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Research on Endpoint Detection Algorithm in High Altitude Explosion Point Location Technology

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Abstract: Aiming at the problem of inadequate positioning accuracy of sound endpoints by the dual-element single-threshold endpoint detection algorithm and the single-element dual-threshold endpoint detection algorithm in the process of locating the sound source of weather modification bombs at high altitudes during artificial weather modification, a multi-element dual threshold endpoint detection algorithm. First, according to the characteristics of high-altitude explosion of weather modification bombs and ground reception, the sound signal is filtered and denoised, divided into frames, and windowed. Then, the time-domain feature short-term energy, short-term zero-crossing rate and frequency domain feature short-term information entropy of each frame of the sound signal are calculated, and double thresholds are set for detection. In this way, the start and end points of the explosion sound in the collected sound signal are found, and the data is imported into the positioning algorithm for processing, and then the explosion point of the weather modification bombs in the high air is located. The test results show that the method can accurately distinguish the end point of effective explosion sound, and has practical application value for the location of the sound source of the high-altitude explosion point of the weather modification bombs.
Keywords: Endpoint detection;Multi-element double threshold; Short-term stability; Weather Modification; Sound source localization

1. INTRODUCTION

Artificial weather influencing is to artificially influence the physical process of the local atmosphere through anti-aircraft artillery operations under appropriate conditions to achieve the purpose of increasing rain and snow, preventing hail, eliminating rain, eliminating fog, and preventing frost [1]. The use of sound source localization technology can effectively measure the high-altitude explosion location information of human shadow bombs, and at the same time effectively evaluate the effect of human shadow operations. When the sound source positioning system is used to locate the explosion point of the shadow bomb, only a small part of the large amount of sound data collected by the system belongs to the sound information of the shadow bomb explosion. A large amount of other redundant information makes the positioning system unable to transmit or process the data in real time. Reduce the performance of the system [2].

Voice endpoint detection algorithm is a common method of voice signal preprocessing [3]. Literature [4] proposed an advanced quantum-based endpoint detection algorithm to process audio data in a quantum computer, but it is temporarily not suitable for embedded audio processing. Literature [5-7] starts with time domain features, and literature [8] starts with frequency domain features. They study detection algorithms based on short-term energy, detection algorithms based on short-term zero-crossing rate, and short-term energy and short-term energy. Zero-crossing rate detection algorithm and detection algorithm based on spectral entropy. Literature [9-11] combined frequency domain features and time domain features, and studied detection algorithms based on short-term energy and information entropy and detection algorithms based on Mel frequency cepstrum coefficients. Literature [12] uses wavelet transform convolution method to detect. These algorithms have achieved certain results in voice endpoint detection.

Aiming at practical application requirements, this paper proposes a multi-element double-threshold voice endpoint detection algorithm based on the time-domain and frequency-domain features of high-altitude explosion sounds. First, filter a segment of speech signal, divide it into frames, and preprocess it with windows, and then calculate the short-term average energy, short-term average zero-crossing rate and short-term information entropy of each frame of speech. Each element is set with dual thresholds. The start point and end point of the collected explosive voice information are determined. The multi-element dual-threshold voice endpoint detection algorithm is convenient for dynamic real-time processing or transmission of effective voice data, and it can also improve the timeliness of the positioning algorithm [13].

2. POSITIONING ALGORITHM

Aiming at the problem of estimating the position of the high-altitude bombing point of human shadow bombs in order to adjust the launch angle and improve the operation effect, a time-delay-based sound source positioning system with low computational complexity and strong real-time performance is designed. The system uses a four-element cross pickup array to collect sound signals in real time. And processing.

2.1 Time Difference Of Arrival

The sound source localization algorithm based on time delay calculates the time delay between the sound source reaching each sensor, and then uses the minimum distance mean square error criterion to solve the azimuth angle, pitch angle and distance of the sound source [14].

