Human Foot Step Impact Based Interactive Flooring System

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Specially dedicated to

My beloved family and friends for the help and encouragement. Thanks for my supervisor, PM.DR. Kok Swee Leong and all the lecturers who gave me guidance and advice throughout the process of finish my final year project

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ABSTRACT

Interaction among people is getting worse and worst against the grow of technology. People like to share their feelings to social media rather than family members or friends just next to them. Nowadays, most of the interactive flooring system are using camera and projector to grab the attention of people. This kind of system is wired, costly and the interaction region is limited. Out of the camera observe range, the interactive flooring system using camera and projector cannot function well. Therefore, this project is proposed to design a wireless interactive flooring system to get the attention of people away from their smartphone. Moreover, an embedded tile is fabricated to replace the camera and projector to have the larger interaction region with people. This interactive flooring system is also able to identify the location of tile. In result, once people stepping on embedded tile, the LED indicator nearby and the tile represented widget in app will activated. Due to this interactive flooring system is wireless communication, thus the system is only working under coverage of Internet. To ensure the system can be implement in workout application, a prototype performance testing is successfully carry out.

ABSTRAK

Interaksi antara manusia semakin teruk terhadap kecanggihan teknologi. Manusia lebih suka berkongsi perasaan mereka kepada media sosial berbanding dengan ahli keluaga atau kawan-kawan yang berselelahan dengan mereka. Pada masa kini, sebahagian besar daripada sistem lantai interaktif menggunakan kamera dan projektor untuk menarik perhatian manusia. Jenis sistem ini adalah berwayar, mahal dan kawasan interaksi adalah terhad. Sistem lantai interaktif ini tidak boleh berfungsi dengan baik jika manusia tidak ada dalam permerhatian kamera. Oleh itu, projek ini adalah dicadangkan untuk membentukkan sistem lantai interaktif tanpa wayar dengan mendapatkan perhatian manusia daripada telefon pintar meraka. Dengan ini, jubin terbenam direka untuk menggantikan kamera dan projektor untuk menpunyai kawasan interaksi yang lebih besar. Sistem lantai interaktif ini juga dapat mengenal pasti lokasi jubin. Akibatnya, semasa manusia memijak jubin terbenam, penunjuk LED berhampiran dan widget yang mewakili jubin dalam app akan diaktifkan. Kerana sistem lantai interaktif ini adalah komunikasi tanpa wayar, dengan itu sistem ini hanya berfungsi dalam liputan Internet. Untuk memastikan sistem ini boleh dilaksanakan dalam aplikasi sebenar, ujian prestasi prototaip berjaya menjalankan.

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LIST OF ABBREVIATIONS

LED	Light Emitting Diode
GUI	Graphical User Interface
CCTV	Close-Circuit Television
FCC	Federal Communications Commission
IEEE	Institute of Electrical and Electronics Engineers
WLAN	Wireless Local Area Network
RF	Radio Frequency
SIG	Special Interest Group
RFID	Radio-frequency identification
GPIO	General-Purpose Input/Out
PCB	Printed Circuit Board
LCD	Liquid Crystal Displays
DIY	Do It Yourself

CHAPTER 1

INTRODUCTION

This chapter provides an overview of the research entitled "Human Foot Step Impact Based Interactive Flooring System". It will embrace the background study, objective, problem statement and scope of the project. The objective of this project will identify the gap of the problem statement that is revealed in the chapter.

1.1 BACKGOUND STUDY

Human foot step impact is happened between the collision of human foot step and floor surface. There is a pressure created while the collision is happened. This pressure is enough to cause the floor surface changing in term of shape if the floor surface is soft. This kind of pressure energy can be useful in a few ways but it can also be used to generate electricity based on different approaches. There are many organizations already implementing human powered technologies to generate electricity to power up small electronic appliances. Other than this, this pressure energy can act as a fuse or switch which can activate the electronic appliances nearby. In this project, the pressure energy is act as a fuse or switch to activate the indicator nearby.

In order to detect the human foot step impact do need a sensor. A sensor device is measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. Sensor is categories into two which are active sensor and passive sensor. Active sensor is a sensing device that need an external power source for working. In contrast, passive sensor is just sense and respond to some type of input from the physical environment. [1] In this project, passive sensor is the most suitable sensor that used to detect human foot step impact. There is a passive sensor that suitable to use in this project which is switch sensor.

