# Design and evaluation of a prototype of augmented reality applied to medical devices.

## Summary

The study was aimed to incorporate all information regarding a medical device through augmented reality. This was done through a mobile application. The method of study had three stages; firstly, assessing user’s requirements through surveys and questionnaire and finding out any important information which will be included in the app such as what medical devices will be used, secondly, prototype development, and finally Software evaluation. The project was based on “Rapid Application Development” (RAD) methodology.

The application was usable on three medical devices and developed by qualified professionals. The human centred model was applied to develop the software taking into consideration the users, the environment in which they will use the application in, user requirements, design features and user assessment.

Results obtained were the following; firstly, 11 nurses and 280 healthcare professionals took part in the questionnaire where the majority agreed t include instructions, indications of use as well as descriptions of the medical device being seen in the AR app, secondly instructions and user friendly and readable description of the prototype application must be included within the app itself through text , images and videos and finally software evaluation .

When evaluating the software, the users described it as “very intuitive” since description of any medical device can be obtained very easily. The think aloud method helped in gathering only the relevant information which was needed in the prototype making it more likeable by the users. Three improvements were identified through the latter method, these were the following; virtual image vibration made the app difficult to use, no zooming function was applied in the application and finally the ability to still keep focus on device without having to keep scanning the actual device. The first problem was solved through dual aim and as a result fixing the virtual image fixed also the functionality of keeping focus on the device. The last problem was solved by including the zooming function.

The main limitation of the application was the process of updating information of medical devices without making use of any databases which in Spain (where the research was carried) did not exist. This results in having to manually updating the application through continuous maintenance.

# General Requirements for Industrial Augmented Reality Applications

## Summary

Technology has been widely and successfully applied to the fields of industry such as medicine. However, the phase of taking a technology out from the laboratory into the real world takes time and constant harsh testing. This paper tries to find what Augmented Reality Applications go through in order to be able to be used in the industrial world especially in cases where lives might matter as well as when used by the general public.

Industrial AR application perform well in the following areas; product design, plant design, training, production assistance, quality assurance, production logistics and remote maintenance. The AR applications must also follow as set of requirements such as the following; cost-effectiveness, data security, applicable regulations, set-up time, system reliability, accuracy of presentation, real-team capability and ergonomic.

The paper further mentions how an Augmented Reality application assists technicians to perform maintenance on a wind turbine. It further goes on to highlights the requirements for the AR app which were cost-effectiveness, data security, applicable regulations, low set-up time, reliability, accuracy, real-time capability and ergonomic.

The second application is an augmented reality training simulator for welders. The devices involved are a computing unit embedded inside a welding equipment, a helmet with cameras and speakers as well as a display. Training involved for such an application are joint training and training for a car chassis manufacturing plant of a German car manufacturer. Requirements for this AR app are the following; cost-effectiveness, data security, applicable regulations, set-up time, reliability, accuracy presentation, real-time capability and ergonomic.

Challenges and limitations faces were a variety for such two applications. Firstly, there was a variance of products and processes to encapsulate in an application. It required gathering a large set of documentation about the wind turbines to be displayed as efficiently as possible, as well as having the welding simulation limited to a predefined set of standard workpieces. Secondly, the working environment in which these apps are applied can be harsh and dangerous. Protective equipment has to be worn by the workers to ensure their safety as well as making sure that the devices concerned with delivering the AR do not interfere with their safety. Thirdly, a limitation encountered was data connection. To solve this the app can work offline, however optical tracking can be a problem in such case.

The results found was that the technology lacks a certain kind of maturity that can ensure full safety to the workers while working or training and making use of the app.

# Potential applications for virtual and augmented reality technologies in sensory science

## Summary

Recent advancements in Virtual and Augmented Reality have allowed us to capture a more vivid idea of sensory perception through immersive experiences. The paper studies the advancement of such technology with regards to complexities of human perception. Sensory data for many years has been tested under controlled conditions in labs. The technologies of nowadays are allowing us to collect new types of information. VR and AR are increasingly advancing as to add new levels of how we can get user output.

