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An IoT Wearable Communication Prototype Tested in Indoor and Outdoor Environments

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***Abstract*-The fast adaptation of wearable communication (WC) technology to be applied in the broad fields has exhibited the incredible trend for the last decade. In this research project, a typical WC 2.4 GHz prototype was developed and practically examined. This wearable device is initially designed for transferring two kinds of data, i.e. voice data and video streaming within the indoor and outdoor environments. However, the current WC system only provides the functionality of video and pictures streaming. The sensed objects or locations captured using the wearable device placed on human body will be continuously transferred via the access point and immediately broadcasted to the registered server or the permitted receiver station. The first trial testing of the fabricated WC peripheral has demonstrated the excellent data transmission performed on those two different environments. The maximum communication range between the wearable device and the access point could be reliable maintaining for both indoor and outdoor testing was abruptly 17 meters. Over that communication range the transmission quality becomes degrading and the failure connection is quite often occurred. The measured power level received at this maximum distance is approximately – 90 dBm.**

Keywords—Wearable Communication, IoT Network, Testing Environments, and Communication Range

I. INTRODUCTION

The world is now entering an era of digital connectivity and the Internet of Things (IoT) which has been applied in various fields, from the use of automation machines that are integrated with the internet network, the development of smart cities, the development of smart cars, and the most prominent feature is the use of wearable devices [1]. The trend in scientific studies has led to a number of devices that are better known as wearable devices that rely on more stable communication and are connected to the internet network. One of the areas of Information and Communication Technologies (ICT) which is very attractive for development and includes wide applications in industries such as entertainment, media and communications (EMC), health (health wearables), retail, technology, security systems, and the military, namely wearables computing. The high demand for smart wearable device technology by consumers in the modern era is inseparable from a number of advantages, namely increasing the comfort and safety of its users, a healthier lifestyle, and the simplicity and ease of use [2]. The integration of the wearable communication system is a very specific technological innovation and is applied especially in the fashion industry to the need for security so that it is more possible for smart electronic devices to become a part of vital accessories in the future [3].

Research related to the prototype wearable communication in certain fields such as in the field of health, wearble devices to monitor the patient's condition by pairing a GPS Vega bracelet that is connected to the patient's family so that they can monitor the physiological signals in people with epilepsy in real time [4] [5]. In agriculture, wearable devices can be used on plants by attaching a moisture sensor to the leaves and connecting to wifi and farmer devices to determine the moisture content of the water, making it easier for farmers to monitor crops [6]. In the field of security, werable communication is used to spy on target movements by attaching ESP EYE to specially designed glasses so that it can send video in real time using a wifi network on connected devices [7] [8]. From the reference about wearable communication in different application fields, you can apply IoT network-based applications, so this research applies the IoT network with the theme A Wearable Communication Prototype Based on Internet Of Things (IoT) by making a prototype and attaching it to clothes that have been designed. specifically in order to be able to send videos and images in real time to connected devices.

II. ARCHITECTURAL DESIGN AND PRINCIPLE OPERATION

A. Design of Wearable Communication

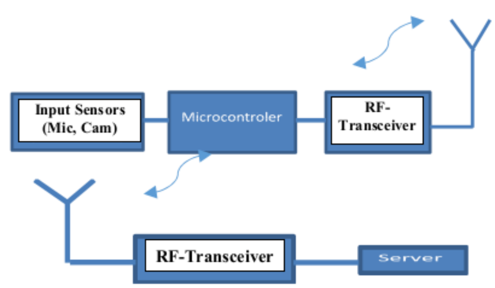


Fig. 1 Schematic diagram of a wearable communication system

In general, the proposed wearable communication system that allow the data transfer, i.e. voice and video/ streaming pictures from a particular remote area to the main monitoring place is illustrated in Figure 1. As described in Fig.1, the input sensors array will be sequentially instructed by a single microcontroller device to scan and to process the sequenced data voices and moving pictures frame/ streaming pictures in a certain interval time. All collected data are digitally converted in the microcontroller device. The generated bit sequencies of converted data then directly fed into a RF-transceiver chipset. Inside the chipset, the data bit sequences is modulated and amplified. The antenna system is then broadcasting the RF-modulated signals to propagate through the free space medium and finally to receive in the server system. The received signals arrived in the RF-transceiver unit are demodulated and converted into the bit sequences replica. The most common server unit that usually utilized to post processing the received bit pulses is the PC desktp or laptop.

