METHOD FOR THE QUALITY CONTROL AND OPERATORS TRAINING IN MAINTENANCE ACTIVITIES

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ABSTRACT: Maintenance activities are very important in the aim to prevent malfunctions and ensure the reliability, safety and performance of a productive process. In this work, a method for the evaluation of maintenance tasks is presented in the aim to give an objective evaluation of the maintenance technicians' skills and therefore for identifying critical areas in which intervene with appropriate training. For this purpose, a smart helmet for the training of the operators and for the control of the maintenance tasks was modified with cameras and sensors. The data collected were analysed with fuzzy logic approach and a score of the operators' skills was assigned in order to increase the quality of maintenance activities.

KEYWORDS: Fuzzy logic, Maintenance management, Quality control

1 Introduction

Maintenance activities are very important in the aim to prevent malfunctions and ensure the reliability, safety and performance of the equipment and the overall quality of a productive process [1]. Best practices of maintenance management include the development of a maintenance strategies through preventive intervention plans, which involve activities such as routine inspections and scheduled maintenance tasks [1]. If appropriate maintenance scheduling is the basis of good management practice in order to minimize the stop of the production, keep accurate records is fundamental in the aim to identify patterns of failure, predict maintenance needs and create statistical historical data in order to forecast interventions with accurate grade of precision [1]. At the same time, IoT technologies, such as sensors together with machine learning algorithms, can detect potential equipment failures and improve predictive maintenance activities [2]. However, best maintenance

practices should also include operators training for improving the efficiency and time of the maintenance operations [3]. In fact, providing training and appropriate know-how to the maintenance personnel can increase efficiency and effectiveness in maintenance tasks [3]. Higher knowledge in maintenance tasks could also promote a culture of safety ensuring awareness of the operators in the risks involved in the intervention tasks and thus implementing the necessary precautions to avoid injuries or accidents [3]. In this work, we present a case study of Ineltec srl, a firm that is specialised in projects and maintenance operations of electric plants together with iInformatica srl, for the research and development activities. The goal of this project was in particular to design a method for the evaluation of maintenance intervention through an objective evaluation of the maintenance personnel skills, and therefore for identifying critical areas in which intervene with appropriate training. The aim of the method was therefore to create a powerful tool based on a first control of the theoretic maintenance know-how of the operators, followed by a further analysis of their practical skills through sensors and camera mounted on a safety helmet. The method gives a score by analysing all the collected data with a fuzzy logic approach in order to give an objective evaluation of the overall operators' skills and improve constantly the maintenance quality intervention. For this purpose, a helmet for the training and control of maintenance activities of the operators was fabricated with the use of a 3D printed plastic shell filled by different cameras and sensors. Finally, an internal survey questionnaire was conducted in order to measure the operator feedback about the implemented method and their awareness about the importance of new technologies in their maintenance activities.

2. Method and results

In this work, a powerful method for evaluating maintenance activities was developed in the aim to improve constantly the quality of the intervention and training the operators in a safer manner. The designed method is based on a first evaluation of the theoretical know-how of the operators followed by a second control of the skills ability in solving the maintenance tasks. The evaluation of the theoretical know-how consists in an exercise in which the operators should choose the right sequence of actions in order to complete a maintenance activity. For the representation of a maintenance intervention we took inspiration from finite-state machine method in the aim to divide a global maintenance intervention in a sequence of events and actions. Taking into consideration the complexity of a maintenance intervention we developed a new method based on bubbles of events which describe not only a binary condition (such as close/open) but also an informative-semantic information of each events. In this way, by dividing and plotting maintenance activities through bubbles diagram we are able to represent complex and not linear activities such as maintenance intervention. Therefore, in order to evaluate theoretical know-how, the operators should choose the right sequence of actions by selecting the right bubbles in the right order (Panel in figure 1).

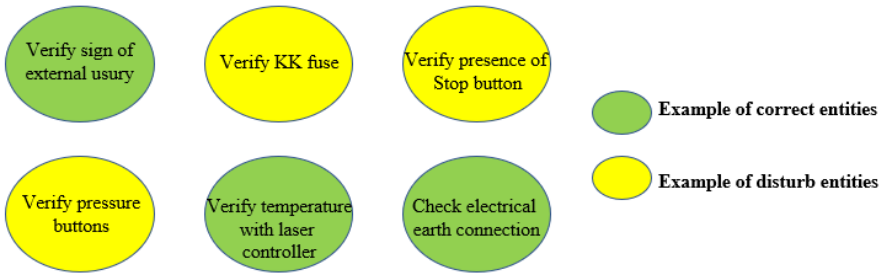

Figure 1. Bubbles maintenance test method

The implementation of also incorrect actions “disturb entities” was done in the aim to increase the difficulties of the test. The score is then attributed by considering the correct sequence of the selected actions (bubbles), decreased by the number of incorrect ones (disturb entities). The second phase of the evaluation consists in measuring operators’ practical ability in solving the maintenance activities. With this purpose we fabricated a device for the remote real-time control of the operator intervention that consisted in a safety helmet modified with sensors and cameras. In particular, the helmet included a camera, a thermo camera and an endoscope for framing inaccessible places. Moreover, a mini screen and a mini sound box were mounted in order to communicate with remote operators for receiving instructions during the training activities. Through an opportune choice of each component, and choosing light 3D printed polymers for fabricating the outer shell of each sensors, the overall weight of the helmet was increased of only 320 grams in order to maintain a good wearability and operators’ comfort during the intervention. In this way, by exploiting the cameras and sensors, a technician from remote can control the activities of the operators and give a feedback also on the practical abilities in solving the maintenance tasks and in case guiding the operators in critical situations. Thus, the final score considered both the know-how test and practical activity intervention taking also into consideration the boundary conditions in which the operator made the intervention through a fuzzy logic approach. The boundary conditions included: cleaning conditions (clean / intermediate / dirty), ventilation conditions (low / medium / high), Light conditions (low / medium / high), Spaciousness conditions (low/narrow/high), Noisy conditions (low/medium/high), customer stress conditions (low/medium/high) in the aim to increase the objectivity of the final score. An internal survey revealed that the totality of the operators was satisfied with the training activities conducted with the smart helmet and that they felt safer knowing that they could receive assistance remotely if needed. Considering the quality of the intervention, 75 % of the operators think that the helmet improved a lot their working activities and only the 25% think that the helmet had a small impact on their working activities. Finally, 100 % of the interviewers consider

important the adoption of new technologies in their work and think that new technologies will change drastically their work in the next years.

Conclusion

In this project, a method for analysing the quality of maintenance activities was designed in order to improve the training of the personnel involved and give a feedback of the quality of the maintenance activities. The method consisted in a first evaluation of the theoretical know-how of the operators followed by a second control of the skills ability in solving the maintenance tasks. A fuzzy logic analysis was implemented in the aim to consider also the boundary conditions in which the operators conducted the maintenance activities and thus assigning a more objective score of the performed task. For the real-time control of the activities, a safety helmet was modified with sensors and cameras in the aim to control the practical skills abilities of the operators. An internal survey questionnaire demonstrates an increase of operational speed, safety and quality of the maintenance intervention through the employed method, and a general awareness of the operators about the importance of new technologies adopted in their work.

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