

# Interactive Beating Drum Unity Game

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## Abstract

Interactive Beating Drum Unity Game is proposed in this paper. The pandemic forced individuals to maintain a prescribed social distance from others, and this way may ignore the individual's mental health and social needs, especially for the elderly. The Unity Engine is used to implement the system to provide a sport and social plane. And Bluetooth Low Energy (BLE) chip is adopted to transmit the beating signal to Unity Engine what following the Bluetooth (BT) protocol. Then the position beat by users will be showed on the user interface tablet. There are two play mode be implemented: single player mode and multiplayer mode, and the latter will include social function. The users are required to drum in short time interval accurately, and the game award points are evaluated for accuracy. The experimental results show the system workable, and the subjects unanimously stated that the operation of the game Easy-to-Use.

*Keywords:* Interactive Game, Unity, BLE

## 1. Introduction

While the World Population Prospects, United Nations report, mentioned the percentage of world population aged that over 65 years old will increased from 9% to 16% between 2019 and 2050. That is, population ageing would become a development trend in future years. The geriatric health make it a key factor to evaluate whether they can contribute for family or community. The physiological degeneration, memory loss and poor physical coordination affecting the daily life as a result of the aging process. So, to improve quality of life, postpone senility is the key. To best our knowledge, the first international congress on gerontechnology in August 1991. Trying to improve the elder's daily life and growing elderly population [1]. In recent years, gerontechnology most used as an adjunct to have continued normal life. For example, health monitoring for wearable device, enable basic warning and prevention. Many papers propose that digital games can benefits improving the elder's wellness, enhancing social bond and generating a sense of happiness [2],[3],[4]. In addition, it considered an effective form of exercise [5].

The pandemic has accelerated the development of information technology and changed people's daily life. The technology makes people keep in touch without the region and time restriction. Moreover, it increases digital game and digital learning development opportunities. During the lockdown measures period, in

the beginning of the epidemic, people have increased interest in games. Instead of online games or console games, portable gaming console market share has steady increased. It shows the potential how the games create the social relation.

## 2. System Architecture

The system architecture is showed in Fig.1. The research use Laser engraving drum head, accomplishing the wireless transmission by Bluetooth Low Energy (BLE) and applying Unity on the tablet to establish the user interface. The applicion of sensing device can display the hitting position effectively. First, piezoelectric sensors convert mechanical energy into electrical energy when the drum is beat. The ADC in Bluetooth module receives the voltage generated by piezoelectric sensors and converts this signal to data in binary format. The module will send the position code to Unity by Bluetooth. In the end, Unity decodes the Bluetooth code and displays the position on the user interface. This rhythm game can not only help the elders enhance muscle strength of their upper limb while playing game, but also interactive with others who are impacted by the pandemic on Internet at home.

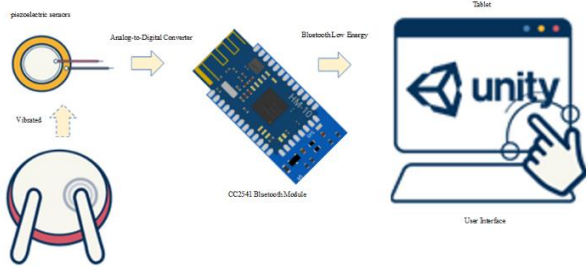


Fig.1 System architecture diagram

### 3. System Development

#### 3.1 Unity

Unity is a cross-platform game engine that can support Windows, MacOS, Linux, iOS, Android, and etc. Besides games, it can develop variety levels of application[6]. The advantages of Unity including the visual window, the function of cross-platform develop and several source plugins. The method of building engine which depends on users' requirements can be divided into two parts, one is two dimension(2D) and another is three dimension(3D). Unity2D is adopted as our development environment because this paper refers the gameplay of Taiko Drum Master. We implement the unity in Android tablet to receive the signal which is processed from the Bluetooth module. The signal connects the game and decides the corresponding drop point on rhythm beats such as left side, left head, right head, right side, both head and both side. Unity collect and process these information, controlling user interface and responding on the tablet by coding. By receiving and integrating the interactive information, the user interface will complete the drumming interactive application.

#### 3.2 Bluetooth Low Energy (BLE)

Bluetooth Low Energy(BLE) is developed by Bluetooth Special Interest Group (SIG). The performance of BLE are completely compared by [7]. BLE optimizes the transmission of small data and has been widely utilized on various occasions, for example, wearable device, automotive application[8],[9], medical environment and home automation[10],[11],[12],[13]. It uses Generic Attribute Profile (GATT) to send and receive application data. GATT encapsulate the Attribute Protocol (ATT) use service[14], characteristic and property to establish the link, to organize data, to read and to write data. Bluetooth SIG specification for BLE includes several definitions for common applications. However, users can define server and characteristic freely with their requirement of application and data structure. This method is suitable for sensor devices that only need to transmit data status. The user interface of proposed system receives the Analog-to-Digital Converter(ADC) sampling signal from sensor by using the Bluetooth module.

