Industrial Augmented Reality (IAR) as an Approach for Device Identification within a Manufacturing Plant for Property Alteration Purpose

Tshepo Godfrey Kukuni
Department of Electrical, Electronic, and Computer Engineering
Central University of Technology, Free State
Bloemfontein, South Africa
email: tgkukuni@gmail.com

Ben Kotze
Department of Electrical, Electronic, and Computer Engineering
Central University of Technology, Free State
Bloemfontein, South Africa
e-mail: bkotze@cut.ac.za

***Abstract*—In this article, a possible solution to the identification and detection of components in a process is investigated within a controlled network environment. This seems necessary as the component is not always identifiable with small or no previous knowledge to the design and implementing phase. Augmented Reality utilising identifiers such as machine vision is investigated rather than the current Quick Response codes or Radio Frequency Identification. If identified at its position, the data and device details are then available to the user for viewing or editing purposes. This project is still in its startup phase thus real data will be addressed and discuss in a follow-up article.**

Keywords- industrial augmented reality; image processing; virtual reality; mixed reality; augmented reality; RFID; QR codes; manufacturing plants; SCADA.

I. INTRODUCTION

In recent years, the demand for software resources has increased drastically due to the rise in smartphones hardware [1]. As a result, researchers have predicted that Mixed Reality (MR) will have the potential to play a very big role in our future daily lives, such as in education, medical, production, etc. It is with such reasons that Virtual Reality (VR), which is a component of the MR technology, can be transmuted into Augmented Reality (AR) by adding real elements such as live video feeds to the virtual world.

Acquiring information about the surrounding objects effectively is a crucial factor for many people including people with disabilities such as the blind. The introduction of the AR application, which is denoted as a powerful user interface technology that augments the user`s environment with computer-generated entities can accomplish this task by making use of AR technologies [2].

The information about reality becomes more interactive between the user`s perceptions of the real and virtual world in an AR environment. The reality happens through the application of the real-time object detection and recognition algorithms that will enable recognition of the surrounding objects in the real environment in order to align the computer-generated images with these objects in an AR view [3].

In comparison with VR, users can see virtual and real-world objects concurrently in an AR system. Since both VR and AR are virtual objects related phenomena's, the concept of enhancing the illusions that the virtual objects are present in a real scene has led to more research attention focusing on the occlusion problem.

The problem with occlusion occurs when real objects are in front of the virtual objects in a scene [4]. However, the information can be inserted in a contextual-dependant way, which therefore allows AR to act as a substitute for the traditional assembly.

The concepts of utilising AR technology as a possible Quick Response (QR) code improved system through the use of Machine Learning (ML), by integrating a well-known AR toolkit, is proposed as a good way to obtain good reputation data. Furthermore, this process can be automated, and robust tracking can be achieved utilising this method [5].

The basic concepts in AR applications depend on the identification of real-world objects on the screen by tracking them, then augmenting the scene with an artificial object. Tracking is often combined with some estimation of the correct 2D or 3D world coordinates for proper placement of augmentation in the scene. The application can further be discriminated to build artificial markers for object detection and those with the ability to use “natural” image features [6] - [8].

The AR application is to be developed and incorporated in the manufacturing plant, using data that is obtained from the sensors that are identical to the Supervisory Control and Data Acquisition (SCADA) system data. This data will accord the opportunity for reading and altering of certain properties of the devices within the manufacturing plant.

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No real applications of this process technology have been found for implementation, thus the reason for the study.

This paper proposes an optimal and efficient model utilising Machine Vision (MV) to detect and identify devices based on their positions within the manufacturing environment with the aid of the AR application. Problem statement outline the reasons for conducting this study, then the aim and objectives of how this study will be conducted.

Furthermore, the methodology section outlines the procedure in which the development of the prototype will be carried out and lastly the conclusion section outlines the overview of the feasibility of the study.