Interactive flooring system is a system that can have some interesting interact among the floor and the people. It is a great combination of interactive floor software and hardware. In this case, the hardware using is embedded tile and the software using is Arduino IDE and Blynk. Embedded tile is one of the detector device that working with interactive flooring system. Once the embedded tile detects the human foot step impact that acting on the surface of tile, the system will activate the indicator nearby. Besides, Arduino IDE is the software that just used as a platform to flash the programming into the Wi-Fi module, ESP8266.

Graphical user interface (GUI) is a human-computer interface that uses windows, icons and menus. It is a way for human to interact with the computers. [2] Such a way, Blynk is select as a user interface for human to experience the interactive flooring system. Blynk is an open source app and it has its own server which is suitable for the use of starting research. Therefore, the interactive flooring system is the combination of the embedded tile and the Blynk. As there are receive any interrupt from the sensors that embed in the tile, the interactive flooring system is not only activate the indicator nearby, it will also display the indicator is activated on app as well. For example, while people stepping on the tile, the indicator nearby is activated and app is display which tile is the human steeping on.

1.2 PROBLEM STATEMENTS

Follows the grow of technology, the interaction between people is getting worse and worst. There is a lot of people willing to interaction with their smartphone rather than family members or friends. At the same time, people would like to express their feelings to social media also not willing to share to their friends or family members just next to them. Based on the survey that completed by Pew Research Center in the year 2014, there is up to 46% of the American say that they could not live without smartphone. [3] It is highly dependence on smartphone and cause the relationship between people become inferior.

In addition, there is a lot of devices that can be used as an interactive system to get the attraction from the people. Close-Circuit Television (CCTV) or camera is the usual device that used to monitor the situation inside a building and to attract the attention from the people. However, CCTV or camera is not only a high cost device, it is also a high power consumption device. Therefore, this interactive flooring system is introducing to overcome the problem. Embedded tile is the device that replaced the CCTV or camera in this flooring system. The tile is embedded with a series of sensor which able to detect the human foot step impact. Embedded tile can have the same functionality as CCTV or camera and it is just a low cost device and low power consumption for operation.

On the other hand, there are many interactive flooring systems already published to the world. For example, Interactive e-Directory System for Shopping Mall from Hong Kong's company, ZTFLOOR from Zhongtian, China and Verity Systems (M) Sdn Bhd from Malaysia. All these company or system are unable to identify the location of tile. Therefore, for my final year project is introducing the function of identify location of tile. This feature can identify which tile is the people stepping and thus can take particular action like activate the indicator nearby or display which tile is the people stepping.

Furthermore, most of the flooring system is using wired communication approach. Wired system makes the appearance of the system look mess and it will costly as well. Therefore, in this project, there is no longer using wired communication for the system, wired communication is replaced by wireless communication. Every information or data will transmit through internet.

1.3 OBJECTIVES

The main objectives of the project are listed below:

a) To design a wireless interactive flooring system.

b) To fabricate an embedded tile for interacting flooring system.

c) To test the performance of prototype.

1.4 SCOPES OF PROJECT

The modality of this interactive flooring system is based on the human foot step impact that acting towards the surface of tile. Once the system detects there is any impact on the surface of the tile, the microcontroller that build in the Wi-Fi module, ESP8266 will decide either to activate or not to activate the indicator nearby. For this project, it is just using a prototype to prove the concept. For the real application, it could be used in multiple field and thus it would not to discuss in this project.

For the software part, there are two software have been used in this project which are Arduino IDE and Blynk. Arduino IDE is the platform that used to flash the programming into the Wi-Fi module, ESP8266. Besides, Blynk is the open source app that used as graphical user interface for user to identify the location of tile and the status of LED indicator.

For the hardware part, two tiles that made by rubber are used to prove the concept. Tile is divided into two layer which are upper layer and bottom layer. The upper layer is embedded with a tile's location sensor and a human foot step impact sensor. The bottom layer is act as a marker for identify the location of tile. The size of tile used in this project is 330mm*270mm. A self-design switch that made by copper plate is used to detect the human foot step impact and a copper contact is used to identify the location of tile. Besides, ESP8266 is a Wi-Fi module which is used for wireless data transmission in this project.