#### 3.3 Piezoelectric sensors

Piezoelectric sensor is made of a piezoelectric material which is a kind of transduction element[15]. We install piezoelectric sensors under the drum head, determining the position of the drum by using the piezoelectric characteristics of component. When there is any external power force to the component, its internal electric dipole moment will be shortened by the pressure and generate voltage in order to resist the change caused by external pressure. If users need to generate electrical energy continuously, they will need to vibrate the sensor. Eq. (1) describe the effect process of piezoelectric that converts mechanical energy into electrical energy. In this paper, we divide the beat position into four, including left side, left head, right head and right side to avoid the vibration effect of beating. Fig.2 shows the method of energy converting of piezoelectric elements.

$$P = d\sigma \quad (1)$$

Where  $P$  is the polarization intensity of crystal,  $d$  is the piezoelectric constant,  $\sigma$  is the stress.

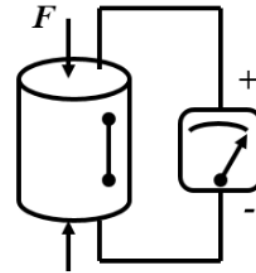


Fig.2 Inverse piezoelectric effect

#### 3.4 Operational Amplifier (OPA)

##### 3.4.1 Voltage follower

Voltage follower is an application of an Operational Amplifier (OPA). We design a high input impedance and a low output impedance for the OPA in the proposed system. Because the gain value is set to 1, output voltage will equal to input voltage. Obviously, the OPA reduce the source impedance without loading effect and reducing sample rate. Finally, we implement a RC filter circuit in the output of piezoelectric sensor to remove the wave noise.

#### 3.5 Analog-to-Digital Converter (ADC)

We use the 12bits ADC in CC2541 Bluetooth module to sample the time domain data. To convert data from continuous-time to discrete-time and to present data as binary coded form are the characteristics of ADC [16]. In our application, we set a threshold range for ADC value. When the converted voltage exceeds the threshold range, Bluetooth will determine where the position you beat and then we will adjust the ADC threshold to avoid wrong measurement because four position affect each other.

#### 4. Result

This paper Unity game engine is used to develop our game content. This software can be used for cross platform development and supports Windows, MacOS, Linux, IOS, Android and other console games. Samsung Galaxy Tab A7 with Unity application is used to be our development platform. The device we proposed in this paper can not only drumming but also interactive with each other on the internet. First, we simplify the gaming operation to reduce the learning burden. Drumming is a low intensity exercise, so it is suitable for elder to increase the strength. Moreover, the behavior of online interaction helps the elder maintain their social connection regardless of time and space.

To combine internet of things technology and sensors, CC2541 Bluetooth module is selected in this paper. The drum design retains the same as general drum, including drum body and sticks. We use the piezoelectric sensors in the drum head to detect the vibration. The sensors are small enough that can hide in the interlayer between the drum head and the bottom to reduce the signal influence while user drumming. When the sensor is pressed by the external force, the piezoelectric element will generate positive output voltage in order to reduce the change caused by the external stress. Fig.3-Fig.6 are the voltage wave form while piezoelectric sensors being pressed. As a result, the voltage will increase with vibration. Also, we applied OPA in order to reduce the loading effect, and filtered the output. At the end, sampling the time domain data by ADC with our Bluetooth module. The Bluetooth module will read the ADC voltage information of the beat, and determine which part of drum be struck. Fig.7-Fig.10 are the RC filtered voltage waveform.

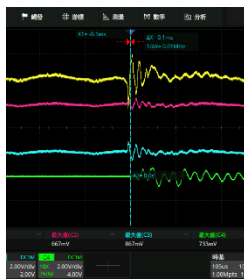


Fig.3 Left side voltage waveform

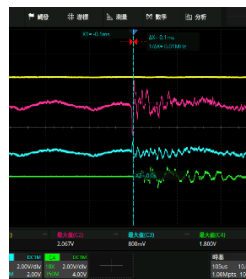


Fig.4 Left head voltage waveform



Fig.5 Right face voltage waveform



Fig.6 Right side voltage waveform



Fig.7 Left side voltage waveform



Fig.8 Left face voltage waveform

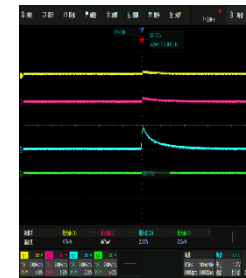


Fig.9 Right face voltage waveform



Fig.10 Right side voltage waveform

Different materials of drum head such as traditional taiko drum, Electronic drum with silencer drum head and the drum head are made of laser engraving in Fig.11 has been test in our research. In order to adapt to home environment and consider the accuracy of beating feedback, the drum head made of laser engraving has been chosen. We change the interlayer from foam in Fig.12 to hollow in Fig.13. In Fig.13 interlayer, we lock the screws to decrease the bottom area of contact. The piezoelectric sensors are installed between the drum head and drum bottom in Fig.14 that can identify the position are beat.



Fig.11 Laser engraving



Fig.12 Left head voltage waveform



Fig.13 Right face voltage waveform

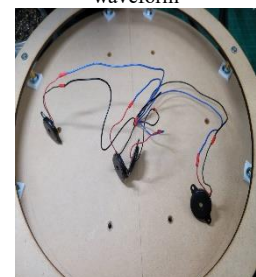


Fig.14 Right side voltage waveform

## 5. Conclusion

In this paper, a simple operation interface is used to reduce elders' learning burden. Elders can play online game with other players though the connection between Unity and BLE technology even at home. With this simple playing way, elders can not only prevent Sarcopenia but also communicate with others at home.

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## Authors Introduction

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