II. PROBLEM STATEMENT

Despite the greatness that AR brings in the Industry 4.0 platform, there have been constraints associated with AR technology. The predominant constraints are categorised into two, namely technology and environment.

Technological constraints on mobile AR are aligned with the resources on most smart devices. This constraint is substantiated predominantly with limited memory, limited computational capability as well as the limited graphics capability.

It is with such reasons that Industrial Augmented Reality (IAR) capabilities need to further be investigated concerning object detection, recognition, and identification of devices within a manufacturing environment.

In a controlled network, the identification of components in the process is difficult without the knowledge and background in the design and implementation process. Thus, the concept of device identification with the aid of AR application utilising identifiers such as MV other than QR codes and Radio-Frequency Identification (RFID) codes needs to be investigated.

The challenge currently experienced by industry is the development, implementation, and integration of MR systems such as VR and AR systems that will have the capability to augment manufacturing operations and deliver cost-effective, time-efficient and ameliorate the quality of service (QoS) and products.

This research seeks to develop an efficient and optimal model to use AR Application, as well as MV to detect, identify and alter the device properties in the manufacturing environment.

A. *The objectives of this study*

- To prove that vision-id could be used for device identification rather than tags or QR codes.
- To use AR application to detect errors, faults or device malfunctions in the manufacturing plant.
- To develop a test bench that will operate as a manufacturing plant.
- To determine the details of the devices by means of their position in the process within the manufacturing environment utilising MV technology.

B. *Original contributions expected from the research*

- Includes recognition of automation structures/ components by means of vision for identification of such process.
- By means of identification, the user will have the capability to view and adjust the parameters of the process in the scaled plant.

III. LITERATURE REVIEW

In recent years, computers have gained a great deal of popularity due to their capability to make human life much easier, and this has also affected the success of businesses that are universally linked to the decisive approach for the establishment of innovative technologies. As the growth and improvement in technology inflated, mobile devices also gained widespread recognition and are considered a technological game-changer due to their powerful processors, etc.

Milgram et al. [7] present the AR definition as a continuum figure where he highlights the (closeness of the AR system to the real environment) and Augmented Virtual (AV - closer to the virtual environment), which both lie between the real and the virtual environment as highlighted in Figure 1.

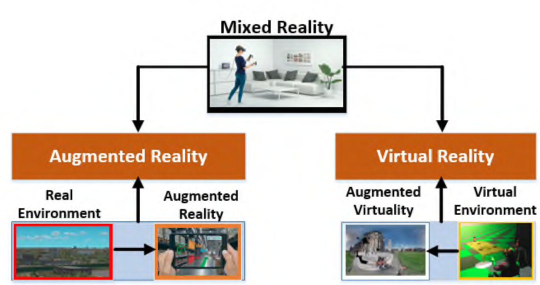

Figure 1. Reality-Virtuality Continuum [7].

Milgram`s definition of AR is supported by Azuma and Stapleton; however, despite support from other authors, Milgram did not cover the 3D aspect of the AR technology. Furthermore, to this discussion, Gausemeier [8], developed an application with interest in the information display.

The study focused on image-based object recognition and tracking for AR applications for inserting information into the user’s field of view through a mobile device (MD) system.

Gausemeier et al. model development are aligned with the 3D-CAD file to the 3D model of the derived object. From the video point of view, Gausemeier used streams, edges, color and textile information. However, Gausemeier`s method is based on extracted pictures for filtering and comparison as compared to utilization of a live video in real-time for object detection and identification.

Silva al et. [9] in his paper outlines the method of utilising Bayesian Network Model, by calculating the probability of an event. Silva`s model is a simplification model based on Jensen Bayesian network model [10].

Silva classifies this model as a simplified model by discarding the third element which in this case is the texture and focuses his study only on the color and shape.

Antonijevic et al. [11] highlight the combination of IEC 61850 feature with augmented reality technology for providing added value visualisation capabilities in the substation automation domain. However, Antonijevic study despite using IEC 61850 as the communication tool, the AR application is still based on device identification utilising QR codes rather than MV.

