ISSN 2004-2965 Energy Proceedings, Vol. 23, 2021

International Conference on Applied Energy 2021
Nov. 29 - Dec. 5, 2021, Thailand/Virtual
Paper ID: 598

Smart augmented reality with AI service expert for world's industries

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ABSTRACT

Many businesses have begun their digitalization journey. 4G/5G and internet of things (IoT) have made their entrance into the industries, universities, society, culture and clothing businesses with new tools and applications that supports for example virtual reality (VR), augmented reality (AR), and mixed reality (MR). AR is a technology that for example allows the ability to support and guide customers, supported by smart glasses and other devices, around the world when service technicians cannot travel to the customer. Despite a pandemic that, as one might think, should have made the introduction of AR go smoothly and quickly, this technology seems to be introduced with a slow pace. In this paper a smart framework for AR utilizing artificial intelligence (AI) will be explored. This literature study investigates a concept and suggest a framework for creating smart AR that learn from all errors handled over AR calls and thus builds up a database of errors and solutions. When services can be provided via smart AR, the opportunity is given to reduce travels, which in turn has a positive environmental impact and additionally contributes to an increased productivity when service can be given instantly when the error occur.

Keywords: intelligent systems, augmented reality (AR), CO_2 emissions, digitalization, internet of things (IoT), industry / service

NONMENCLATURE

Abbreviations

AI	Artificial Intelligence
AR	Augmented Reality
CNN	Convolution Neural Network
CV	Computer Vision
GAN	Generative Adversarial Network
IoT	Internet of Things
IS	Information System
IT	Information Technology
LDA	Latent Dirichlet Allocation
LSTM	Long Short-Term Memory
ML	Machine Learning
MR	Mixed Reality
NLP	Natural Language Processing
SVM	Support Vector Machine
VR	Virtual Reality

1. INTRODUCTION

Increased demand on real-time communication accompanied by a growth in the numbers of networked users is unfeasible due to e.g., limited bandwidth and inadequate network infrastructure. These trends can be attributed to the wider use of digitization, decentralized communication, and advanced analytics. These concepts are trending due to the demand towards industries to increase production, efficiency, and safety. Additionally, industries are pressured to provide the market with custom made product at mass production rates. In addition, the Paris agreement has also increased focus on environmental issues and set goals to reduce emissions for the industries, for example the Swedish government has decided to become a fossil-free country in year 2045. Which has led to several industries switching to meet these goals. As an example, Aitik, Boliden, has started electrifying parts of the truck journey to transport ore with good results in terms of both productivity and emissions. These requirements force industries to apply new technology to minimize downtime in production that can be created through a more efficient and improved maintenance process that today may require weekly outages for some industries.

In this article the possibility with AR is investigated and concludes with a discussion concerning smart AR as a possible solution to meet the above-mentioned challenges. This paper provides a literature review and subsequently creates a conceptual framework. The

Selection and peer-review under responsibility of the scientific committee of the 13th Int. Conf. on Applied Energy (ICAE2021).

reviewed literature topics are AR and AI. The related results of the literature review suggest a real and conceptual framework for a smart AR solution to create efficient maintenance processes in the future supporting autonomous operations.

2. BACKGROUND

2.1 Service and Maintenance

Recent studies [1] based on 72 interviews with large-scale industrial organizations around the globe shows that unplanned downtime costs, on average, $148 a second – or almost $9,000 a minute. Among the Fortune Global 500, the industries are valued to forfeit 3.3 million production hours and $864 billion on the occasions of unplanned downtime each year. The financial losses have been estimated to 8% of organizations´ annual revenues. Furthermore, it has been appreciated that approximately 25 incidents occur of unplanned downtime a month per organization. Service organizations is labor intense and global organizations seem to be represented in many countries with both sales representatives and providing local services. But will this really be needed in the future? This indicate that predictive maintenance as well as introducing smarter tools might play a crucial role for reducing costs and to improve the productivity by reducing the unplanned downtime for customers as well as for the structuring of a service for a global organization.

2.2 Augmented Reality (AR)

AR can be described as an enhanced version of reality created using technology to overlay digital information on an image of something being viewed through a device. By adding virtual objects to your reality, you get more out of what you see. When a person's reality is supplemented, or augmented (amplified), with computer-generated images, you experience AR. A few industries and organizations like ABB, TÜV, Alstom, Siemens, Nestle, Electrolux have initiated a service with AR. The service allows troubleshooting and simple errors to be fixed over an AR call supported with various devices such as mobile, computer, iPad, and smart glasses. The technology makes it possible to photograph and record the conversation so that the recorded information can be forwarded to experts for further analysis if the error could not be fixed at once. This is where a smart AR solution is proposed to handle all information by saving text, audio, images, and videos into a database and in the future learn which are the most frequently asked questions and errors that occur and propose maintenance activities.

