Mobile AR System using QR Code as Marker for EHV Substation Operation Management

Ayyaj S Maner
O&M, Mumbai Transmission
Adani Electricity Mumbai Ltd.
Mumbai, India
Ayyaj.Maner@adani.com

Dilip Devasthale
O&M, Mumbai Transmission
Adani Electricity Mumbai Ltd.
Mumbai, India
Dilip.Devasthale@adani.com

Vikas Sonar
O&M, Mumbai Transmission
Adani Electricity Mumbai Ltd.
Mumbai, India
Vikas.Sonar@adani.com

Dr. Rajamani Krishnamurti
Chief Consultant
Adani Electricity Mumbai Ltd.
Mumbai, India
Rajamani.Krishnamurti@adani.com

Abstract— Augmented Reality (AR), is the extension of the virtual reality technology, which brings together real environment and virtual information, text, video, image etc. to experience digital things in a real world environment. Computing device is necessary to user to interact with in real-virtual fusion environment.

This paper presents architecture design and implementation of android mobile augmented reality system for Extra High Voltage (EHV) substation to ensure safe and correct operation of switches and its real time status confirmation from sub-station SCADA. It is based on web application and mobile android system. QR code as a marker is generated in a standardized and efficient way for unique identification of each switch of Substation. Further it is integrated with existing SCADA for obtaining real time switch ON/OFF status by means of web service.

This application assists the operator of EHV substation with continuous audio and visual support to take live equipment out of service sequentially without bypassing the interlock for maintenance activity. Augmenting the manual process of operation with this mobile app eliminates errors as the application does not allow the operator to proceed in case of any mistake or mismatch from predefined Standard Operating Procedures (SOP). This greatly enhances the safety of personnel and equipment.

Keywords—AR, EHV, Android Mobile, SOP, SCADA, Web service.

I. INTRODUCTION

This paper presents AR Application pertaining to EHV substations in general, and in particular AR based operating management system for EHV substations.

Augmented reality is a live direct or indirect view of a physical, real-world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. It integrates digital information with the user's environment in real time. It uses the existing environment and overlays real time information on top of it [1].

The AR based mobile application takes into account real time SCADA status of Switches such as Circuit breaker, isolator and earth switches. A unique Quick Response (QR) code is assigned as a marker for each switch to be scanned while performing operation as per predefined procedure. Manual operation supervised by AR processes improves security of personnel and equipment.

II. BACKGROUND

EHV substation consists of major equipment like transformers, circuit breakers, isolators, earth switches, capacitors etc. To maintain the quality/health of equipment and Transmission lines, maintenance activity is carried out periodically as per set schedule. Equipment or lines to be taken out for maintenance is isolated from live power system and earthed to ensure safety of the maintenance crew on site. This isolation procedure involves multiple operations to be done strictly as per predefined sequence. Break down in sequence or wrong operation may lead to severe damage of assets and site crew. The process being manual in nature, probability of making mistakes while performing operations is high. EHV system is complex and the number of procedural steps to be performed being large, the chances of making inadvertent mistakes like bypassing of interlocks are significant.

To improve safety of operating personnel during outage maintenance, a need was felt to augment manual procedures with real time feedback to maintenance crew. Each step of SOP is to be available on line with real time feedback of switch positions. This is achieved with new android based AR tools developed for this specific application in conjunction with existing SCADA system.

III. PREPARE MOBILE AR ARCHITECTURE DESIGN

A. The Overall Architecture Design

Refer Fig. 1. The four major constituents are:

1) Android AR application for client device
2) Real-time integration with substation SCADA
3) Web-page application for creation of SOP database
4) Designing switch identification code

Mobile AR system uses Client-Server architecture. Mobile device is used for image acquisition which is encrypted and sent to remote AR server. Remote AR server performs all the visual processing algorithms and sends the results back to mobile device. The communication between mobile device and remote server is through wireless network [2].
B. Android AR application Architecture

Fig. 2 represents the android AR application architecture. This android application is linked to SOP database. Each outage may involve 30 to 40 steps and they are documented in SOP. When the supervisor authorizes a maintenance engineer to perform an outage, each step of SOP is available on mobile device of operation engineer and supervisor. Supervisor can keep track of every step being executed by operation engineer. When operator starts the SOP, AR android mobile guides him step by step. At each step the ON/OFF status of switches and circuit breakers are obtained from SCADA and displayed on mobile devices.

