VIRTUAL AND AUGMENTED REALITY AS ENABLERS FOR IMPROVING THE SERVICE ON DISTRIBUTED ASSETS

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ABSTRACT
The evolution of Augment and Virtual Reality is enabling new solutions. This paper addresses creation of applications to support service and maintenance of distributed systems. Indeed this approach could be applied to devices provided as service for industrial and individual use and could introduce new capabilities in terms of training for operators, control and remote service support. The paper presents a case study devoted to lead the introduction of these innovative solutions in industrial and health care system.

Keywords: Augmented Reality, Virtual Reality, Simulation, Maintenance, Service, Distributed Systems

1. INTRODUCTION

Different kind of equipment and systems are extensively outsourced in Industry as well as in Public Sector. One of major aims promoting the diffusion of this approach is related to the possibility to simplify the management and to concentrate on the core activities by outsourcing the other elements affecting the processes. In addition to this aspects, outsourcing services is expected to guarantee fixed costs and to keep quality under control from sponsor point of view . The basic idea is that the external companies taking care of the outsourcing become specialized on these service and evolve to critical masses able to provide the new services as a competitive costs; basic good examples are cleaning services, energy, gas, etc.. Indeed, even if this approach is currently growing also due to popular tendencies in enterprises, it is evident that the new technologies are enabling new opportunities for outsourcing being able to address and solve specific challenges (e.g. remote control). In particular, while dealing with outsourcing related to provide and operate (or guarantee operations) of distributed systems and equipment, the tracking and maintenance of these elements becomes a pretty crucial factor. In facts, the final customers are very interested to the reliability of the systems, but being distributed such activities could result challenging and could require specific approaches. In facts, these aspects were very well addressed in ICT sector, where most of all the new hardware are remotely monitored and specific updates and maintenance procedure are performed through distributed service (e.g. mobile phones, servers, etc.).

The developments of the IoT (Internet of Things) is further reinforcing this capability and provides new solutions to integrate distributed systems and components in networks; within these architecture it could be possible to develop innovative solutions for monitoring, tracking and maintenance. This paper addresses specifically the case of equipment, systems and components that are geographically distributed and require to conduct even physical maintenance and service. A good example is related to the reload process for gas tanks, or the check of n medical equipment deployed in patient houses or hospitals. In these cases it is not possible just to operate remotely the software: it is necessary to develop a local and responsive capability to provide the service on site. In addition, in these cases, the monitoring and tracking of the equipment is also very important to increase availability, reduce losses and also to have an updated situation awareness. Indeed, another not negligible aspect is that one related to robberies and misuse of the equipment that could lead to reduced expected life and increase in costs. Due to these aspects, the authors are evaluating the development of combined approach based on Augmented Reality (AR) and Virtual Reality (VR) to support training and remote supervision to operations and maintenance of distributed systems.

2. SIMULATION, VIRTUAL AND AUGMENTED REALITY FOR SERVICE

The use of simulation for supporting education program in Industrial Plant and Components is a very consolidated approach (Ferrington et al.1992; Mosca et. Al. 1995, Del Rio et al., 2013) and even the use of Virtual Reality has been extensively applied in several sectors for training (procedures and equipment for remote operators) (Psotka 1995; Mosca et al. 1996, 1997; Moline 1997; Wilson et al 1997; Stone 2001, Longo et al., 2013).
Indeed, once innovative virtual frameworks are created, it becomes possible to use them also to improve maintenance and service in different ways, such as optimization of the service, logistics as well as preventive analysis on the context (De Sa et al. 1999; Bluemel et al.2003). Indeed the innovative use of Simulation to support service of distributed systems has been effectively applied to aerospace and energy industries (Bruzzone & Simeoni 2002; Haritos 2005).

Figure 1: Concept of Virtual Mock Up for an Educational and Training Aid for AUV Service

