Ariot: Augmented Reality Using Fiducial Markers And Image Recognition For Wireless Triggering Of Internet Of Things Devices

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Abstract: ***This paper refers to the simplified yet effective idea under Soft-Computing domain for wireless triggering, switching and regulation of devices remotely in a completely new approach. It involves the simple and convenient application of a mobile camera with or without a HMD (Head Mounting Device) headset which can be used to instantly recognize a trained set of household electronic devices and those under similar categories to switch it on/off or have extensive regulatory controls. It will involve the usage of a multitude of platforms both from the computing and electronics domains to design a feasible working model to be made available at the disposal for a common man targeting convenience of home automation directly from his/her mobile camera. It aims towards enhancement of applicability in day to day scenarios to a further control of industrial applications in future scopes of improvement. Augmented Reality, Internet of Things, Embedded Systems, Wireless Sensors, Image recognition, Wireless Controllers.IOT usage is implemented in near field regions and in further scope implemented over the cloud as well. The recognition of the devices can occur in real-time based on the python coding platform as per the training set which is pre-fed for training the object model or it can be used for low latency devices like mobile phones directly and portably using Vuforia for mapping certain fiducial markers to particular objects that opens up its control when the identity icon matches.***

Index Terms. -Augmented Reality, IOT – Internet of Things, HMD – Head Mounted Device, Node MCU-Main Wi-Fi board, HC05-Bluetooth Module.

I. INTRODUCTION

The initial architecture planned involves a sequential flowchart of connections that start from the Light Bulb/Led Bulb/Indicators/Buzzer to be used connected to a switch/relay board using Jumper Wires, Bread Board or Green Dot Soldering Boards. The connections are verified within each connected node using a Multimeter. Technologies involved are Augmented Reality, Fiducial Markers, Unity Engine 5.6.1f / 2018.2, Vuforia, image recognition and Matlab programming,

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Internet of Things (IOT), Android App Development using MIT App Inventor Device triggering and Wireless Sensor Networks.Once the flow of continuity has been established there is use of a Wi-Fi Module and Shield for near field control and IBM Bluemix-NodeRed, cloud service provider like Amazon Web Services – AWS or Heroku for control over the cloud. It uses the most convenient microcontroller depending on the number of connected devices (i.e. based on the set of 5 devices to be triggered here a relay module of 5 is being used on the auxiliary board and the connections are bridged using an Arduino Mega), power distribution, triggering, cost estimation and.convenience. For testing purpose use of a USB Debugging connected to the System and a LIPO Battery setup/Controlled Mains Setup for remote independent usage. The connections can alternatively also be controlled by a Bluetooth/GSM/XBEE-XCTU module but for practical implementations under the purview of this project only WiFi (NODE MCU – ESP 8266) and Bluetooth module (HCO5) are in use onto which programming is done using Arduino official software module. There needs to be a WiFi router or a mobile hotspot as a 3rd Party device for near field communications within a room or range of interference with stable internet supply. Receiver module of the WiFi is pre-embedded in the Mobile Device as well as the Microcontroller Device. The coding in the electronics and controllers are handled by the Espressif Systems IOT Board instructables, XCTU for handshaking communication if required in case of XBEE (TX)Transmission-(RX)Receiver Handshaking control and Arduino Programmer generic controls (Here its over WiFi or Bluetooth). The Coding of the mobile application is handled by Java 1.8 JDK/SDK, Python, MATLAB, Android Studio, Unity Engine and Vuforia.

II. OBJECTIVES OF THE PAPER

•To develop methodologies and present concept of wireless home automation system from a naïve mobile camera viewfinder.

•To integrate IOT, ML and AR in a single platform to bring in ease of usage of simple electronics from the convenience at fingertips.

•To make a universally usable convenient application in connectible and reprogrammable modules that are portable enough at any scenario ready for deployment and can control simple switch

boards to home electronics and industrial devices too all in a user friendly out of the pocket application from the mobile camera.