C. Integration with real-time

Ronald Azuma defines augmented reality as a system identified by three characteristics: it combines the real and the virtual, it is interactive in real time and it is registered in 3D [3]. Fig 3 represents the real time integration of AR with centralised SCADA. The existing SCADA system is from ABB, Spider NM 5.5.

- The main function of a SCADA system is its ability to collect information from a variety of equipment of different make, model and size located in geographically separated areas and supervise system operation. It also provides real-time visualization of status changes that actually occur in the field.
- Field inputs (Status/Measurement/Operation) are connected to SCADA for continuous monitoring and control.
- The SCADA server communicates with the field equipment through RTUs. The collected data are stored in a database, which is updated in real-time, and serves as a central repository for the information needs of the SCADA clients[4].
- While the operations on the SCADA database are done using SQL language, the SCADA applications themselves are implemented using web services.

D. Web-Page Application Architecture

Generally power system substation contains hundreds of elements. For taking outage of each element, unique SOP is prepared containing series of steps. For ensuring safety, correct SOP allocation for specified outage job is very essential. This important requirement is met with the help of web-page application, by creating library of precise EHV operation SOPs with job details in defined format on server, named as SOP database. User’s Excel SOPs spreadsheet can be directly imported, which helps to eliminate the chances of manual error. SOPs are thoroughly checked and validated at two levels before they are stored in SOP data base.

Fig. 4 represents the Architecture design of Web-page application
E. Designing of Switch Identification Code

Quick Response (QR) code is used as a marker for switch identification during operation. A unique QR code is designed for each switch as shown in Fig 5. Each QR code is tagged with name of sub-station, voltage level, equipment ID number and company name. QR codes are pasted on control panel as well as on switch in such a way that operator can access them easily. Design of unique QR code is necessary to eliminate duplication of switch names.

IV. IMPLEMENTATION OF THE SYSTEM

A. AR Based EHV Operation Management

AR based EHV Operation management is described in Fig 6 and Fig 7. Sequence of isolation and identification of correct switch are very important while performing the operation in EHV substation.

Supervisor allocates particular job to specific operator and this appears on his device shown on left side of Fig 8. After successful creation of job, the details appear on device of operator assigned to the job as shown on right side of Fig 8.

AR mobile shows the operations step by step for systematic navigation. Mobile camera detects the switches by means of associated QR codes. After performing each operation, status of switch position (ON / OFF) is obtained from SCADA server. The operator has redundant information about switch status, from local control/switchgear panels as well as SCADA. This increases confidence of crew that intended operation is successful. The Application moves to next step only after real time validation of preceding step.
Fig. 7. Representation of AR system

QR Codes scanned by AR system are mapped in SCADA. With that mapping in place web service directly fetches the status of switch from SCADA within 4-5 sec from the time of request initiation.

AR System confirms the correct operation and alerts the operator with multilingual audio support if he by mistake reaches and scans wrong switch, as shown in Fig 9. Security and privacy are ensured by registering IMEI of mobile, only registered mobile can access the android application. This AR application is available only on permitted devices with login username with password protection.

This AR system can be customized as per the user requirement. In this paper the main focus is to improve the safety when outage is taken for EHV equipment. However the same can be used for other applications.

Results of operator action after execution of every step of SOP get saved in database with timestamp enabling reports to be generated whenever required. Data analytics can be done after sufficient data is collected, which helps to identify the issues related to System & SCADA response, operator competency etc.

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CONCLUSION

The size of substations has increased dramatically to meet increased power demand. There is a corresponding increase in number of components. Also the switching arrangements have become complex. The situation is accentuated with introduction of extremely compact switchgears. Substation outage management is manually done. It is becoming a challenging task and probability of making a mistake while performing operation is not insignificant leading to injury to personnel and equipment damage.

We designed an Android Smartphone based AR Assistance and implemented for use by EHV substation operators by assisting him with continual audio and visual support while performing operation for taking outage and normalization of equipment mainly power transformer and EHV lines (220kV), 33kV Boards and feeders etc.

Correct identification of switch and its operation are now getting confirmed in real-time with the help of AR system. Augmenting the manual process of operation with AR mobile app eliminates errors as the application does not allow the operator to proceed in case of any mistake or mismatch. This greatly enhances the safety of personnel and system as well.
REFERENCES


