Development of a Mobile Application for Monitoring and Controlling Stage Lights

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Abstract*— The great evolution of technology has caused a change in perspective of how automation processes are handled. Today, technology has become an integral part of the human life that continuous to affect several areas of human endeavors such as the ability to indulge in social interactions, media and entertainment. The entertainment industry has become part of the lives and activities of many individuals in recent times, attracting technological innovations in enhancing better interaction. A typical performance stage is arrayed with several lights both big and small. While the conventional way of looping several lights together involves a cable-to-cable approach, the limitations of configuring, controlling and monitoring the entire lighting clusters is a major setback. This research proposes the development of a cross-platform mobile application for controlling stage lights via a Bluetooth communication channel. The results obtained validates the use of flutter frame work for building better user-friendly applications to interact with hardware devices. With the app a control distance of 10 to 15 meters was achieved.

Keywords—Communication technology, Flutter, Dart, and control

I. INTRODUCTION

As the world experiences rapid growth in the area of technology, the need to change the order in which certain things are done is rather urgent. The great evolution of technology has caused a change in perspective of how automation processes are handled. Since the rise of the first generation of computers, it has been anticipated that computers would exceed the function of just doing a few calculation and arithmetic operations. Early researchers envisaged the use of computers and electronic devices to make living simpler at individual level [1].

Today, technology has become an integral part of the human life. It continues to affect several areas of human endeavors making room for better social interaction, ease of transportation, the ability to indulge in entertainment and media as well as developing the medical line. The invention of many devices such as mobiles phones which are a type of portable smart computers has promoted human reliance on technology to communicate with friends loved one. Useful information such as pictures, movies, documents and music are being stored on such devices [2].

As smartphones, tablets and mobile devices attain a global recognition with a rapid growth, the development of mobile applications has become a widely known medium of software creation. Statistics have shown that mobile applications have become essential components of several businesses and revenues were predicted to hit nearly 600 billion US dollars by the end of 2020 [4]. The development of mobile application involves the creating of software applications that can run on a mobile device. Creating installable software bundles, backend service implementations such as data access with an API and running the application on target devices are all processes involved in the mobile development of an application.

Stage lighting has been in use since the 15th century when there were theatres which were the stage for showing the plays of many great artists [5]. These lights are still very popular worldwide in the world today. The entertainment industry has become part of the lives and activities of many individuals in recent times, attracting technological innovations in enhancing better interaction.

A typical performance stage is arrayed with several lights both big and small. In the jilt of excitement, when a technical fault occurs where any of the lights is turned off or out of control, then such events take a contrary outcome. While the conventional way of looping several lights together involves a cable-to-cable approach, the limitations of configuring the entire lighting clusters is a major setback.

In order to solve the problem of manually monitoring and controlling stage lights, this paper proposes the development of a cross platform mobile application for monitoring and controlling lighting devices

II. AIM AND OBJECTIVES

The aim of this paper is focused on the development of a mobile application for monitoring and controlling

stage lights. This aim would be achieved through the following objectives:

i. To build a native mobile application based on flutter for controlling and monitoring stage lights.
ii. To carry out a performance evaluation of the developed system.

III. LITERATURE REVIEW

The functionality of a device and its' efficiency is largely dependent on a factor described as "ease of access". The ease of controlling devices with precision without the use of switches and native triggers for powering and monitoring these devices is an interest to modern day smart design. The modern-day venue is equipped with a broad range of lighting devices that serve similar purposes. However, there is never any link between these devices especially across multiple brands leading users to control individual devices without appropriate aid [3]. The advent of information technology has created a base for the implementation of systems, with the ease of monitoring, observing and processing of data with our mobile devices. Humans now implement this in the simple package of a Mobile application. The mobile application communicates with a micro-controller that in turns implements the remote commands. The micro-controllers require a network medium to receive the instruction from the Application while the lighting devices are connected physically to the micro-controller.

a) Review of the WIFI Module Approach

Arduino technology was used to serve as the microcontroller, the Arduino Atmega1280 micro-controller showed compatibility with a Wi-Fi module that readily communicates with a smartphone over the Internet, with an included feedback system using LCD display [6].

In a different yet similarly Methodology Zafar et al., [7] used the Arduino Mega 2560 as a controller for the system and in their monitoring system, they integrated an LCD display and ESP8266 that interfaces with a current and a voltage sensor. This sufficiently displays the sensing data and state of each device connected. Zafar et al., utilized a specific sensor (DHT11) to feed the ESP8266 module and similarly Arduino technology was used to control.