To implement the designed wearable communication system that is typically sketched in Fig.1, an ESP32-Cam chipsets was utilized. This chip is a camera module that is equipped with wifi and Bluetooth and has a small camera size so that there are very many enthusiasts for application in various fields. ESP32-CAM is a development board with an ESP32-S chip, an OV2640 camera, microSD card slot and several GPIOs to connect peripherals (see Fig.2) [9]. This module is very suitable for IoT projects so that many IoT applications use this camera module for smart home devices, industrial wireless control, security systems, QR code identification, and other IoT applications that use wireless or bluetooth networks. The ESP32-CAM is a full featured microcontroller which also has an integrated video camera and a microSD card socket which can be useful for saving pictures taken with the camera or for saving files. The ESP32-Cam has a pinout consisting of 8 digital pins and 40 analog pins.

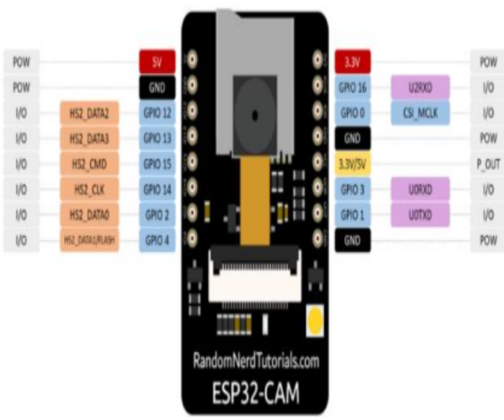
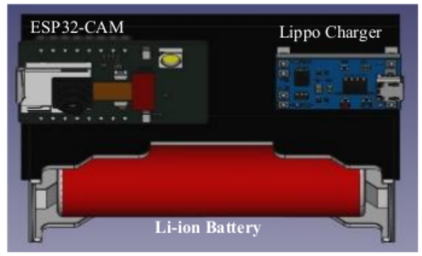
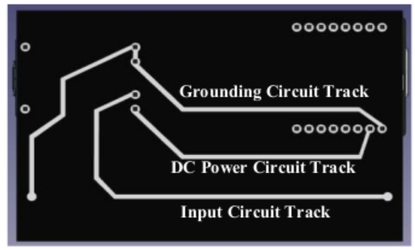


Figure 2 Pin Out Esp 32 Cam [9]

In this study, the software applications used to create the 3D designs of a wearable communication prototype are Skectchup and FreeCad. For the hardware required is an ESP 32-Cam microcontroller, Fritzing is used for making schematic designs and the software needed is the Arduino IDE and a web server to display the results. Following is the front and back view of the wearable communication design.



(a)



(b)

Figure 3. The 3D designs of a wearable communication prototype: (a). Top view of WC electronic components configuration; (b). Bottom view of WC printed circuit layout.

B. *The Operation Principle of Designed Wearable Communication*

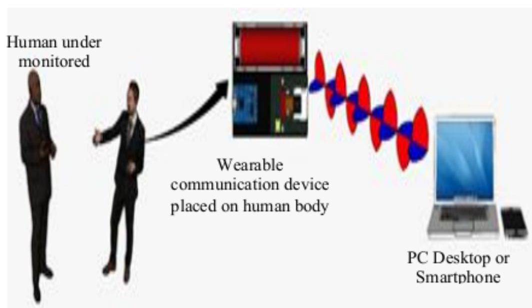


Figure 4. The operational principle of the constructed wearable communication.

The principle operation of wearable communication, namely the performance of the hardware used is shown in Figure 4. First of all, the wifi modem transmitting a signal to ESP 32-Cam microcontroller which is equipped with a camera. As ESP 32-Cam microcontroller read the message which has been given instructions via the Arduino IDE, then the ESP ESP 32-Cam microcontroller provides images and videos, which are forwarded by the web server to be displayed on a PC or it can be via an Android smartphone in the real time mode.