Augmented and Virtual Reality could support many aspects and the service and maintenance are among the most promising since the introduction of these techniques (Azuma 1997). Also the use of mobile technologies is very interesting when we move to address distributed systems; indeed the mobile solutions for simulation based training in external logistics have been demonstrated very successful in several contexts; in facts these achievements confirm the potential of mobile training concept (Bruzzone et al. 2004a, 2004b; Monahan et al. 2008; Ally 2009; Lee 2011). Indeed, the interactive Virtual Worlds are effectively enabling new opportunities in training applied to procedures and operations in many sectors (Bruzzone 2009; Raybourn 2014). The authors are currently considering to apply the use of AR/VR to health care for supporting equipment deployed in hospitals or in patient houses; in faacts the applications in Health Care of Simulation and Virtual Reality are pretty popular since many years and demonstrated to be effective (Giribone et al. 1996; Zajtchuk Satava 1997; Gaba 2004). In this paper it is proposed to investigate the use of web technologies and cloud approach to support services in conjunction with AR, VR and M&S. For instance, applications to industrial plants and components based on web technologies and virtual reality are popular from almost two decades and are continuously evolving (Bruzzone 1999; Monahan et al. 2008). Therefore even if these concepts have been investigated since many years, the recent evolution in web technologies is enabling new opportunities in service and maintenance (Bruzzone et al. 1999; Vora et al. 2002). In facts, another potential in this sector is to provide the remote users with devices able to evaluate the status of the operator in order to optimize the effectiveness of training and of operation. In this sense, the use of innovative solutions based on the capability to capture physiological parameters remotely (e.g. EEG, muscular tone, cardio frequency) has a great potential in supporting operator and user supervision; from this point of view these researches are very consolidated (Orlansky 1994; Brookings 1996) and are leading to new solutions (De Crescenzio et al.2011; Bruzzone et al. 2016a).

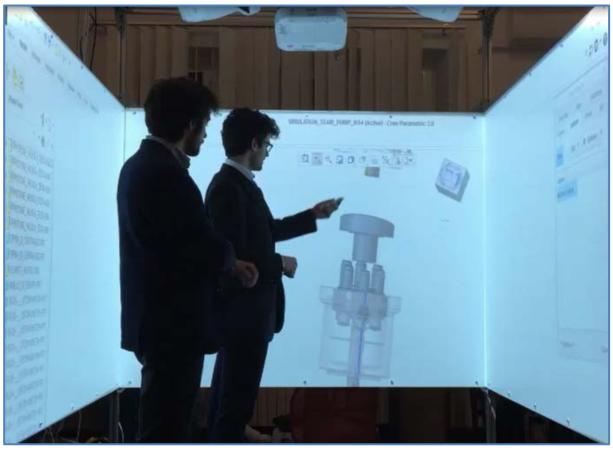

Figure 2: SPIDER: the Virtual Immersive Interoperable Interactive CAVE for Virtual Training and Engineering

The authors propose for this research the use of the innovative MS2G paradigm (Modeling, Interoperable Simulation & Serious Games) that integrates M&S (Modeling and Simulation) and Serious Games (Bruzzone et al. 2014). Indeed in our case the combined use of AR and VR strongly benefits of this new paradigm.

3. THE PROPOSED SOLUTION

The author studied in the past the potential to use AR/VR to support maintenance of complex systems; for instance studies were conducted on using these technologies on autonomous systems: for instance on AUV (Autonomous Underwater Vehicles) and USV (Unmanned Surface Vehicles) to support the service as proposed in figure 1 (Bruzzone 2013). Moreover, the Simulation Team developed an innovative mobile solution, named SPIDER (Simulation Practical Immersive Dynamic Environment for Reengineering) that allows to experiment different combinations of real equipment and virtual immersive framework (Bruzzone et al. 2016b). The SPIDER is an innovative compact and scalable CAVE (Cave Automatic Virtual Environment) based on modular units designed to fit within a standard 20’/40’ High Cube Container (just 2m x 2m x 2.6m) as proposed in figure 2. The SPIDER solution is easy to be federated with other interoperable simulator and the surface of the faces are interacting by touch screen and/or tracking pencil, guaranteeing fully immersive experience (e.g. sound, vision, vibrations and acceleration, touch).

Along last months, the SPIDER has been used to support R&D in defense, marine applications as well as transportation and logistics. In this last case, the BBBUS Simulator (Box Bull Bus Simulator), developed in close cooperation with Central Labs University of Cagliari and designed to support training, demonstrated its capabilities to support also procedural training by using the same virtual reality framework as happens in other crane simulators (Bruzzone et al. 2011).

Figure 3: Head Mounted Display in Virtual Prototyping

Figure 4: VR based on Oculus and Game devices

During the lasts years, also other solutions have been experimented by Simulation Team Partners for supporting AR and VR in multiple applications from Virtual Prototyping of Cranes to Electrical Boards and Marine Solutions (Bruzzone et al 2010).
Figures 3, 4, 5, 6 show different combinations of AR/VR devices during experimentation carried out by Simulation Team Members (e.g. DIME, Liophant, MAST, MSC-LES, CAL-TEK). They include Head Mounted Display (HDM), VR Googles and Glasses, AR Tablets and integrated HDM/CAVE

4. SERVICE DISTRIBUTED SYSTEMS

The researches carried out by Simulation Team identified a specific case study in service for distributed systems. In particular the analysis addressed tanks, containers and equipment used to provide O_2 to industrial operators, Health Care Infrastructures and individual patients at home. In this case, the components/systems moves from simple O_2 tanks to cryogenic containers and to respiratory devices. In addition the application field include industries, public institutions and consumers.