Dos Reis et al. [12] present an application that uses a paranomic augmented environment to extend the information shown to power systems operators supporting data interpretation, monitoring, and manipulation. However, dos Reis, study is based on a live environment and proved the feasibility of IAR.

Furthermore, to IAR application, Marcincin et al. [13] present new attitude in imaging of combined working environment and its practicality for realising the principle of the utilisation of half-silvered surface, which provides the advantages for displaying AR objects directly in the working view of the user and free motion without hardware device connectivity.

IV. METHODOLOGY

In recent years, the QR codes have been identified as an improvement technology to Bar Code (BC) technology. The introduction of QR technology came about the limitations that are experienced in BC technology such as storage capacity and character type.

The QR codes introduction came about the capabilities of encoding and decoding of the different types of data such as binary, numeric, alphanumeric, etc. as indicated in Figure 2. QR codes are pinpointed to have a significant problem associated with slow QR detection.

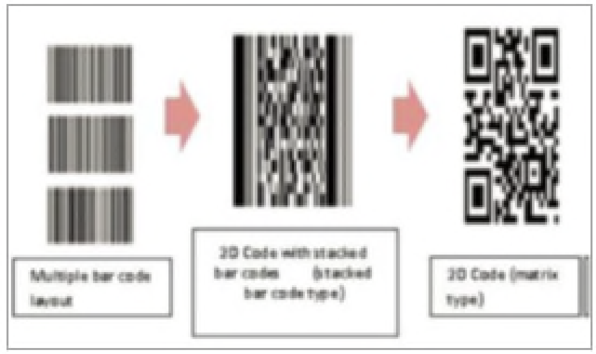

Figure 2. Multiple bar code to 2D [14].

A key upcoming type of technology (MR) will be used in the same principle in which QR technology has upgraded the BC technology.

The device tracking will be utilising the high-resolution camera, MV and OpenCV library. While the AR application, which is regarded as the computer technology that enhances real environments through visual represented information which has the following features:

- Object tracking;
- Ability to superimpose virtual objects on to user`s view of a real-world scene;
- The positioning of virtual objects in a real-world scene;
- To combine real-world images with virtual images in real-time.

MV is defined as knowledge and approach cast-off to provide an image-based automatic examination for quality control, process control and robot guidance [15]. MV is regarded as a real-world component as highlighted in Figure 3.

There are several shortcomings such as light intensity for the camera to sense. However, such shortcomings will be depicted by the Arduino which acts as the control system due to its interface with sensors and sending of data to the SCADA were the user can monitor and be alerted of any anomalies within the factory. However, the very same information can be obtained using the AR app.

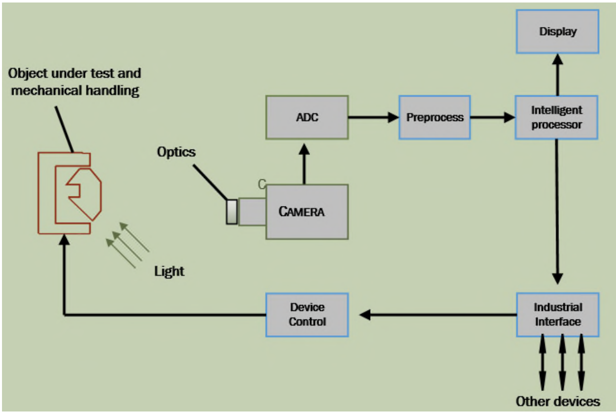

Figure 3: Industrial machine vision system for inspection [16]

Industrial Machine Vision (IMV) comprises of the following components: Lighting, Optics, Image sensing, and Image processing.

As the sensing happens, AR applications will be used to identify the devices based on their positions and outlines their details and the Artificial Intelligence (AI) of the system will kick-off in the background. Then, the AR application will be activated to detect and identify the devices while communicating with the SCADA to have identical data.