III. Practical Testing and Evaluations

The critical task on the construction and the development of any wearable communication devices is to examine the hardware and software functionalities including the signal integrity issue in the actual environment operations, i.e. indoor and outdoor. Thus, it is very important to perform several experimental testing to the wearable communication prototype.

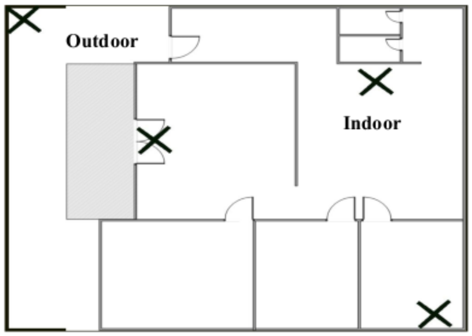


Figure 5. A schematic diagram of the outdoor and indoor environments of a typical house area 20 m x 25 m under observed for testing the actual operation of wearable communication prototype.

The WC testing configuration for both outdoor and indoor environments is described in Figure 5. A typical house area 20 m x 25 m under observed for testing the actual operation of wearable communication prototype was grouped into 4 locations to place the access point (i.e. smart phone) and WC peripheral set-up to have flexible movement to approach or to move away the WiFi source.

A. Indoor and Outdoor Environments Testing

Sending information in the form of images and videos on wearable communication devices attached to surveillance clothing used by the security agency is still ineffective because it is only able to take pictures manually and stored on Micro SD memory can only be accessed via a computer so that the user cannot know the results from taking pictures or videos directly and the user is also unable to monitor activities in real time,

By analyzing existing problems, it takes a software and hardware development that can monitor or monitor anytime and anywhere through a device that is connected to the user. So the features of this software must be connected to the internet, so that users can monitor or monitor events that are happening in real time. With technology that provides services to get the latest desired information and can be displayed in the form of streaming video and video recording by displaying images directly or storing images inside a memory device integrated inside a smartphone or PC desktop/ Laptop.

A.1 Indoor Testing

A preliminary sequential testing of wireless communication prototype operates on both indoor and outdoor environments were performed with the same procedures as described above. One type of the video streaming testing is shown in Figs.6 (a) and (b).

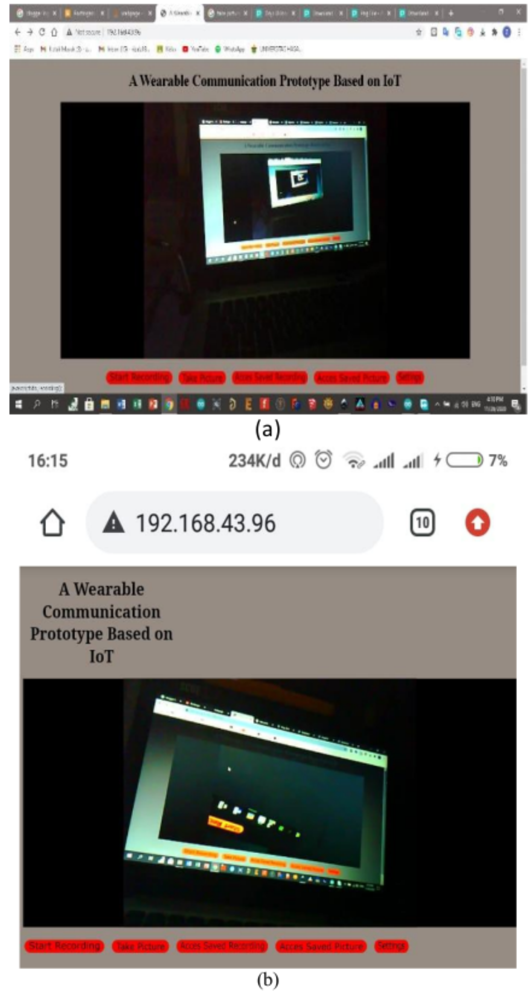
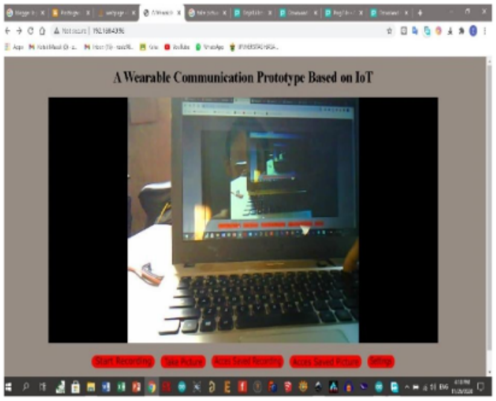