4.1. Gas Container Service

Indeed the Gas Container business sector involves big enterprises and include management and logistics of several hundred thousand containers of different type and size. This issue is even more crucial in Healthcare Sector. Given the average cost of a single unit, the container stock represent a capital for the companies; furthermore the containers, in particular gas cylinders, are easily lost or stolen and require to be controlled over wide regional distribution. Currently, it results pretty interesting from major companies active in providing these service to investigate new solutions and architectures to track cylinder locations in the gas container business. This aims to reducing cylinder losses, improving containers managements and stock controls. In addition, the producers of medical ventilators result interested in developing new capabilities to remotely assist patients increasing direct supervision and reducing the manning required to maintain the apparatus.

Respect old solutions, currently the use of innovative technologies based on web applications, cloud approach and enabling technologies in terms of markers and trackers allow to create really new and ad hoc architectures supporting good scalability and flexibility, as well as reusability in a wide spectrum of applications. In this sense the use of AR and VR creates synthetic environments to represent the current situation for management as well as training and educational activities. The authors are currently investigating combined solutions to propose a specific configuration and a road map for developing a prototype and a pilot experimentation on a set of gas containers.
The research aims to finalize a feasibility study on configurations and architectures able to track and monitor medical gas containers and ventilators. This research is focused on creating a tailored solution to guarantee overall performance and benefits, taking into account constraints and reliability of the adopted elements. Indeed the design of the configuration will be based on the following functions: capability estimation, costs and development times for virtual prototyping, tailoring and engineering, integration and implementation, verification, validation and testing.
The proposed solution is currently based on the integration, within a cloud, of different technologies such as AR, VR, Markers, RFIDs, Trackers, Webcams, Cloud Connectivity, Smart Phones and Web Applications to provide distributed services, tracking and training for medical ventilators, gas containers such as cylinders and cryogenic containers. The solution is expect to be available to support logistics and reduce risk of losses as well as to assist the patients remotely, limiting the need of qualified operators and supporting planned and preventive maintenance. In addition this solution will be flexible for being extended to other sectors where the containers are used (e.g. industrial application for O_2)
One major achievement is using the Augmented and Virtual Reality for remote support of the service, training and supervision of the equipment within the proposed architecture. This further increases the benefits of the architecture and prepare a large number of operators through distributed training.

Figure 5: Solution based on tabled and AR

Figure 6: AR solution based on web application

5. VV&T

It is fundamental to conduct integrated Verification, Validation and Testing (VV&T) of the proposed solution, in order to guarantee its effective application. From this point of view, it is proposed to use the AR and VR environments to conduct tests with Subject Matter Experts (SME) and to evaluate reliability, effectiveness and efficiency. Also, it is proposed to adopt different techniques during the development of the proposed solution (e.g. walk through, face validation, virtual examples). The dynamic testing on the virtual simulator and the use of Augmented Reality, on real system and mockups, guarantees to perform early-phase tests, supporting the adoption of Virtual Prototyping approach. The authors are currently working on developing an framework to be reused over different systems and component for conducting multiple experimentations. Dynamic validation on the experimental case is based on the application of Design of Experiments to identify critical factors and reliability of the proposed solution (Montgomery 2008). Moreover, the authors are considering the use of smart phones and tablets as main support for AR/VR on the field and specific testing activities are on going for identifying the hardware/software platforms to be used by the operators. The dynamic performance measurements on the proposed architecture is conducted, until now, mostly in laboratory, waiting to move to an external pilot test in synergy with a major industrial operator. Indeed a specific complex element to be evaluated is the capability of this approach to be resilient respect non-cooperative behaviors, carried out by external people and final users, that possibly damage or alter the distributed systems to be maintained and its components.

CONCLUSIONS

The paper proposes a preliminary research about the use of Virtual and Augmented Reality for the remote service of components and systems. The proposed architecture guarantees the possibility to support local operators as well as remote supervision. In addition, the approach provides a very effective framework for training and education for staff to be involved in service both remotely and in main control rooms. This approach is expected to reduce the cost of the distributed components/systems and to increase their reliability. This will lead to further reinforce the outsource services and the competitiveness of operators The specific case related to the O_2 Containers and equipment is a good example where the use of this technologies demonstrated to be very promising. The authors are working to develop a first pilot to demonstrate and promote this research track on the field in cooperation with a leading industry of the sector.

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