to error types of greatest importance. A simplified diagnosis method was developed in order to estimate the relation between selected problems and the possible involved human error types. The employed list of problems and solution suggestions was compiled from the literature on RE and human error. To evaluate the acceptance of the method, an application prototype was produced and applied as part of an activity with volunteering RE practitioners.

From the interviews carried out with the group of volunteering RE practitioners and their consequent interpretation, it was possible to gain greater understanding of the influence of human error in the RE process. We noticed in the responses: (1) the occurrence of error types with high importance for each distinct activity, (2) the possibility of existing latent error types, (3) the varied degree of importance of error types for different contexts, (4) a possible relationship between the perception of the importance of the error type and the stage in the human action cycle in which it took place, (5) the perception of the RE practitioners of the need for a tool to help organize the activities of the process, and (6) the awareness of how to identify and treat the human error in their activities. In addition, based on data acquired from RE practitioners, classifiers able to estimate the presence of error types and the most affected phases of the process were constructed.

This paper is organized as follows. In Section 2, a review of related work considering both the aspects of human error and the improvement of the RE process is presented. In Section 3, the most relevant points of the HETs are discussed: the definition, the nature, the typology and the dynamics of the human error. In Section 4, the conceptual RE process adopted in this work is presented. Section 5 describes the research methodology: the method for knowledge acquisition from the RE practitioners through questionnaires as well as the method of diagnosis and solution management, including ways to evaluate them. Section 6 reports and discusses the results of the many parts of the adopted methodology. Section 7 finishes the paper, presenting the conclusions and a summary of hypotheses to investigate in the future.

2. Related work

The HETs are successfully applied in many areas [24,28,30]. The reader interested particularly in software requirement errors is referred to a survey by Walia and Carver [42], or, if the interest area is soft computing for human error risk assessment, to the work of Li et al. [17], which uses fuzzy logic, and Zhang et al. [45], which employs self-organizing maps.

There are many recent works on process improvement for software engineering that involve the human factor. Measurement is important for most of the techniques, either quantitative or qualitative. In [3], developer behavior is analyzed using datasets of objective quantitative information. The requirements activities are also analyzed quantitatively in [20] by considering the transformation of data during the process for early prediction of software cost. Abrahão et al. [1] evaluate requirement modeling methods using variables which measure the user's understanding and retention of the model. Fuzzy set techniques are employed to deal with qualitative information in [46], which helps developers evaluate non-functional requirements, and [19], which employs fuzzy cognitive maps to manage enterprise resource planning (ERP) application risks by aggregating knowledge from experts.

A recent comprehensive survey of software process improvement [37] may be of interest to the reader. Our following review is focused on product development with emphasis on RE. The reviewed works may be divided according to the target of improvement, either the product or the process.

Among the work concerning the improvement of products based on the HETs, Pocock et al. [27] propose a technique to anticipate interaction failures between humans and computers. This technique takes into consideration the HETs and employs cognitive error analysis, which is based on the model of human information processing by Fields et al. [7], to identify the possible human errors and their consequences for the interaction by using scenarios, checklists and questionnaires. After the application of the technique, the obtained result is a list of new requirements for the system, with the purpose of solving the identified errors, and a report about the implications of these errors in the design, to warn the project manager in the case of a decision not to implement the new requirements.

Lauesen and Vinter [16] proposed an experiment to reduce the number of defects in requirements. This experiment was used to analyze the defects present in a real product and to estimate the probable effects of 44 prevention techniques leading to the conclusion that only 10 of the techniques added value to the project. This work was based on an approach developed by IBM, named "defect analysis approach". In this approach, the defects present in a product are analyzed, the defect prevention techniques are identified and the best selected techniques are tentatively put into practice in newer projects. The analyzed defects are classified regarding many criteria, such as source of error, related interface and maintenance cost. It