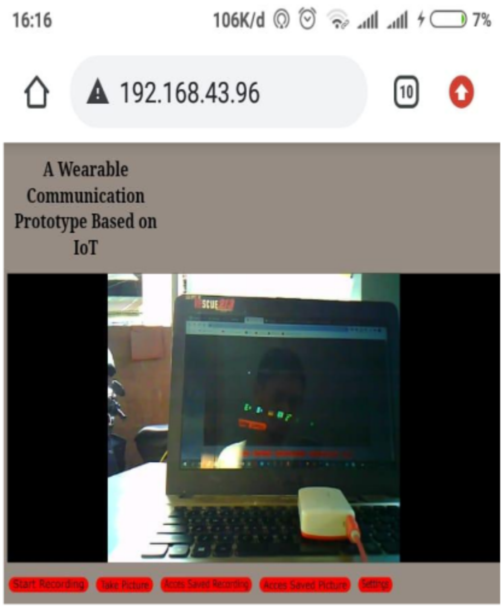
Figure 6. (a) Indoor video streaming using Laptop browser; (b) Indoor video streaming using smartphone browser.

A.2 Outdoor Testing

The wearable communication performance for transmitting the video data streaming by varying the distance between access point and the manufactured wearable device utilizing the local host is described in Figs 7 (a) and (b), respectively. It is noticed that the quality of video streaming during the actual operation of WC peripheral both in indoor and outdoor environments is relatively the same along the interval communication range. It is obviously demonstrated that the far the distance of WC device removed away from the access point the weakest the power level received. The transmission performance will significantly degrade outside that optimum communication range. This situation is illustrated by the most common event occurred in the network such as the failure connection amongst devices under communication due to the poor level of signal received. The strong evident regarding the problem is described in Figure 8.



(a)



(b)

Figure 7. (a) Outdoor video streaming using Laptop browser; (b) Outdoor video streaming using smartphone browser.

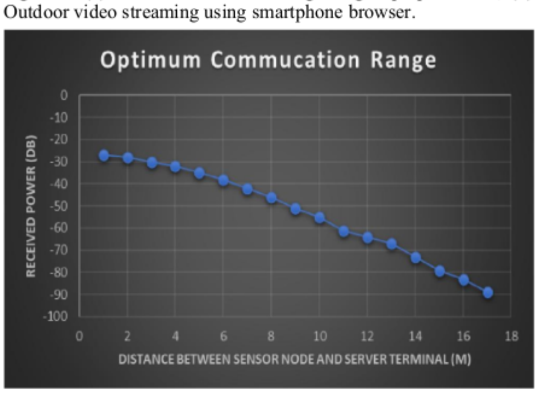


Figure 8. The measured signals power level received using a cellular hotspot.

B. *Limitation Factors of Wearable Communication Operation*

Considering whole fabricated wearable communication testing conducted both in indoor and outdoor environments, several factors that might be limiting of its practical operations are summarized as the following:

1) The light factor can affect the quality of the resulting image so that there will be differences from the test results as can be seen in Figure 6 and Figure 7 obtained from both the indoor and the outdoor testing.

2) The selected camera resolution factor can affect the value of the delay that occurs when sending images and videos directly to the user. As the comparison purposes by using the different camera types, i.e. UXVGA and VGA resolutions, the testing delay varies about 15-25 seconds.

IV. CONCLUSIONS

A typical WC 2.4 GHz prototype was developed and practically examined. This wearable device is initially designed for transferring two kinds of data, i.e. voice data and video streaming within the indoor and outdoor wireless communication environments. In order to obtain the better operation quality of wearable communication peripheral a couple of limiting technical factors such as lighting factor and the proper camera resolution must be taken into consideration.

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