The paper goes on to highlight recent advancements in virtual and augmented reality technologies. VR from being head mounted displays (HMD) have become more portable. It explains the history of origin of the first VR system and explains how the technology has evolved. On the other Augmented Reality is a recent form of emerged technology. Augmented Reality has been provided through two platforms AR Core, AR Kit and Vuforia. The paper highlights that both technologies originated from “swords of Damocles HMD” thanks to Ivan Sutherland.

The study delves into the potential uses of VRs and Ars in sensory science. The first form of technology is what is known as ‘Context enhancing technology’. It is the gathering of information when food or drinks are taken in a context or environment. The cheapest and least time-consuming way of performing sensory context testing is through VRs and Ars. Both forms of technologies create immersive experiences as to illicit similar stimuli when doing these activities and data through nowadays state of the art sensors can easily be gathered.

The next form of technology is Biometrics, which is a term for body measurements. This is normally done through rating your preference of something one ate or drank. This way of measurement seems fully dependent on the consumer’s hedonic and emotional perceptions to food stimuli. Brain Computer Interfaces are being used to collect signals from the brain during an AR and VR experience.

Food structure and texture is necessary to understand and appreciate what the consumers desire for their taste. VR and AR enable the users to clearly study into depths the structure and texture of food and step even into the molecular level of the food visualised.

This paper explains what VRs and Ars provide to the world of food and drinks taste testing. They are means of how we can achieve new, accurate and more detailed information from what the consumers feels during the consumption of a meal.

# Potentials of Augmented Reality in Training

## Summary

Technological advancements in respect with the world of work, have redesigned the way we train and learn in order to integrate in a job. In this paper it is discussed, the idea of using Augmented Reality as a medium of going past this barrier and meeting the requirements of digitalization. A 3-step methodical approach was used to reflect on this idea. Recommendations through results achieved from training on or near the job are provided for interested companies to make use of.

The paper described what Augmented Reality is and in what forms with respect to hardware it comes in. It describes the advantages it provides for the industrial world. Training on the Job is the ability to learn for a particular job in this case using Augmented Reality, On the other hand training near the job is when the person need to train in a protected environment as it involves a really dangerous job that does not allow room for errors as it can be life costly in this case as well using Augmented Reality.

The research applied was started at the institute of industrial management in 2017. A 3-step method was used for this research, the first step was the detailed assembly process using process management and analysis. The second step, potential of AR in correlation with the hardware used. The third step, learning objectives including methods for AR integration.

The Results are divided into separate steps; the first one is process analysis. It is furthers then subdivided into four sub-processes, warehouse removal, piston assembly, piston rod assembly and cylinder assembly. These are processes, a product from a warehouse goes through. Step two is AR potential analysis. An analysis of an assembly and quality control process is carried out, describing the individual activities according to similar tasks. The third step is the development of AR based training possibilities. It identifies the AR hardware along with their requirements.

To Conclude, recommendations and benefits are provided from using AR in relation with a job training. It describes how AR can be further improved in order to adjust it to the training it needs to perform as well as identifying how the training will also improve by benefiting from the fruits of this new technology.

# AugmentedrealityinsupportofIndustry4.0—Implementation challenges and success factors

## Summary

Augmented Reality is a tool for workers to interact with the digital world. This paper analyses the issues, challenges and benefits AR bring into the world of Industry. The technology, organisation and environment framework are used for the quantitative section of the questionnaire. The paper discusses how the AR market will grow in the coming years. AR will help in completing tasks faster and more efficiently, given a suitable task is chosen. The paper proceeds to give some general information regarding AR in contrast to Virtual Reality.

Augmented Reality has the capability to help us in tasks like design, maintenance, supervisory control and data acquisitions. The methodology proposed is in relation with the six design principles of Industry 4.0; interoperability, virtualization, decentralization, real-time capability, service orientation and modularity. AR will be provided as an interface that will replace any paper based or hardware/ machinery-based architecture.