The sensory part of the system will have the input functionalities for reading in the manufacturing plant`s temperature, humidity, light intensity, and motor speed. This sensory data will register out the pneumatic outputs on the SCADA App and this data can also be obtained using the AR App.

The light sensor will be a critical sensory part of the study since the study is based on MV. The reasons are that MV depends on image acquisition utilising cameras with high resolutions whilst light depends on the light sensors. The light sensor will control the light intensity of the plant to allow the camera to operate optimally by using vision to capture accurate data. With this said, the study will be divided into 3 sections namely; sensing, automation and vision.

Automation will be accomplished by applying the Artificial Intelligence (AI) algorithm that will learn the environment as well as the behavior of the devices through Machine Learning (ML) application. This will be accomplished by the development of a vision application based on open-source software called OpenCV due to the cost affiliated with this software. C++ based software called OpenCV provides the tools needed to solve computer vision problems and also can process low-level image functions and high-level algorithm [17].

In addition, OpenCV will provide a common infrastructure for computer vision applications and also accelerate the use of machine perception in the manufacturing environment.

Figure 4: Proposed architecture solution for AR identification solution in Manufacturing Environment

Figure 4 highlights the proposed system for the AR application solution interfaced with a SCADA system for device detection and identification based on the AR application developed in Unity3D on an Android platform.

The SCADA application will be developed in C language through the use of Arduino microcontroller which will be interfaced to the physical sensors. Furthermore, the Graphical User Interface (GUI) will be developed in C# language using Microsoft Visual Studio 2012. MV will be realised by the use of an open source library called OpenCV technology. This MV processing will be realised through the use of a high-quality resolution camera and it will be used to identify objects on the conveyer belt for the Robotic Arm (RA) to pick.

SCADA will be linked to all the system components of the manufacturing plant such as conveyer belt, motors driving the conveyer belt, RA as well as the sensors that will provide the manufacturing environments with data such as motor failure, motor speed, light intensity, temperature, and plant humidity. These sensors will indicate when to activate the cooling system etc, or how negatively the light intensity affects the vision camera. In addition to the sensor's responsiveness, the SCADA will save the information for later analysis. However, data analysis is not accounted for in this study.

MV will be accomplished by the use of a high-resolution camera which will be placed on a fixed position on top of a servo motor to monitor, detect and identify the devices (motors and a robotic arm) within the manufacturing plant.

Several OpenCV algorithms such as Canny edge detection, image recognition, color detection, and shape detection will be utilised on one side of the study utilising MV. Due to the progress in AR technology, related researches along with advanced computer hardware and software has let to AR technologies in getting more attention.

An AR Application will be built with several functionalities such as identification, detection, and recognition of devices (motors and a robotic arm). An AI application will be embedded in the background of the App for device recognition.

The application designed for this study will be used for detecting the factory phenomena such as temperature and humidity obtained by SCADA technology. Then, SCADA will act as the control system to control the movement of the motors to direct the conveyer belt within the factory. The object recognition, identification, and detection will be based on the motors as indicated in Figure 4 for detection and identification of motor information such as motor speed, motor direction, motor model, etc. However, an embedded identifier will be used as the focal point to the motor and robotic arm but in an interacted manner with the motor information. The device details obtained from the SCADA will match the device details provided by the AR application to improve productivity and have an earlier notification of device malfunction within the manufacturing plant.

V. CONCLUSION

This paper has proposed an efficient and optimal model that considers the use of AR for use in manufacturing plants.

- An approach in device detection and identification is presented where image processing through image acquisition is utilised for device identification. The knowledge of the devices and their positions within the manufacturing plant will be known through the use of an Android device that will identify those devices utilising AR technology.
- MV will be used to identify objects of a certain shape and color. Furthermore, all the sensory data from the sensors will be displayed on the SCADA system.

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