However, instead of an Arduino Mega 2560 like in [8], [7], an Arduino UNO board was used indicating an obvious replaceable nature among Arduino controllers. Dhobi and Tevar [9], in designing were able to automate diagnosis by implementing a Naïve Bates classifier algorithm. Interfacing to the controller by ESP8266 described to act as a Serial-to-WIFI module.

Zhang, Li and Li [10], implemented a monitoring system that also works on Arduino technology, however instead of a Wi-Fi module that bridges directly to Mobile Application, the Arduino (UNO) micro-controller by use of a network communication module accesses the yeelink IoT server that can be accessed remotely VIA the internet. Limitation in this design includes the use of cables to transmit between the monitoring, this implies wires must be run around the house

Tastan and Gokozan [11], came up with a predesigned IoT controller (NodeMCU), the controller possessed inbuilt Wi-Fi capabilities. The controller was remotely accessed by the Blynk IoT platform which was primary designed to access controllers such as the NodeMCU and Raspberry Pi VIA the internet, all monitoring and control were then done through a mobile application that communicates with the Blynk platform.

Across all systems the use of Arduino based control has shown the most prospect, the Arduino micro-controllers have a wide range of compatibility with the networking modules, this feature gives it access to the internet. The internet solves the problems that arise from remote control, the only feasible hindrance might be the lack of internet in certain locations but with critical observation the use of a network transmitter that does not use the internet as its platform solves the problem. [4], applied the methodology, and yielded fruits of real time monitoring. A web server is queried by the Wi-Fi module and the Mobile device receives real-time sensing data. Concerns might arise from range of the module and the mobile device.

b) Review related work on the Bluetooth Approach

Nathan, Abafor, Aronu and Edoga [12], introduces a design that applies two of the most generally used methodologies which are Bluetooth communication and web server accessing. The mobile device can access the Arduino Micro controller via two media, one is the Bluetooth shield that communicates with a mobile application and the other is a WIFI shield. If the Bluetooth shield is accessed, the mobile device communicates directly to the controller i.e. its' devices and sensors. If the internet is available it is accessed by the WIFI shield using web application, this also grants access to the controller. The use of two platforms accounts for the range issues from using just one but the platforms have to be switched manually based on the location of the user.

Sachin [13], applied Bluetooth compatibility to household device monitoring while still meeting significant conditions. The mobile application was designed and applies the following working protocol. The mobile device checks the device Bluetooth state, if it is on, it searches for the Bluetooth module of the Atmega micro controller, if the device is active it pairs. The status of the micro controller ports and pins are checked in a text-like format. As the controller responds if a pin of a PIC micro-controller is enabled/disabled it signifies that the device on that node is on/off. The AVR Atmega processor is connected by series of relays that are latched to the micro controller's on relay. A unique control technique was described, applying the use of IR signals to remotely and on-sight control the devices [14]. This stands a possibility that is plausible, and its direct interaction means there is no need for a microprocessor. However, major setbacks are that the control range is restricted, very selective mobile devices have these capabilities, and that there is no observable basis for controlling analogue devices.

A well thought out structure includes an IoT between the micro-controller and the mobile device to primarily process the sensors input before been accessed by the devices [15].

Pachube is a networking cloud tool that in its uniqueness streams every device as a separate unit and data point. Dickey, Banks and Sukittanon, built a system with this tool

and linked it to an X10 home automation System module to manage the devices and at the same time take commands from the iOS mobile application [16]. The cloud network makes it assessable over long distances anywhere in the world.

A simple home automation system was demonstrated that allows a user to control home appliances through wireless means [17]. In the system, controlling and monitoring the appliances was performed in two methods. The first method was through a web server (A desktop PC was used to run the server software). This web interface had a framework known as Restful API and function as to control Raspberry Pi GPIO using an http request. The second method was by using smartphone based on Android application.

A system was developed that contained a great elasticity by using wireless reliable technology to interconnect various modules to the server of home Automation system [18]. Raspberry Pi was used as the microprocessor and provides a medium for communication with the web server. The system showed compatibility with cameras and sensors, these pose as possible monitoring media. In working theory, a vast majority of the models using Raspberry Pi require a PC working as a server. Jabbar and Kawitkar utilized smartphones in an intelligent home-control without needing a PC server, the setup was a low cost-effective and robust control system that enable devices to be controlled by a mobile device and with functionality beyond switching on/off [19].