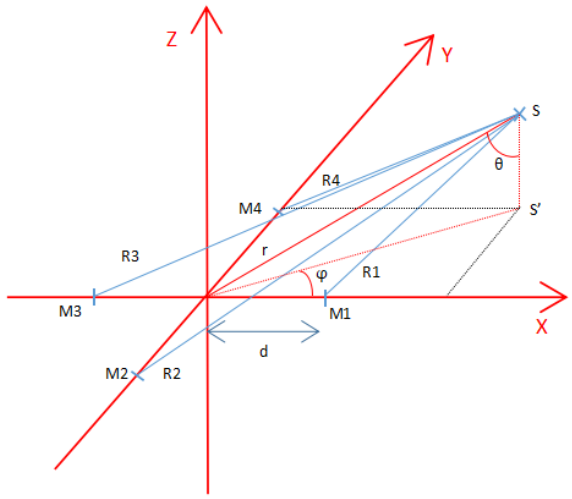

Figure 1. Four-element cross localization model diagram

The construction of the four-element cross sound source localization model is shown in Figure 1. The four high-precision capacitive pickups are located at M1(d,0,0), M2(0,-d,0), M3(-d,0,0).),M4(0,d,0). The origin coordinate is O(0,0,0), and the sound source is located at S(x,y,z). The projection of point S on the XY plane is S'. The azimuth angle of the sound source point S is φ, and the pitch angle is θ. The azimuth angle is the angle between the positive semi-axis of the X axis and the counterclockwise, and the pitch angle is the angle between the positive semi-axis of the Z axis.

Establish a system of equations, and then according to the minimum distance mean square error criterion, we can get:

distance: $$SO \approx \frac{c*(\tau_{12}{}^2+\tau_{14}{}^2-\tau_{13}{}^2)}{2*(\tau_{13}-\tau_{12}-\tau_{14})} \quad (1)$$

Azimuth: $$\varphi \approx \arctan(\frac{\tau_{14}-\tau_{12}}{\tau_{13}}) \quad (2)$$

Pitch angle: $$\theta \approx \arcsin(\frac{c*\sqrt{\tau_{13}{}^2+(\tau_{14}-\tau_{12})^2}}{2*d}) \quad (3)$$

Among them, $\tau_{12}, \tau_{13}, \tau_{14}$ are the time delays of the sound source reaching sensor 1 and reaching sensors 2, 3, 4, c is the speed of sound, and d is the distance between the sensors.

2.2Time Delay Estimation Method

When the sound source is located $r > 2 * d^2/\lambda$, the sound source is considered to be in the far field position, and the sound source is a plane wave when it reaches the sensor, which is the maximum wavelength of the sound source. Ignoring the amplitude difference between the received signals of each array element, it is approximately considered that there is a simple time delay relationship between the received signals. Suppose any two sensors and the received signals are respectively

$$x_i(m) = s(m - \tau_i) + n_i(m) \quad (4)$$

$$x_j(m) = s(m - \tau_j) + n_j(m) \quad (5)$$

They are N-point discrete signals sampled by ADC. Among them $s(m)$ are the sound source signal, $n_i(m)$and $n_j(m)$white noise, $\tau_i$andτ_j the time that the sound propagates to the sensor M_i and M_j ,the time delay between the sensor M_i and M_j is $\tau_{ij} = \tau_i - \tau_j$. The cross-correlation function of the received signal can be expressed as:

$$R_{ij}(\tau) = E[x_i(m) \cdot x_j(m + \tau)] \quad (6)$$

Because $s(m), n_i(m), n_j(m)$ are not related to each other, we can get equations (4) and (5) into equation (6) and simplify

$$R_{ij}(\tau) = E[s(m - \tau_i) \cdot s(m - \tau_j - \tau)] = R_{ss}(\tau - \tau_{ij}) \quad (7)$$

It can be known from the nature of the autocorrelation function that at that time $\tau = \tau_{ij}$, the cross-correlation function has the largest peak. However, in the actual environment, the cross-correlation function will produce many peaks due to non-Gaussian white noise. When the reflected wave is too strong, the cross-correlation peak of the direct signal will be overwhelmed, resulting in inaccurate experimental estimation. In order to suppress the influence of noise, the generalized cross-correlation method can be used to weight the cross-correlation function in the frequency domain to make the peak of the cross-correlation function more obvious [15].

3. SIGNAL PREPROCESSING

When the sound signal is used for positioning, the final sample value matrix of the sound signal imported into the positioning algorithm should be the sound fragment of the human shadow bomb explosion in the air. The proportion of the effective sound segment in this sound has a great influence on the positioning accuracy. Therefore, it is necessary to distinguish between a section of sound containing noise (unused sound section) and explosive sound (effective sound section), and extract the effective sound section containing only explosive sound or as little noise sound section as possible. The preprocessing of sound signals mainly includes filtering, framing, windowing. [16].

3.1 Filter

The signal contains various noises that will cause interference with short-term energy, short-term zero-crossing rate, and short-term information entropy. Therefore, it is necessary to use a filter to filter out some noise. According to the sound attenuation, the sound of the explosion can be known from the sound attenuation after being spread over a long distance in the air.The energy of the explosion wave reaching the acquisition system is mainly concentrated below 1000 Hz. Therefore, the filter is a Butterworth bandpass filter with a passband frequency of 50Hz~1000Hz. As shown in the band-pass filter diagram in Figure 2, the upper half is the original signal collected by the first sensor, and the lower half is the original signal after the band-pass filter. The filtering effect is ideal.