For the prototype performance testing, the human's weight for stepping on tile is limit from 40kg to 80kg to avoid spoiling the human foot step impact sensor. The system is only working under coverage of internet due to this system is wireless communication

system. The prototype performance testing is carry out in indoor for optimize the performance of the prototype. Normal walking step is needed in the performance testing to avoid the damage happen on the human foot step impact sensor.

1.5 PROJECT OUTLINES

Chapter 1 is the introduction of the project. It is consisting of background study, problem statements, objectives and scopes of the project.

Chapter 2 is to describe the literature review. It is a summarization of previous research that related to this project. It is also to identify the gap of research where this project attempt to fill and reorganize the important of the research.

Chapter 3 is to identify the methodology of the project. It is describing about the communication between tiles and mobile app, the functionality of the switch and the tools required.

Chapter 4 is to determine the result of the project. It is highlighting the response that obtained from the sensor and a desired circuit is designed for the embedded tiles. It is also determining the action taken when there is a force impact on the tiles.

Chapter 5 is to conclude the overall progress of the project based on the findings and recommendations for the research advancement. Its sustainability and impact for commercialization are discussed in this chapter as well.

CHAPTER 2

LITERATURE REVIEW

This chapter presents the literature survey from the related journals or articles on the theoretical background. The former research that has been done or similar to the project will be discussed.

2.1 WIRELESS DATA TRANSMISSION

Wireless will be a term used to explain telecommunications to which electromagnetic waves carry the signal through a piece or every bit of the correspondence way. [4] The most common wireless technologies are using radio waves. In computing world, most basic sort of wireless abilities computers have are Wi-Fi and Bluetooth. Wi-Fi is the innovation utilized for remote systems administration. [5] Wi-Fi provides Internet access to anyone who connected to the wireless network. Bluetooth is the technology that frequent used for wireless mouse or keyboards, wireless printing, and wireless headsets.

2.1.1 HISTORY OF WIFI

In year 1985, Wi-Fi does not exist without a decision taken by Federal Communications Commission (FCC), America's telecoms regulator, to get a few group of wireless spectrum, enabling them to be utilized without the requirement for a government permit. In year 1988, NCR Corporation, which wanted to use the unlicensed spectrum to hook up wireless cash registers, asked Victor Hayes, one of its engineers, to look into getting a standard started. Mr Hayes, along with Bruce Tuch of Bell Labs, approached the Institute of Electrical and Electronics Engineers (IEEE), where a committee called 802.3 had defined the Ethernet standard. [6]

Wi-Fi was designed and first discharged for buyers in 1997, when a board of trustees called 802.11 was made. This prompt the production of IEEE802.11, which alludes to an arrangement of gauges that characterize correspondence for remote neighborhood (WLANs). Taking after this, a fundamental particular for Wi-Fi was set up, permitting two megabytes for every second of information exchange remotely between gadgets. This started an advancement in model hardware (switches) to conform to IEEE802.11, and in 1999, Wi-Fi was presented for home utilize.

In 2003, faster speeds and separation scope of the prior Wi-Fi variants joined to make the 802.11g standard. Switches were improving as well, with higher power and further scope than any time in recent memory. Wi-Fi was starting to discover up – contending with the speed of the speediest wired associations.

2009 saw the last form of the 802.11n, which was significantly quicker and more solid than its forerunner. This expansion in effectiveness is ascribed to 'Numerous information different yield' information (MIMOs), which utilizes various radio wires to improve correspondence of both the transmitter and collector. This took into consideration noteworthy increments in information without the requirement for higher transmission capacity or transmit control. [7]

801.11ac is to improve the 5Ghz territory. It had four times the speed of Wi-Fi 801.11n, a more noteworthy width and could be sent all the more rapidly. Year 2012, the introduction of the Beamforming idea, which is clarified by Eric Geier as focusing information transmission, thus more information achieves the objective gadget.