•Dynamic usability by all age groups and diverse scenarios from plug points to home electronics.

III. LITERATURE SURVEY

IOT has created a new era for home automation with devices such as Raspberry-pi and emphasizes it to be of a credit card size computing device which consists of media like ports of Ethernet, USB and HDMI, Display Serial Interface, Camera Serial Interface, Bluetooth versions and Bluetooth low energy. It helps in controlling numerous home appliances simultaneously, local servers are created on Raspberry pi or other similar modules in common usage. Users can access the appliances using portable devices like smartphones, Laptops, Tablets with the help of UI created on web page and it is preferable due to its low cost. [1]

The project provides an easier way to control home appliances using "Arduino Uno" connected to the mobile device through WiFi or Bluetooth. The commands are given through the developed Android application connected to the Arduino-Uno with the help of WiFi or Bluetooth and then the home appliances such as lights, fans, washing machine, and air conditioner can be regulated. Automation system consists of sensors connected to a central hub from which the appliances are controlled with a user-interface that is interacted via mobile phone application. [2]

Speech recognition is used to control the home mechanism, an android application is connected with the IOT-ADK which in turn is implanted with microcontroller .User can collaborate with the android telephone which sends the control flag and other decoded signals to the android ADK which further controls the electrical gadgets and sensors. The microcontroller accepts the flag values such as (1 and 0) indicating the operation that has to be undertaken for the devices connected to the IOT ADK .The general cost is exceptionally modest and it is moderate by a typical individual. [3] Gesture Human Machine Interface uses accelerometers and flex sensors to detect hand gestures which helps in controlling electrical devices. The algorithm states that when the bell is pressed camera module will capture the image and generates a text message to intimate the owner about someone's presence at the door and the image will be sent to the owners mobile or to the email, a call will be received from the service provider to the owner. The accelerometer detects the device which needs to be powered ON/OFF and flex sensors turns the device on/off. [4]

Home automation is controlled through internet from anywhere in the world at a low cost. Intel Galileo is used with integration of cloud networking, wireless communication, to provide the user with remote control of various devices by storing the data in the cloud. The Intel Galileo is connected to the WiFi-card with antennas for holding the connectivity with the internet, the data is sent to the web server and a IP-Address is typed on the web browser to access the web server page and the user can control it from any part of the world, it also analyses the condition of the various parameters and updates the user by storing it on to the cloud. [5]

To control the home automation GSM modem or similar related technology was used. The security is controlled by text messages which isn't much reliable as per present scenarios i.e. SMS. For GSM communication and status of device the AT commands is used where we know that the device is switch ON or OFF. [6].

IoT as a platform has received much attention from scientists, industry and government all over the world since it's initiation for its potential in changing modern day living. IoT is envisioned as a lot many sensors connected to the internet through wireless and other communication technologies. The sensors generate large data pool which needs to be analysed, interpreted and utilized. IOT needlessly to be noted need to be an interwoven network of communication at the convenience of fingertips. These all would time the automation and technology hand in hand. [7]

Growth in the wearable sensor market stimulated new opportunities within the domain of Ambient Assisted Living, providing methods of collecting occupant information. This approach leverages contemporary wearable technology, facilitating a unique first-person view or FPVs of the occupants' immediate environment. Machine vision techniques are employed to determine an occupant's location via the environmental object detection. This method provides additional secondary benefits such as first person tracking within the environment and lack of required sensor interaction to determine the occupant location. Object recognition is performed using the Oriented Features from Accelerated Segment Test and Rotated Binary Robust Independent Elementary Features algorithm with a K-Nearest Neighbours matcher to match the saved key-points of the objects to those in the scene. [8]