A well-defined structure was outlined by Witthayawiroj and Nilaphruek [20], with a fully web-based protocol for the entire system. The DCU (Data center Unit) remains idle till a “wake up” is summoned by the user through API, the DCU used in this work is Raspberry PI 2 model because of compatibility with web socket protocols again showing the popularity of Raspberry Pi amongst designs.

The reviewed work shows that communication technologies such as the Bluetooth, wifi, GSM, and Zigbee have been used alongside mobile application tools for remotely operating electronic appliances and systems. While the wifi module has a very wide range of remote controlling, it is still limited to the strength of network signal. Major setback for the Bluetooth module is that the control range is restricted and very selective mobile devices have these capabilities. Zigbee are limited in range when compared to a Bluetooth module although they consume less power.

IV. METHODOLOGY

The methodology implemented in this work involves building a cross platform mobile application for monitoring and controlling stage lights. The mode of communication applied in enabling the app transmit and receive control signal to and from the stage light is the Bluetooth communication technology. The general system overview is described by figure 1, in which the stage light communicates with the app via the Bluetooth technology offered by the mobile device.

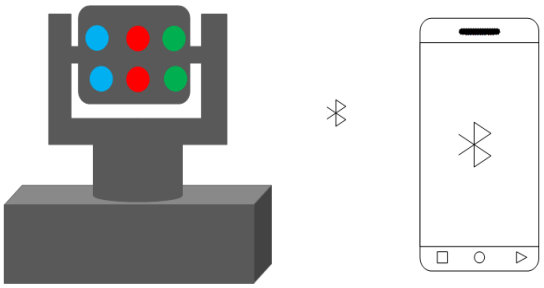

Fig. 1. System overview

In order to build a simple and interactive application, a wire frame designed is considered. The design interface is shown in figure 2 having the arrow pointers as links from one tab to the other.

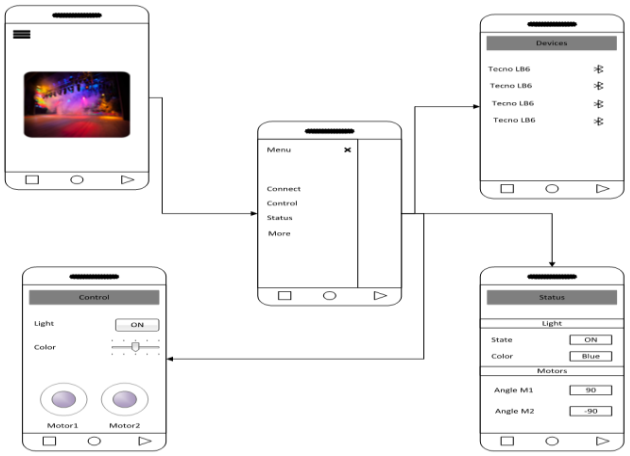

Fig. 2. Application design wire frame

The first tab is the home view which is the initial outlook of the app after launching on an android device. Features of this tab includes, a moving image of various stage setup to create a user-friendly experience and then a collapsible navigation bar for switching between tabs. The next tab is the menu tab which opens on clicking the nav bar. This tab contains a list of several other tabs like the connection tab, control tab, status tab and more feature tab. From the menu tab, users can assess the connect tab from which the application is being interfaced with the physical hardware setup via a Bluetooth connection. This tab displays available Bluetooth addresses of devices within the wireless communication range.

The control tab is consisting of a button to switch the state of the connected stage light both in the on and off states. It also contains a color changing scale switch and then nobs to control the angular rotation of the servo motors. The status tab displays information about the stage light for the purpose of monitoring the operational condition of the stage light. This information includes the state of the light, the colour and then the current angular position of the servo motors.

System flow diagram

The system flow diagram is described by figure 4 showing the program flow of the mobile application in operation with a designed stage light. It shows the step by step process in

which the application communicates with the physical hardware.