2.3 Artificial Intelligence (AI)

AI has been widely used in many areas. For example, in the customer service area, Natural Language Processing (NLP) is popular, because it enables a smart question and answer system.

NLP is relied on tokenization of text documents and processing the matrix related to tokens. Typical tokenization techniques include affix removal, successor variety, table lookup, N-gram [2], LemmaGen [3], Dictionary Based Search by Removing Affix (DBSRA) [4], and Graph-based lemmatization [5]. Different languages require different tokenization techniques. The matrix processing techniques include Support Vector Machine (SVM) [6], Long Short-Term Memory (LSTM) [7], Latent Dirichlet Allocation (LDA) [8], and so on. SVM is mainly used in classification task; LSTM can use previous information to get better understanding of current text; LDA is mainly for topic modelling. These algorithms have shown their power in NLP and are updated frequently in recent years.

Another example is the computer vision (CV). In this area, a lot of machine learning (ML) techniques have been developed as well, such as convolution neural network (CNN) [9], generative adversarial network (GAN) [10], scale-invariant feature transform (SIFT) [11], convolutional autoencoder (CAE) [12], and so on. These techniques could support tasks such as image recognition, image reconstruction, object detection, and so on. CNN is useful in image recognition, GAN is useful in image reconstruction, SIFT is powerful in object detection, and CAE is based on CNN but is more suitable for more effective computing. The above-mentioned AI techniques form the basis for creating smart AR for the industry.

2.4 Case Study: Underground Mining

Mining production is predicted to completely develop into an autonomous operation. Developing an autonomous underground mining manufacturing system proves difficult due to inadequate connectivity and non-uniform manufacturing environment. To solve the connectivity issue, the mining industries are investing in information system (IS) and information technology (IT) infrastructure to provide connectivity to the overall control system. It is understandable that there is a large interest to early diagnose as for detection of problems that can occur in underground mines. However, the transition to a fully autonomous mining will not happen over a night. A fully autonomous mining operation will demand solutions that can be trustworthy. So, the detection of faults that can lead to harmful situations is of outmost importance when approaching an autonomous mining operation. Preventive maintenance will play an important part of the success.

3. METHODOLOGY

3.1 Test Cases

To create awareness of AR a series of tests have been conducted [20] however in this paper only three of the tests are highlighted. Some of tests were performed at the mine sites while one was conducted in a laboratory. We have followed a few AR suppliers and validated them for a couple of years from the time the software and hardware were created to the mature product for which it has been developed today. In the last year, it has matured so much that industries are now showing interest and starting to use it for simple service matters. Different devices like mobile phones, iPads, computers, and smart glasses have been used in the tests. Different service situations have been staged to validate the tools whether these can improve the service experience but also to understand AR improvement areas.

3.2.1 Test Case 1

An emergency arose when a drive system broke down at a customer site. The supplier used a computer for connecting the AR call and guiding the customer who was equipped with a mobile phone. Both supplier and customer were in the same country but in different cities, when conducting the AR guidance.

3.2.2 Test Case 2

A customer problem had been unresolved for several years. An AR call was established between a service technician in one country and the customer in another country far away which would have taken 1 day to just travel to. The supplier and customer used same equipment as in test case 1. The only different between test case 1 and 2 was that the troubleshooting was being recorded.

3.2.3 Test Case 3

In this case, a spare part was needed to be replaced on a switchgear in a laboratory. Two experiments were performed twice. In the first experiment with a person with a behavioral science background and in the second with an electrical engineer. Both were guided via AR smart glasses at the same switchgear in the same country by the same expert who was in another country far away. The expert who was connecting via the computer gradually took them through everything from making sure they were protected and grounded, to changing spare parts and finally starting the switchgear. In this test smart glasses were used to have hands free so they could be used for changing the spare part.

4. RESULTS

4.1 Results of Test Case 1

With AR, troubleshooting and error correction was fixed within 30 minutes. The lesson was that with guidance amplified by AR proved to be successful. Such a problem would have taken at least 8 hours before it could have been solved. That would have been the case if service technicians had traditionally had to travel to the customer. The stop time was now significantly reduced, which can be compared with a production loss cost of $50,000 per hour with a minimal environmental impact.

4.2 Results of Test Case 2

Thanks to that the AR call was recorded during the actual troubleshooting and when the error occurred. The recorded session was later shown over a Skype meeting with ten experts around the world who solved the problem after 30 minutes. The solution was communicated to the customer who could solve the problem. Lessons from this test, none of the ten experts needed to travel meaning zero CO_2 emissions. In addition, saving travel costs for the company as well as the time for the persons that was not forced traveling to the customer and conduct the troubleshooting at site. Finally, it was the combined competences that solved the problem. The recorded troubleshooting could be stored and reused to train new employees.