The Internet is a fabric of classic networks and interconnected objects. Content and services will always be available, paving the way to new applications, enabling new ways of working; new ways of interacting; new ways of entertainment; new ways of living. Internet as an infrastructure network reaching out to end-users' terminals will fade, leaving space to a notion of interconnected objects forming pervasive computing and micro-computing environments. The Internet infrastructure will not disappear. Internet will retain its vital role as global backbone for worldwide information sharing and diffusion, interconnecting physical objects with computing/communication capabilities across a wide range of services and technologies. This innovation will be enabled by embedding electronics into everyday physical objects, making them interactive and letting them seamlessly integrate within the global resulting cyber physical infrastructure. This will give rise to opportunities for the Information and Communication Technologies (ICT) sector and IT Industry, paving the way to new services and applications able to leverage the interconnection of physical and virtual realms. [9]

IV. ARCHITECTURE AND TECHNOLOGY INVOLVED

Augmented Reality (AR) is an interactive experience of a real-world environment whereby the objects residing in real-world are "augmented" by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory, and olfactory. The overlaid sensory information can be constructive (i.e. that adds over the natural environment) or destructive (i.e. that deducts from the existing natural environment) and is seamlessly interwoven with the physical world such that it is perceived as an immersive aspect of the real environment. In this way, augmented reality alters perception of a real world environment, whereas virtual reality completely replaces with a simulated one.

Internet of Things (IOT) It is the network of physical devices, vehicles, home appliances, and items embedded with electronics, software, sensors, actuators, and connectivity which enables them to connect, collect , analyse, interpret and exchange data, creating opportunities for more direct integration of the physical world into computer-based systems, resulting in efficiency improvements, economic benefits, and reduced human exertions.

This AR + IOT basically forms ARIOT with the added spice of Image recognition, Machine Learning and Wireless Sensor Networks.

It involves the added advantage of all these underlying technologies and extracts the best possible outcomes from the same to design a suitable environment for the user focussing on multiple aspects of convenience and ease of usage. This targets towards creating a dynamic and scalable model of a fully optimized home automation system like never before implementing all basic procedure of features along with the added advantage of accessing things directly from the viewfinder of the mobile camera. This has been made possible because of the availability of intents in present camera application. A new layout is chosen for the base design of a camera application which is embedded onto the top frame and then includes other parameters of features for detecting devices that have been explained in details under the innovation idea of the project section.

This not only creates a revolutionary change in design avenue rather opens up the usability and convenience to users of all age groups who wish to control basic to complex electrical appliances from their smartphones in multiple modes either in near field communication or over the internet cloud just for the sake of convenience, in case of remote requirements, in case of emergency situations, for the specially abled or maybe just for fun.

V. INNOVATION AND IDEA BEHIND THE PROJECT

This project underlies basic principles of updating the Mobile Home Automation Platform to the best possible extent involving present low latency communication protocols that leads to hassle free device control. It can be used as standalone platform or be integrated easily with existing small or large scale system to make them automated and remotely controllable. Again for the user for the first time it allows to view the device to be controlled, recognize it through the mobile camera for layman usage without going into a list of available options, model numbers, build specifications and signal types to do a simple operation like switching on or off. Let's consider the option where looking at a device through your mobile camera pops up the control directly on your mobile screen against the existent systems which makes you go through exorbitant amount of documentation before reaching the requisite target. Going into the prospects of scalability it can be used for controlling a simple switchboard to multiple high voltage devices (implemented here in the scope of the project) and maybe even industrial electronics at a later stage of time. The connectivity options made available from a single interface to complement each other to involve a WiFi and a Bluetooth for Near Field Control and an IP Base with Login Security Credentials to securely access the home control panel from anywhere around the world over Internet. The signal processing, image processing or direct triggering either by paired modes or Fiducial Markers (Paired images/Prioritized pairing/QR Codes/Bar Codes) happens using two options and multiple assembled platforms.

A. Modular Platforms to be integrated:

- **Platform Part 1:**

AR application using VUFORIA (AR Development Database for API keys) and UNITY (For designing the GUI Interface) along with Android Studio/Eclipse Kepler/Eclipse Oxygen or even via the MIT App Inventor.