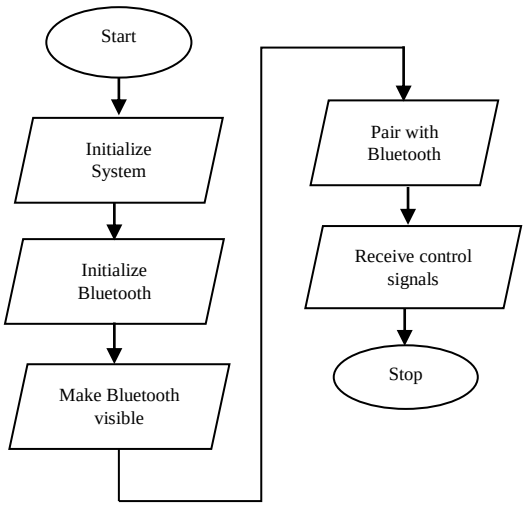

Fig. 4. System flow diagram

The behavior of the mobile application is observed based on some parameters such as operational distance, efficiency rating, launching time, tab response, connection and then visibility time. The operational distance describes the ranges of distances at which the application would be at both maximum and minimum operation respectively. The efficiency rating is considered based on the operational distance. The time taken for the mobile application to open on a mobile device is the launching time. Other parameters are focused on the operational modes inside the application after launching it. Table 1 and 2 contains the data computed during testing of the mobile application and the response time of mobile application operation respectively.

Table 1. Operational distance comparison with efficiency rating

Operational Distance	Efficiency rating %
1 meter	100
3 meters	100
5 meters	100
7 meters	100
9 meters	90
12 meters	40
15 meters	10

Table 2. Mobile application response time evaluation

Parameter	Response time
Launch time	0.5 seconds
Tab response	0.3 seconds
Connection time	1 seconds
Visibility	2 seconds

V. RESULTS AND DISCUSSION

The result of the mobile application developed is shown in figures 5a and 5b consisting of the home page, menu tab (which is a list of items for better usability of the application). The control item describes the tab for connecting to a Bluetooth device, while the control item tab shows the manipulation buttons and knobs used for control, the status tab shows the control state of the stage light in terms of angle of rotation, color and switch mode. The application was tested using a breadboard connection of RGB (red, green and blue) light emitting diodes, servo motors and a Bluetooth wireless communication module as shown in figure 5c.

