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Reducing Dangers within Industrial Plants by Extended Reality

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Abstract

Every now and then, it is possible to hear about world-famous accidents occurred in industrial plants. Indeed, many of these facilities are characterized by multiple risk factors, such as areas with excessive temperature or noise level, presence of dust, chemical agents or other hazardous materials. On the other hand, there are numerous and less known minor accidents and near-misses involving operators that in other circumstances could lead to more or less serious injuries. In this study authors propose addressing of the problem of safety by creation of an interactive environment representing dangerous areas, such as confined spaces, in order to improve preparation of operators. In particular, it is studied use of AI (Artificial Intelligence) in joint connection with immersive, interoperable, cyber-physical system including a wearable solution in order to increase the perception and the ability to contribute to the management and control of the process.

Keywords: Safety in Operation; Extended Reality, Dangerous Areas, Simulation

1. Introduction

It is very common for Industrial operators to manage with dangerous goods or to work in a risky environment. For example, in some industrial Plants there are many confined spaces in which the storage of dangerous goods represents a real hazard for human safety. Indeed, research in the area of safety measures in order to preserve health of operators is constantly growing but the overall number of accidents remain high. Many of these accidents are caused by the inexperience of the operators or paradoxically by the over self-confidence of the most experienced workers. Thus, it is very important to constantly improve and create new safety systems. To reach this goal it is essential to properly train personnel providing them new tools capable to recreate the real environment and immersive situation in which the operator can live a real experience. Thanks to the fast developments in software and hardware fields, nowadays new opportunities to create advanced technologies tools to support personnel arise every day. Extended Reality (XR), which includes Mixed reality (MR), virtual reality (VR) and Augmented reality (AR), represent the best tool for an immersive experience and to train operators constantly and in a safe way, without risk to damage working equipment or be injured. These Immersive Technologies, also known as Digital Reality, allows users to interact with virtual environment in apparently physical way using wearable or mobile devices (Bruzzone et al., 2020). In addiction modern industrial plants and production lines are characterized by advanced control systems, numerous sensors as well as capability to collect and transfer a huge amount of reliable data. The amount of data available could contain the crucial information to characterize the status of the systems and to feed the simulation models devoted to predict its behavior. In this way it could be possible to control the operations in real time and to predict and optimize many aspects of the industrial processes, fact that turn even more critical when

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dealing with dangerous environments (Bruzzone et al. 2018). Indeed, this data could be used to create even more realistic virtual facilities and even to reproduce dangerous situations occurred in the real life. For all these reasons it is evident advantage to create models capable to reproduce the risky environment and even to optimize the industrial process. In this case, modeling and simulation represent powerful tool that can be used in order to find the most efficient way to reduce risk and optimize process in Industrial Plant.

2. State of the art

The risk of accidents is often associated with the incorrect storage of dangerous substances in high quantities, excessive temperature, high concentration of chemical agents and other factors that can create, if not properly managed, potential threats to human health (Christou, 1999). There are several world-famous examples of these accidents, such as the Union Carbide in Bhopal (1984), AZF in Toulouse (2001), BP refinery in Texas City (2005), Deepwater Horizon in the Gulf of Mexico (2010). On the other hand, there are also many minor industrial accidents every year caused by high level of noise, presence of various agents, dust, inexperience or negligence of the personnel, that can cause more or less serious injuries. Reviews of case studies indicate that the most frequent cause of accidents at work in industrial processes is the incorrect handling of the process units by the operator (Coleman, 1994). In some studies, it was mentioned that accidents occur and re-occur in the process industry because of the inefficient use of information and he lack of learning form the lessons that are available from accident data (Kletz, 1998; Nazir et al., 2014). Thus, it is very important to constantly train plant operators in order to reach a safety-focused approach in which they can act properly. In addition, there aren't too many occasions in which they can train in dangerous situation because the real training in risky environment is not safe and also very expensive and time consuming. Indeed, reducing incidents, increasing time to value employee skills represent a primary objective to focus on. For these reasons this research focuses on testing of innovative solutions and techniques for different applications, such as improvement of safety of operation, boost of performance and efficiency and even to support supervision and maintenance for industrial production line, with particular attention to the Extended Reality (XR). With the advancements in Industrial Internet of Things (IIoT), the capability to gather large amounts of data, combined with evolution of acquisition, storage and processing techniques, often referred as Big Data, highlighted importance of XR solutions, capable to visualize information in interactive and immersive way. Indeed, XR has become a crucial technique for monitoring, tracking and maintenance in industrial plants and for support of operations and troubleshooting (Bruzzone et al., 2018). In addition, the developments in software and hardware allow to create more and more sophisticated and realistic experience while at the same time the price of respective technological solutions is decreasing (Hale & Stanney, 2014; Bruzzone et al.,2016; Berg & Vance, 2017). Indeed, nowadays there are available several low-cost, feature-rich and extendable solutions, while in the past more limited and much more expensive systems were available mostly to big companies and institutions, such as in defensive and aerospace field (Vandervliet 1992; Oberhauser et al.,2015). For instance, we can mention Hololens for AR (4'000 $), Oculus Rift (400 $) down to less than 40 euro for a Headset holder for a smartphone able to support stereoscopic viewing and VR (Papachristos et al.,2017; Bruzzone et al. 2019a; Elor et al.2020).