2.1.2 HISTORY OF BLUETOOTH

In year 1994, Ericsson, the Swedish telecommunications company, have the idea of replacing the tangle of RS-232 cables that usually used to communicate between instruments with an RF-based 'wireless' alternative. At the same time, Intel and Nokia had also have the same idea of wirelessly linking cellphones and computers. In turn, they realized that to have any chance of universal interoperability (allowing products from different companies to connect because they used a common RF protocol) the technology would need to be standardized and driven by a Special Interest Group (SIG). The companies met at the Ericsson plant in Lund, Sweden, in December 1996 to agree on the formation of a SIG.

The Bluetooth SIG was authoritatively formed with five companies which were Ericsson, Nokia, Intel, Toshiba, and IBM in 1998. Version 1 of the technology, Bluetooth SIG was launched a year later. By 2005, Version 2.0 had been approved, the SIG had welcomed its 4,000th member and shipments had reached 5 million per week.

In June 2007, the Bluetooth SIG procured the Wibree Alliance, a Nokia-led activity that incorporated Nordic Semiconductor and which had set out to develop an ultra low power (ULP) form of wireless connectivity. Nordic and others brought their expertise to develop a form of Bluetooth wireless technology, initially dubbed ultra low power Bluetooth and later Bluetooth low energy.

In year 2010, the latest version of Bluetooth wireless technology, Version 4.0 which included Bluetooth low energy as a hallmark element was ratified and soon after the two types of chip described in the core specification.

Today, Bluetooth wireless technology is consolidated under billions of chips to many applications. It is convenience on an immense new division for units powered toward coin mobile batteries. Then afterward almost two decades for development, combined Bluetooth item shipments have passed 2.5 billion, participation has arrived to 19,000. The innovation organization is maturing under an item that need a brilliant future in fact. [8]

2.1.3 COMPARISON OF WIFI AND BLUETOOTH

	Wi-Fi	**Bluetooth**
Frequency	2.4, 3.6, 5 GHz	2.4 GHz
Cost	High	Low
Bandwidth	High (11 Mbps)	Low (800 Kbps)
Specifications authority	IEEE, WECA	Bluetooth SIG
Security	Security issues are already being debated.	It is less secure
Year of development	1991	1994
Primary devices	Notebook computers, desktop computers, servers, TV, Latest mobiles.	Mobile phones, mouse, keyboards, office and industrial automation devices. Activity trackers, such as Fitbit and Jawbone.
Hardware requirement	Wireless adaptors on all the devices of the network, a wireless router and/or wireless access points	Bluetooth adaptor on all the devices connecting with each other
Range	With 802.11b/g the typical range is 32 meters indoors and 95 meters (300 ft) outdoors. 802.11n has greater range. 2.5GHz Wi-Fi communication has greater range than 5GHz. Antennas can also increase range.	5-30 meters
Power	High	Low
Ease of use	It is more complex and requires configuration of hardware and software.	Fairly simple to use. Can be used to connect upto seven devices at a time. It is easy to switch between devices or find and connect to any device.
Latency	150ms	200ms
Bit-rate	600 Mbps	2.1Mbps

Table 2.1 Comparison of Wi-Fi and Bluetooth [9]

2.2 TILE'S LOCATION SENSOR

Tile's location sensor is a sensor that able to identify the location of tile. The following Table 2.2 is the comparison among the Bluetooth tracking, copper plate marker, Radio-frequency identification (RFID) and ultrasonic sensor.

	Bluetooth tracking [10]	**Copper plate marker**	**RFID** [11]	**Ultrasonic sensor** [12]
Type of sensor	Active	Passive	Passive	Active
Cost	High	Low	High	Low
Hardware requirement	Bluetooth tracking tag	Copper plate (marker and sensor)	RFID (tag and detector)	Ultrasonic sensor
Detector range	Long	Short	Short	Long
Accuracy	Low (estimate location)	High	High	High
Measurable	Yes (estimate measurement)	No	No	Yes
Detection volume	High	Low	High	High

Table 2.2 Comparison of Bluetooth tracking, copper plate marker, RFID and ultrasonic sensor

2.3 HUMAN FOOT STEP IMPACT SENSOR

Human foot step impact sensor is a sensor that used to detect the people stepping on tile. The following Table 2.3 is the comparison of the suitable sensor for detecting the human foot step impact. The sensors involve in comparison are copper switch sensor, capacitive sensor and pressure sensor.