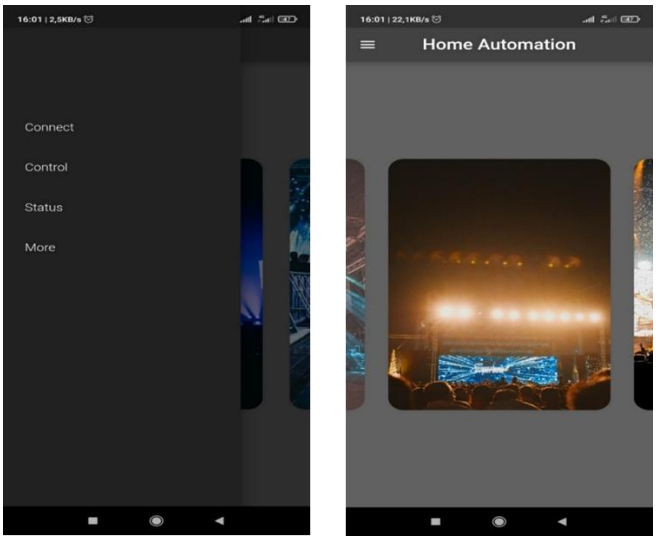

Fig. 5a. Mobile Application User Interface

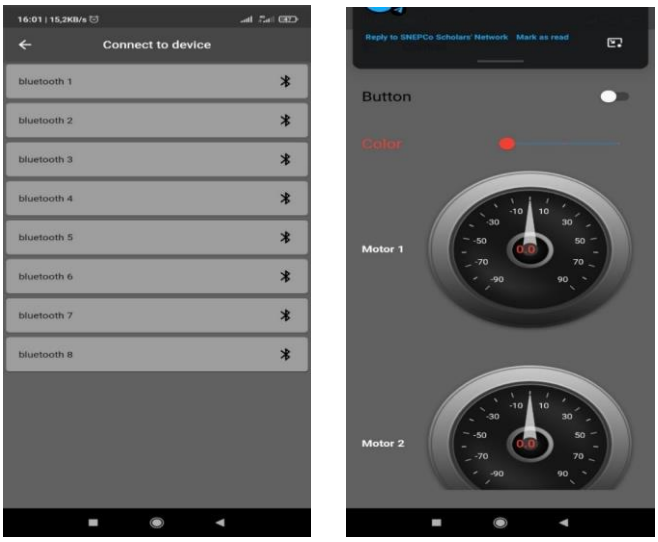

Fig. 5b. Mobile Application User Interface

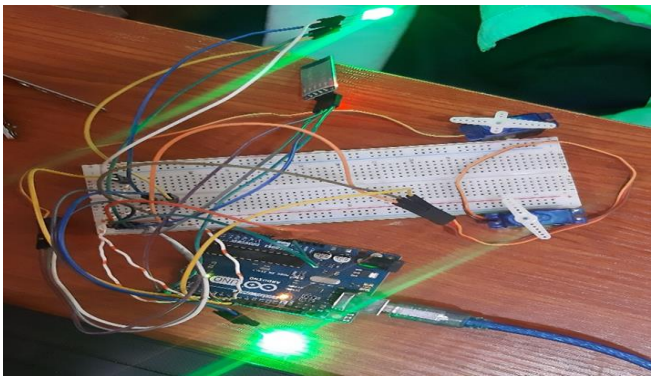

Fig. 5c. breadboard hard ware connection for testing

In evaluating the performance of the mobile application based on the parameters highlighted in Table 1and 2, a comparison relationship is plotted as shown by figure 6 relating the efficiency of the application in communicating with the physical hardware within specific distances. The variation showed a 100 percent efficiency at 1 to 8 meters, while an efficiency of 90, 40 and 10 percent were recorded at distances of 9, 12 and 15 meters respectively.

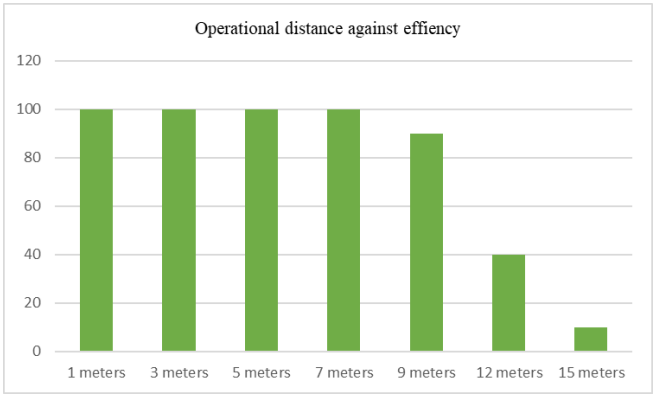

Fig. 6. Plot of operational distance against efficiency

The operational response time of the mobile application computed in table 2 was also plotted as described by figure 7 below. It indicates that the application is able to identify the hardware Bluetooth protocol at about 2 seconds, connection time with the designated hardware was 1 second, the tab response as well as the launching time was 0.3 and 0.5 seconds respectively.

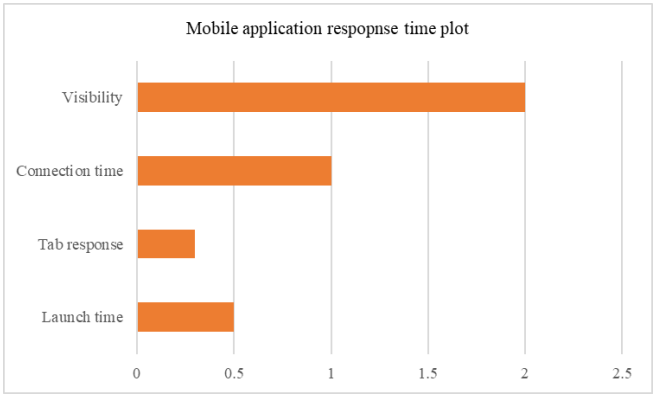

Fig. 7. Plot of application response time

VI. CONCLUSION AND RECOMMENDATIONS

The development of a mobile application for monitoring and controlling stage lights was successfully achieved. Using a flutter frame work and dart programming language the mobile application was developed to communicate with a physical stage light device via the Bluetooth wireless communication channel. Also, the performance evaluation of the mobile application was carried out, and the results proves that stage lights can be controlled within defined distance range without control signal obstacles.
The mobile application was also tested with a physical bread board connection as shown in Figure 5c.
Finally, with the outcome of the system built, control of stage lights can be achieved within the 10 to 15 meters range of the wireless technology.

Recommendations for future works

Further improvements and advancement can be done in several ways. An authentication feature can be added to the mobile application to provide security from random access control. A Wi-Fi based internet communication technology could be used to configure multiple array of lighting system controlled and monitored over a longer range. Also, an intelligence algorithm can also be implemented on the system to reduce the human involvement during operational time.

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