3. Case Study

In this study it is proposed creation of an interactive environment to support activities in dangerous areas, which could be done through the combined use of AI (Artificial Intelligence) and in particular, Intelligent Agents (IA) in joint connection with models integrated all together with Immersive, Interoperable, Virtual Environment. In this there are identified following principal goals such as creation of a training platform for operators in a wearable solution. The study focuses on confined spaces that represent a high risky environment.

This simulation tool should be integrated in a low-cost solution such as smartphone or VR device. In this case the use of IA is crucial to reproduce real actions and reactions of the players within the scenario.

Fig. 1 *Example of XR application using Hololens*

Development of an innovative remote support system, capable to take advantage of combined utilization of XR and digital twin of a facility or of a machine in order to extend capabilities of traditional remote supervision by integration of data provided by the digital twin. Considering this, it could be possible to compare real and expected output as well as to test hypothesis on simulated analog before actually implement them in the real system.

3.1. raining of personnel

In this study many dangerous areas were analyzed, while the most interesting resulted to be the confined space for storage hazardous substances. Indeed, accidents in confined spaces, which are often caused by presence of gases, arouse attention and considerable interest from the point of view of prevention and handling of emergencies. In such confined spaces it is important to evaluate the quantity of dangerous substances and / or pollutants introduced and how they are stored. It is also necessary to use dedicated sensors to ascertain the quality of the air and the conditions of the instrumentation inside the confined space. The training then proceeds with the use of such equipment for the detection of characteristic parameters. The user after carrying out the preventive checks can proceed with his usual maintenance. The

simulator introduces elements of difficulty into the game to which the user must react. These elements are divided into two categories. The first includes all those pre-established events, which, thanks to a data collection, seem to be the most frequent. In this way the user is trained to face a dangerous situation, but thanks to virtual reality he can do it remotely in total safety while still living a realistic experience. The second element, on the other hand, is represented by unexpected factors that the simulator introduces. To reach this goal the AI could be used by Intelligent Agents (IA) able to reproduce the actions and reaction of the different players within the scenario, such as operators, competitors, external threats, internal threats, coordinators and supervisors that by dynamically perceiving the status of the situation and reacting to it, determine the evolution of the system. Artificial Intelligence is based on techniques designed to reproduce intelligent processes. Modeling and Simulation and AI are strongly connected because simulation often has to incorporate intelligence to control assets, virtual human beings, virtual organizations, planning activities. Intelligent Agents represent an AI solution for coupling complex scenarios with many entities that interact in a complex way. These IA should be interoperable with the different models that compose the virtual environment without any pre-established schemes in order to guarantee flexibility and composability of the proposed approach. IA are crucial element to provide the user with the possibility to live a realistic experience within the virtual world, in which the stimuli are not always the same, but change based on boundary condition evolution and human player actions and decisions. In this way it turns out another need for the AI integrated in the proposed architecture that deals with the necessity to be able to finalize the user, produce some self assessment capability and even support the player(s) on its own decisions. In fact, by this approach it become possible to evaluate the ability of the users to react and adapt themselves respect unexpected, hostile and/or sudden events.