The technology obviously like everything else come with a certain bag of challenges. Reported challenges were of the following; hardware and software issues, weight, ergonomic issues, limited user acceptance, might be unhealthy at certain number of hours to user, data problems, security issues, reliability and cost.

The technology adoption and implementation model were used as an implementation framework. It is suitable for companies without any knowledge of AR or VR. It consists of three elements which are; the technological context, organizational context and environmental context. The technological context is about currently used technology within the firm. The environmental context is focused on having external entities increasing the knowledge with regards to AR. Organisational Context relates to assets of the firm itself.

The research approach was made through a qualitative and quantitative approach through surveys and questionnaires. Data collection involved a total of 365 participants were the criteria for participation was only if the individual was involved in AR development or projects. The qualitative part was aimed to fill gaps of information not gathered through the quantitative one.

As a discussion the papers compares the quantitative and qualitative results. It shows striking differences such as user acceptance, information visibility and user-centric improvement. Several explanations are provided as to why that is so. Several limitations were discovered, for example the scalability of the technology. The technology is recent and still needs further development. However, through industrial implementation interest will increase and the technology may become more applicable to important tasks.

# Towards augmented reality manuals for industry 4.0: A methodology.

## Summary

Augmented Reality is a promising technology for manual to instruct and train employees in their field of work and industry. AR manuals can take the form of 2D graphics using the Darwin Information Typing Architecture (DITA) and Information Mapping (IM). Industry 4.0 is the 4th Industrial Revolution and along with this revolution emerged Augmented Reality. The design principles of technical documentation are the following; interoperability, virtualization, decentralization, real-time capability, service orientation and modularity.

The methodology used to manage existing technical instructions for their use in visual manuals consists of; optimizing text use, using ASD Simplified Technical English, the conversion of text instructions to 2D graphic symbols and the organization of information using DITA and Information Mapping. The paper mentions two ways how AR can help the operator and in which tasks; localization of components and procedure to carry out. Visual elements for AR technical documentation can be categorized into fixe parts; 2D simple graphic elements, icons and symbols, multimedia elements, 3D navigable models and 2D technical drawings and illustrations. Information mapping follows a certain amount of principles. The principles are the following chunking, relevance, labelling, consistency, integrated graphics, accessible detail, hierarchy.

Two case studies were performed both from real maintenance manuals. First case was generating an AR manual from a real manual. Second case study involved creating a visual manual for user validation. The limitation in this study was that the person who needed to make use of this AR manual needed to have the pdf manual translated to a language of his own county. The instructions were presented in bullet form to improve readability. To determine whether the methodology used is effective or not user preferences were evaluated, without comparing the GUI but rather compare user acceptance. Validation comparisons were made through visual manual, PDF and iFixit. A questionnaire involved seven questions were at the end of each question users answered the question with point, were ‘1’ meant ‘Strongly Agree’ and ‘7’ meant ‘Strongly Disagree’. The questionnaire was presented to 22 volunteers and the average age was 36.5 years.

The technical documentation presented through the Augmented Reality involves less text and more graphical and visual interactive objects. The same application can be applied to documentation which involves a lot of text as well, which makes it very beneficial to implement and use. The documentation provided is compliant with Industry 4.0 and its principles; Interoperability, Virtualization, Decentralization, Real-Time capability, service orientation and modularity. The implementation was tested with a real maintenance manual of hydraulic breaks. Users complained with the PDF version. However, iFixit seemed to not have any problems.

To conclude, the methodology provided support technical writing which can be used for Augmented Reality. The implementation was made on two case studies to provide proof that this can be successfully applied in industry. A subjective user study was made for feedback. As a result, an improved GUI will be created to improve accuracy, scalability and user friendliness.