- **Platform Part 2:**

It contains the electronics subsystem that involves the Arduino mega as the major interface board with a functional brain provided by the NodeMCU ESP 8266 by Espressif Systems that control the WiFi Triggering, Access and Control both behaving as WiFi Receiver and Transmitter that can function on all WiFi protocols (except 802.11b which has not been included for this particular implementation but can be scaled to if required), or even using Routers and Mobile Hotspots. The other means of nearfield communication being that provided by Bluetooth v4.0 that being offered by BC05 module that is easily available and can send hexadecimal or binary codes over the air for triggering device controls.

- **Platform Part 3:**

It involves the Electrical part of the project where a board is created which is directly accessible by the mains voltage on one end has proper power distribution and regulation, shields spikes, connects multiple devices using plug points, they being further connected to the single, binary or quadratic channel relays that support devices up to 5A or need specialized relays for heavy load devices up to 15A. The electronics part to which it interfaces to the control board or the Arduino is powered by an AC to DC adapter of 2A.

This completes the standalone platform that can be used for project implementation and practical purposes and later can be interfaced with the mains control board of the house to literally have the controls at your fingertips.

- **Platform Part 4:**

It uses an app with a login option and control over the internet by using Android Things and Firebase with suitable authentication to access all control over the web, on App or using a progressive web application.

- **Fiducial Markers:**

A fiducial marker or fiducial is an object placed in the field of view of an imaging system or in front of an imaging interface which appears in the image produced, for use as a priority point as a makeable measure. It may be either something placed into or on the imaging subject, few set of priority points or a mark or set of marks in the reticle of an optical instrument. These can be limited to a single distinguishable set of points, or a set of priority points as in the case of Objects like Currency Notes, Statues, Fruits, etc. to those in common practices like QR or Bar Codes.

VI. PURPOSE OF THE PROJECT

The purpose of the project is to create convenience to humans, bring applicability of home automation to the smartphone, control over near field or over cloud, access devices from anywhere around the world, provide a systematic system upgrade to remotely distributed connection systems for home automation under different applications and integrate it under a single roof. This makes it usable for every individual of all age groups use it as easily as taking a photo on the mobile camera.

VII. SCOPE OF THE PROJECT

The scope of the project extends from Switchboards to Homes, Heavy industries to Strategic control bases. It also involves integrating the best possible and low latency communication protocols at disposal to create a failsafe module that can be used under every circumstance. From near field communication to using it from anywhere around the world, it's a newer leap. The scope is immense and has options of specificity as well as dynamic scaling. Convenience to users and universal applicability is what it aims at.

VIII. PRESENT SYSTEM

The present systems have already been highlighted as parts in the literature review. All existing models had a single interface of control built into them and none of the models targeted a universal approach. In present there are a lot many home automation systems available but none have been able to satisfy the consumer needs in a cost effective and user friendly manner thereby have found lesser acceptance.

A. Limitations of the present system

- **Company specific apps:**

Compatibility issues with other similar systems, hundreds of 3rd party apps overload, overutilization of mobile hardware, difference in ranges and issues due to non-universality in test and design parameters that result in difference of performance from scenario to scenario.

- **IR blasters:**

Modes, options, choice of device parameters are plenty but it is like randomizing possibility of a match, and in case a match is not found the user is not able to contribute towards adding a device to the pool of predefined devices. Not all electronics are equipped with an IR device maybe a receiver or transmitter is missing in multiple platforms of existing infrastructure.

- **Standalone home automation systems:**

Lack features of alternatives, security and failsafe procedures, some work with outdated GSM Bands that are too slower in response, few use ZigBee protocols that can range between hundred meters but face a lot of connectivity issues, some use Bluetooth or WiFi/IP based protocols but generally don't have all of them altogether and are not at all portable in nature.

- **Dedicated remote controls:**

Need panel boards or specialized display devices to be wall mounted or in the form of remotes to be made available and thus may not be highly convenient for all users in all scenarios.

