Using virtual reality for the training of the Metallographic Replica technique used to inspect power plants by TECNATOM S.A.

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Abstract

TECNATOM S.A., an engineering services company which uses the metallographic replica technique in their maintenance procedures within industrial facilities and industrial power plants, is using Virtual Reality (VR) along with haptic feedback to test how these technologies could potentially improve safety and risks management and be a cost efficient way of training and planning of this technique. The paper presents how VR has been used to support this process as part of an EU funded project ManuVAR (http://www.manuvar.eu) and concludes with a discussion on some of the perceived benefits and future requirements of the technologies.

1. Introduction

TECNATOM S.A. is an engineering services company that provides training and assistance in safety issues within industrial facilities and electrical power plants. As part of the evaluation of the structural integrity of the major components within the plant, Tecnatom regularly performs the inspections and tests required by the applicable standards. In many cases, these activities are carried out with high levels of radiation and contamination and in places that are difficult to access. The scope of the activities includes a wide range of inspection techniques, combining the use of remotely-controlled robot-operated equipment and manual tasks carried out in-situ.

2. The Metallographic Replica technique

One test performed by TECNATOM is the metallographic replica which is a non-destructive sampling technique used to measure and analyse the obsolescence of the inner material of structures such as valves, pumps and pipes. The metallographic replica technique is a long and precise process involving several steps that include: preparing the surface of the pipe by grinding, polishing and chemical etching before the Replica application takes place. Some of these steps are performed many times under hazardous conditions in areas with high levels of radiation and contamination and in regions that are difficult to access. In addition, the accurate planning of the Metallographic Replica activity can be complicated due to the lack of up to date information.

Efficient training on Metallographic Replica task is mainly performed in situ and can be undertaken at three different levels (motor skills, procedural and managing hazardous situations). The consequence of this is that workers spend more time on the power plant site and risk being exposed to radiation and other toxic conditions. There is no software solution to support efficient training and task analysis at the laboratory. Task planning is commonly based on obsolete 2D representations of power plant pipe displayed on paper supports.

3. VR training of the Metallographic Replica technique

TECNATOM in collaboration with AARBA, the University of Malaga and the University of Nottingham are developing a methodological and technological

framework to support procedural and motor-skills training in VR for the performance of a Metallographic Replica task in a real environment under industrial conditions using a haptic device, as part of the EU funded project ManuVAR [1]. The haptic interaction technique is presented to be of great interest for motor-skills training and has already been included in a large number of commercial and non-commercial Virtual Reality (VR) applications, implicated in educational [2] and industrial [3] domains.

In both procedural and motor skills training cases, the ManuVAR architecture [4] fully supports and manages technological implementations. The Application Tool Specific Logic (ATSL) dedicated to manual work training management in an industrial environment performs necessary mathematical calculations to support users training effort evaluation, and handles communication between all technological components connected to the ManuVAR platform.

Procedural training implementation is based on a Precision Teaching (PT) method. PT is a learning paradigm, developed by Lindsley in the field of Behaviour Analysis [5]. It consists of "basing educational decisions on changes in continuous self-monitored performance frequencies displayed on standard celeration charts". Trainers may monitor performance through a performance analyzer, embedded in the Lesson Runner module, which manages the learning rules. This module shows a chart displaying the behaviour fluency (i.e., accuracy and frequency of his/her training sessions calculated as right answers per minute).Training items are displayed through a 2D graphical user interface (GUI).

Motor-skills training consists of a Sensable Technologies Phantom haptic interface that provides information on the user´s hand position and orientation with 6 Degrees of Freedom (DOF) onto a stereoscopic display supported by Virtools 5.0 VR player, and supplies moderate force feedback with 3 DOF. It is implemented in two applications: the training program, which focuses on the transfer of motor skills such as motion, angle and force, and the simulator, which is used to train the metallographic replica polishing stage. Both applications include real-time and step information feedback related to task performance

The motor skill training program also includes the PT method which divides learning into small steps allowing the trainee to improve his/her skills. The simulator takes on a holistic approach. The trainee has to complete one of the steps of the polishing task and the system estimates how well the task has been performed at every single point on the surface being polished, providing feedback at the end of the simulation in the form of a colour map, representing the level of completeness of the polished surface.

4. Potential benefits of using VR

One of the main benefits perceived by TECNATOM for using VR for training is to improve safety as well as communication between workers and maintenance engineers. It could also help in minimizing asociated risks and execution costs. Other potential benefits of VR Metallographic Replica Training include:

- a low cost training solution compared to the real world training carried out in situ, which is not always possible and affordable
- training in different situations and locations with possible display of relevant aspects of the working area, such as radiological map or hot spots
- an unlimited possibility for retrieving training sessions as much as possible without any inconvenience to the workers
- creation of scenarios within the same virtual environment to simulate different operational situations with the aim of training workers under different conditions.

In addition better and more efficient planning of the task within VR/AR in advance of the works would allow the workers to plan their activities, consequently reducing task completion, radiation exposure and stressful situations. It could also show relevant aspects of the working area as well as, classifying the tasks depending on their potential risk. This could help to minimize the risk of radioactive contamination.

5. Future work

The next phase of this work is to demonstrate the potential of the VR Metallographic Replica training system within TECNATOM facilities for improving training and task planning. The system will be installed in the organisation to be assessed by the real workers. An evaluation study including qualitative and quantitative analysis, and experimental tests performed by senior experts and junior workers will capture information regarding the costs and benefits of the application from a technological, methodological and business view point.

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