# Design Considerations for combining Augmented Reality with intelligent tutors.

Augmented Reality is an integration of an integrated layer on the real world, an overlay. Combining AR with intelligent tutoring systems can enable us to learn in a more intuitive and interactive way. The paper discusses the benefits of combining the two technologies as well as its challenges. Both platforms complement each other, and they can help each other to create an improved system. The paper aims to summarise AR training system and intelligent systems, develop a proper definition for Augmented Reality tutors, designing and implementing ARAT systems, and discussing the challenges and benefits. Through such research and discussions an ARAT system is proposed, whilst also giving a list of contributions to a newly discovered technology which has had little research in the past few years.

Technological requirements for augmented reality are three, these are the combination of real and virtual objects, the virtual content must be registered in 3D real time and finally the content must be interactive in real time. The three technological components of Augmented Reality systems are of the following; tracking display and interaction technologies. Benefits of VR and AR intelligent systems are tracking capabilities and the wide variety of applications in industry it can be used in is also a plus. Its limitations are adaptivity and task sequence capabilities, mixes two user interface paradigms and uses a desktop-based AR system. The paper mentions several types of systems that one can create by combining the two technologies together, the first one is a Virtual and augmented reality design system ,the second one is a Virtual assembling guidance system, the Augmented anaesthesia machine, and finally the pepper’s ghost mixed reality work support system.

There are also several limitations within this system. The three major ones; instructions are provided in a linear way, there is almost no explainability as to how it is following certain instructions, cannot provide the learners with his improvement in knowledge being learnt from the system and no feedback is provided by the system. The system will have all the capabilities a mixed reality can provide and in turn it will harmoniously work along with all an intelligent system can provide such as problem solving, error detection and correction, and task sequencing. ‘ITS’ have shown to have improved results on whoever learns on them, research have shown that whoever studied on ‘ITS’ have improved their grades drastically. ‘ITS’ have come in, in 5 generations each of which tries to improve on the limitations from the ones before it.

The paper keeps on describing the ideal Augmented Reality intelligent system (ARAT). It describes the several designs, implementations and forms it can take such as the design space and reality-virtuality continuum. An adaptive ARAT system is also mentioned, where it has the capability to adapt to the user’s requirements. Designing ARAT systems comes along with its limitations such as; authoring support, extensibility, system usability and interoperability. However, the applications t can be used for are extensive.

To conclude, there is still a lot of work and research to be done in education theory, augmented reality adaptive tutor design, learning effectiveness and technical research. However, although the technology is still in its infancy it has a lot of potential to be a breakthrough in the world of industry and technology.

# Mobile Augmented Reality: the potential for education

## Summary

Augmented Reality has proportionally grown with the growth of the mobile phone industry. Traditionally education occurred face to face between students and a teacher physically in the room. Technology has been used for education for several years, with ever emerging technologies. As result it has shown that students find it more engaging and has helped them to improve their academic records.

The paper describes the history of Augmented Reality and its evolution. It mentions the “Milgram Reality-Virtuality Continuum” scale, which is a scale describing what is completely real to what is completely virtual. Augmented Reality sits somewhere in between on this scale. Augmented Reality can encourage kinaesthetic learning. This brings a lot of advantages along with it, for example 3D registration of virtual and real objects.

The analysis then moves on to understanding the different ways of how education was provided using technology, starting from the CONNECT concept which was a first form of Virtual Reality moving on to finally using Augmented Reality with mobile phones. As the technology slowly progressed to becoming more immersive, students started being ever more interested in what they were learning and finding education more satisfactory. One such example was the Squire and Klopfer collaboration where students took the role of Environmental Detectives.

To conclude, the results for using AR to provide education have been highly positive. With the industry of mobile phones slowly growing and developing new forms of advanced technology education is becoming an immersive experience, making it easier for the student to utilize their imagination and creativity for an educational purpose. The barriers of understanding the tutor are slowly fading away through such technologies. It is advisable that when implementing AR or VR for the educational value a focus needs to be made on pedagogical and learning theory.