B. Benefits of the proposed system

Instead of completely replacing the existing system innovation lies in incorporating available or existing systems as well as adding functionalities to it. Similar are the attempts being made at this project. This would bring home automation under a universal interface and would herby allow implementation to an array of electrical devises used at home. This would allow experimentation at the level of a switchboard, to implementation in housing mains connections and even automations at industry scenarios and help trigger applications on and off even in hazardous access points or for safety measures in case a natural calamity strikes at a remote location to enable a complete lockdown. I.e. Nuclear Power Plants.

C. Trade-off: proposed and existing system

There is a certain level of trade-off that needs to be achieved among the proposed and existing system in order for this system to achieve total recognition:

• Widespread Access
•Multiple Access Points and Access parameters
•Convenience to users in all age levels
•Easy interface, Simplicity of application
•Dynamic usage possibilities
•All scenario usage and implementation
•Cost effectiveness
•Multiple backups for connectivity
•Low Latency
•Integrable with present platforms

IX. HARDWARE AND SOFTWARE REQUIREMENTS

A. Electronics modules:

• Regulated power supply
• 2A AC to DC Convertors and Vice Versa (in form of adapters)
• Brown-Silver Dot Soldering Board
• Male and Female Spike Pin Connectors
• Male-Male, Female-Female, Male-Female Jumper Wires
• Multiple Bread Boards
• 10MicroFarad Capacitors for lessening noise in connection bridges
• Soldering Kit – Solder Rod, Solder Wire, Flux, Stand
• Mini Drilling and Fixing Kit
• Connector Wires
• Led Indicators for checking On-board Functionalities
• Relay Modules (Based on number of devices to be connected, their Power Factor, Amperage and Watts)
• Preferably Android mobile (For App Access)
• Other Mobiles (With PWA or Browser Access)
• Wire Cutters
• Anti-Static Gloves/Mat

B. Electrical modules:

• 5 Different household electrical appliances
• Electric Buzzer
• Bulb
• Bulb Holder
• Switch
• Switch Board
• Power Indicator
• Fibre/Vinyl Board
• Board Driller
• Pliers
• Hammer
• Screw Driver
• Tester
• Safety Gloves
• Rubber Slippers
• Black Tape

C. Special hardware

•Microcontroller (ARDUINO MEGA 2560)
• WiFi module (ESP8266)
• Bluetooth 4.0 Module (HC05) Low Power Low Latency
• Android Things supported by Google Cloud IOT Board

D. Implementation of software tools

- **Open Source:**

•MIT App Inventor – Plug & Play App Fragments
•Android Studio – Detailing the Android App
•Notepad++/Eclipse/Anaconda – Text Editors and for developing the web access and authentication
•PHPMyAdmin – Backend Server Management when tried locally using XAMPP/WAMP
•Python/Matlab
•Proteus for Hardware PCB Simulations

- **Licensed:**

• Vuforia and Unity 3D Pro
• Firebase
• Google Cloud
• Tensorflow
• Tensorflow Lite

X. CONCLUSION

There won't be the requirement of standalone applications for every different device rather they will be controlled by intents and action listeners in android terminologies. In a simple layout we use the camera view that scans for electronic devices when in the viewfinder mode and starts waiting for a fiducial marker input, if that's not done within a stipulated time it starts scanning for the electronics in view and tries to make the display as a list on your side screen while the camera is on so that you can choose which device control needs to pop-up. For initial connect and pairing with your home devices the base app needs to used once which can pair up using stored set of fiducial markers, Bluetooth v4.0, WiFi based IP, or if none is in proximity then over the web which would require an access and authentication procedure above all of these. This attempt being made is a complete solution to Home Automation and can be encouraged to be one of the ultimate approaches towards full efficiency. It is deployable in modules so the deployment of stages as and when required, repairs and maintenance is easily possible instead of dismantling the whole system at once. There can be always a scope of improvement that is proposed. For practical demonstration purpose the minimal scale of controlling a switchboard using maximum of the techniques stated here will be a practical target and based on the level of scalability all other forms can be made possible to be presented as a business model.

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