3.2. "Smart " Control

The amount of data nowadays available could contain important information in order to characterize the status of the system and to predict its behavior. Indeed, it may be possible to control operations in real time, predict and optimize many aspects of industrial line and monitor the efficiency and the security of all the instrumentations and processes. In this way Augmented reality and related wearable technologies represent very powerful instrument, capable to alert managers and on-site operators about the necessity of immediate intervention.

Thanks to Big Data and Machine Learning algorithms it turns possible to create "smart" machines that synchronize with the real operations and processes at any time, providing a clear understanding of the current, past and possible future situations. Sensors constantly send signals on the status of the equipment to the control room.

Fig. 2 Example of AR to support Industrial Production

The large amount of data not only allows to alert in real time if there is a failure, but can create a predictive model able to alert in advance whether or not a failure will occur.

The operator on the spot thanks to the wearable solution through augmented reality is coordinated directly by the highly specialized staff in the control room. Moreover, by modifying the present state of the equipment, the operator will be able to see in real time how the scenario can change, the consequences of his actions and possible solutions.

3.3. System Architecture

In order to create this complex and flexible model for all proposed solutions, it is necessary to develop a support architecture that is able to integrate the various devices, information, models and wearable technologies (Longo et al., 2012). An example of on-line control of a production plant is summarized in figure 3. Because of the central role of Big Data, it is necessary to set up a data acquisition and exchange system that is fast, efficient and flexible. To reach this goal, it is proposed to create a centralized database which stores and save data and periodically retrieved them from the server and send to the client.

The Server therefore also performs analysis of the data and the elaboration in order to create the prediction model and to send alert and corrective actions. Another important aspect is to guarantee security because of the sensitive data; in order to reach this goa,l it is possible for the server to access to some parts of the production line through a read-only access.

This solution, with the addition of a firewall, reduces the possibility of unexpected intrusions. Another critical issue is the connections security and the most suitable solution it is WPA2 for the connection while all connected devices must operate within a secure Virtual Private Network (VPN) (Nguyen, 2018).

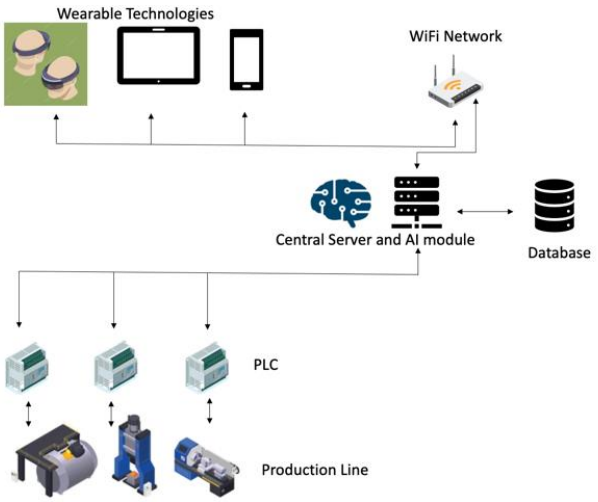

Fig. 3 System Architecture

Probably, due to human factors that are strongly correlated with security and safety aspects (Bruzzone et al., 2019b) it turns necessary to implement access control on the devices introducing policies and encryption.

4. Conclusion

The study proposes an interactive multifunctional environment devoted to train and support operators in their activities in dangerous areas.

The project shows the possibility of integration of modern mobile and wearable technologies in the production line. Literature reviews and past data show us how many accidents are the result of low experience or absence of training of the operators, or how we still do not notice the signals that alert us to a malfunction.

Availability of large amounts of data makes it necessary to use new, simple and low-cost solutions capable of integrating and processing a lot of information.

Thanks to relation between M&S and Artificial Intelligence, it is possible to create predictive model and identify synergies with available information system and to integrate data in modern plants in order to improve efficiency and safety. The complexity of these systems and the related data could provide a great benefit by using effectively the new capabilities provided by recent technologies related to extended reality (Virtual and Augmented reality in combined way). The consistent advancements within the immersive technologies such as Headsets and/or Hololens and other full range of interactive devices (e.g. force feedback input/output, motions 6DoF). The authors are currently working on new developments to demonstrates specific scenarios.

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