# Perspectives on how to evaluate augmented reality technology tools for education: a systematic review

## Summary

Education is benefiting from the use of Augmented Reality, providing an immersive learning experience for students to experience and interact with. This paper reviews on how Augmented Reality affect on educated has been evaluated. Open source data mining was performed to extract necessary data to perform research, while the qualitative and quantitative data were compared and analysed.

The main question asked is “how do researchers evaluate AR-based educational technology?”. Questions asked during evaluation are of three categories, descriptive questions; such as “What institutions are most involved in performing this type of research?”, classificatory; “what are the different designs used in these studies?” or “did the study use multiple metrics (both quantitative and qualitative?” and relational and effect, “what impact has this tool?”.

The research done found that from 2009 interest in conducting research in this technology has steadily increased. Quasi-experiments where the first form of conducting research, second place were questionnaires. Observations appeared in most of the studies unlike case studies. However, a huge amount used both metrics. The recently developed apps were used for testing on real users and their satisfaction was evaluated. The question they tended to ask them for the latter study were learning contents, interface design and applications. Augmented Reality was mostly applied to STEM fields.

Research questions were also analysed and grouped into two types; design questions and knowledge questions. Effective integration of technologies in classrooms is important. There are two ways on how to accomplish this;” teacher must act as instructional designer and the schools must support the teachers with this role.”

# Supporting Remote Maintenance in Industry 4.0 through Augmented Reality

Augmented Reality has become one of the most important factors during the Industry 4.0 initiative. Challenges and limitations of AR are being till today being solved as the technology has only recently been introduced and developed on. The technology allows a trained employee to connect with an untrained employee to perform maintenance from a distance.

Implementation of AR has not been completely introduced into every workplace as the technology might be still underdeveloped for the environment and expensive for the limited service it provides, performance/cost ratio.

Sometimes distance maintenance between two operators takes place through multimedia devices such as, pictures, videos and chatting. AR can be the medium by which the two operators communicate in order to perform distance maintenance. AR can provide the trainees with new skills and acquisitions such that they can be more effective and efficient in less amount of time. Main drawback to AR apps is that they take long authoring time while real geometries might not be well superimposed. When can solve this by making the app simple, use no communication and using 2d models imposed on real objects.

The requirements for such an app are the following, maintenance expert should see “why and where the failure occurred”, use of universal language for better understanding, a remote person view, a maintenance recorder module, high speed internet connections, maintenance performed on known machinery and tracking algorithms for AR.

The architecture of the application is of the following way. An unskilled operator sends pictures to a skilled one. The expert sends symbols, text and sketches to the client to the unskilled one, were they will be seen on tablets or goggles.

# A MOBILE APPLICATION OF AUGMENTED REALITY FOR AEROSPACE MAINTENANCE TRAINING

Maintaining an aircraft is not an easy task and certainly requires new levels of skills and knowledge. The paper analyses whether AR can be an effective means as to delivers such training. It could reduce cost and improve efficiency. There are four key categories of aircraft maintenance: software, hardware, environment and liveware. To perform any of the four categories, one needs experience and when new employees are being assigned such task some may lay this experience, which can be a problem, especially when observing a piece of hardware to see if it is airworthy.

Implementing new forms of technologies such as Augmented Reality could minimize any human errors and provide the necessary training to solve where experience is lacking. The paper describes and provides any necessary certification for an AMT job. The training provided for the job is of several forms: on the job training, face to face training, computer-based training.

The paper explains how Augmented Reality can be used as a training medium, what it is exactly and in what shapes and forms it comes in. Firstly, AR can be an HMD or as a see through display. It can assist in a good number of jobs raging from office jobs and technical ones to more maintenance and aggressive jobs.

AR could help the employees with an improved cognition, recall and long-term memory. It is an interface for multiple senses, it can facilitate learning and recall of what one learnt.

# Retargeting Technical Documentation to Augmented Reality