4.3 Results of Test Case 3

Both succeeded to replace the spare part. However, one person managed to complete the task much faster than the other. In this case, it was the person with a behavioral science background since that person was completely in the hands of the expert and asked no questions. While the engineer asked several questions e.g., why should I do it like this? I would have done it like this instead. So, it took longer time to do the spare part change.

4.4 Framework for Smart AR with AI Expert

An illustration of proposed smart AR in industry is shown in Figure 1. The AR is used by the on-site labor in the industry. When this labor faces some maintenance problems, he could report errors in form of text, audio, image, and video. The self-learning AI expert behind the smart AR will understand errors and provide solutions in AR for it. The AI expert is self-learning means that it will learn from human expert and historical data. In the beginning, the AI expert may have quite a lot of unsolved errors from on-site labor. The AI expert will pass these errors to human expert and get the right solutions for it. As more and more errors are solved, the database of AI expert will be enriched enabling it becomes smarter and has less unsolved errors for human expert. Therefore, the production of industry will be more efficient.

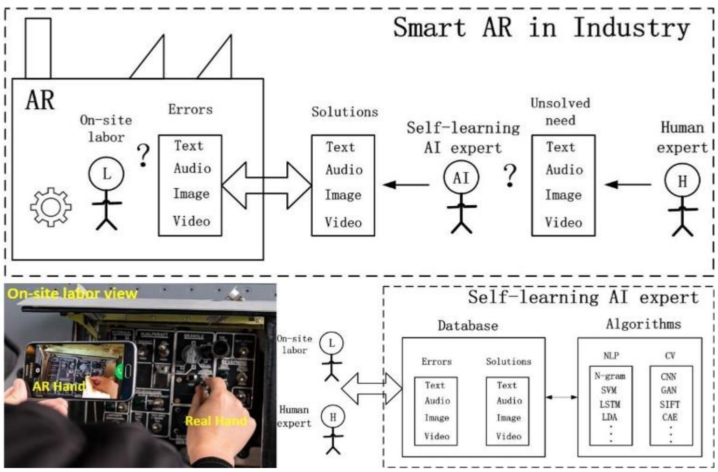

Fig. 1. Illustration of smart AR in industry

5. DISCUSSION

The results from the described cases showed that downtime was improved with an increased resolution time. Competence sharing, and improved service quality and access to quick support from different parts of the world was highly appreciated by those who was being guided. Travel costs was reduced and CO_2 minimized.

To introduce only AI solutions for monitoring and predictive as for preventive maintenance in the industries [13] a study shows a reduction level of unplanned downtime by 50% are possible and a payback of the investment in this technology is less than three months. However, if we combine AI with smart AR we believe an achievement in reduction of labor cost on maintenance and even faster resolution time could be the result. That study concluded [1] with Fortune Global 500, to have a possibility to reduce the downtime by 1.7 million hours and deliver a 4% productivity increase worth $432 billion by introducing AI for maintenance. This shows that AI will be an important player in the future for the industry. Combining AI to develop Smart AR supports the need of structuring the information that will be collected and used for training the AI application. This article proposes a framework of smart AR supported with AI. This will store, in a database, all information that will be communicated over the AR call. By practicing, AI algorithms will learn what the most common errors are and thus suggest maintenance activities. Smart AR allows that simple and frequently occurrence of errors could be handled via AI while those that occur with less frequently could be transferred to a human expert, like in figure 1.

Creating services via AR has also a positive impact on CO_2 emissions which was discussed at last year ICAE [21]. When we do not need to travel with airplane, train, buses etc. to support a customer and considering the direct CO_2 reductions, it most likely would be possible to half the emissions from business travels. Which is equivalent to at least 50 Mton CO_2 eq.

In one of the tests, it was also proven that being guided by an expert the person that had no engineering background was the fastest to exchange the spare part. Meaning does this kind of service really need to be done by a local experienced service engineer? Most likely it could be done by anybody who can follow instructions over AR tools. In some countries there are restrictions today who are authorized to conduct such work. With the new IoT tools, these rules can be challenged in the future as service organizations introduce new ways and tools to perform a job where customers need faster resolution time to maintain or increase their productivity.

6. CONCLUSIONS

The conclusion from this study is that service and maintenance organization is an area that can most likely benefit from introducing IoT tools that are smart, as suggested in figure 1, and thus contribute to a sustainable world. Most likely, the simplest problem can be solved with an AI expert without local experienced representatives and thus use human expert more effectively to solve more severe problems. Making AR smart with AI will support also that information is properly stored, and one can learn from it and reuse the information.

ACKNOWLEDGEMENT

We like to thank our sponsor Vinnova and Aitik, Boliden, in Sweden and George Fisher Glencore in Australia, mining businesses for the test opportunities.

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