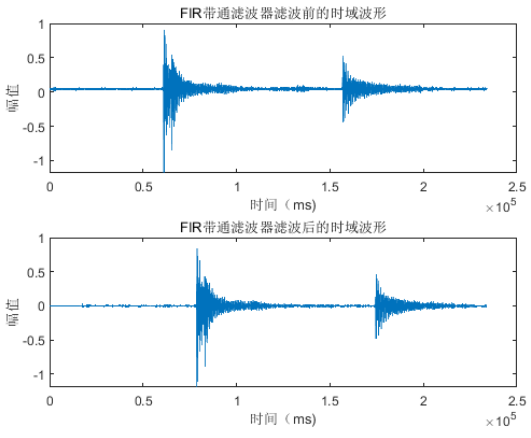

Figure 2. Bandpass filter diagram

3.2 Framing and Windowing

Fourier transform is to study the relationship between the entire time domain and the frequency domain. When processing sound signals, it is impossible to measure and calculate infinitely long signals. Therefore, the sound signal is divided into frames, and the long sound signal in a period of time is divided into multiple shorter frames, and then the short-term energy, short-term zero-crossing rate and short-term information entropy can be calculated for each frame. . After an infinite signal is truncated, its spectrum is distorted, which is also called spectral energy leakage. In order to reduce spectrum leakage, different interception functions can be used to intercept the signal. The interception function is called a window function, and the sound signal is windowed. More stable [17]. The sound signal is a random signal. According to the recommendation in [18], the Hanning window is selected to process the sound signal, the frame length is set to 1024 sampling points, and the frame shift is 512 sampling points.

4. ENDPOINT DETECTION

4.1 Short-term Energy

The difference between the sound segment and the noise segment is particularly obvious in terms of energy. The energy of the sound segment is obviously higher than the energy of the noise segment. At the same time, the energy of the sound segment is the sum of the noise energy superimposed on the sound energy [18]. As shown in Figure 3, when the signal-to-noise ratio is very high, only the short-term average energy can effectively distinguish the sound segment from the background noise segment. Within the error allowed by the positioning algorithm.

The short-term energy is defined as:

$$E_n = \sum_{m=-\infty}^{\infty}[x(m).w(n-m)]^2 \quad (8)$$

It can also use the short-term average amplitude to replace the short-term energy. The short-term average amplitude is defined as:

$$M_n = \sum_{-\infty}^{\infty}|x(m)|.w(n-m) \quad (9)$$

Among them, w(n) is the window function.

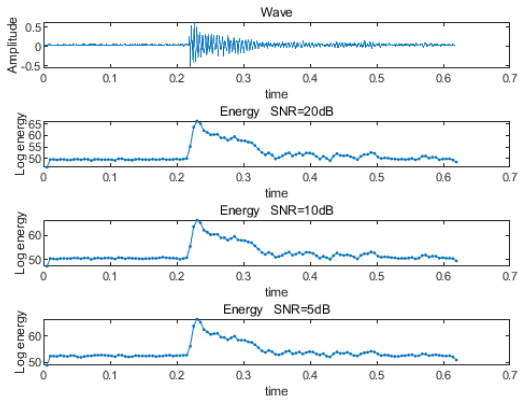

Figure 3. The effect of noise on short-term energy

4.2 Short-term Zero crossing Rate

The number of times a frame of sound crosses the zero point, that is, the horizontal axis, is defined as a short-term zero crossing. For continuous sound signals, zero crossing means that the time-domain waveform crosses the time axis. For discrete signals, if the sign of adjacent sampling points changes and the product of two adjacent sampling points is less than zero, it means zero crossing. The zero-crossing rate is the number of sign changes.

The short-term average zero-crossing rate is defined as:

$$Z_n = \frac{1}{2}\sum_{m=-\infty}^{\infty}|sgn[x(n)] - sgn[x(m-1)]|.w(n-m) \quad (10)$$

Among them, sgn(n) is the symbolic function.

From the definition of the zero-crossing rate, it can be seen that the zero-crossing rate is easily interfered by low-frequency signals, and part of the noise is concentrated in the low-frequency part. Therefore, before calculating the short-term zero-crossing rate, a high-pass filter can be used to filter out the low-frequency noise, and then the zero-crossing rate can be calculated. You can also perform median filtering on the data, then modify the traditional zero point and set the zero point threshold T, so that zero crossing means crossing the positive and negative threshold T[19]. It can effectively reduce the false zero-crossing rate caused by noise and improve the efficiency of endpoint detection.

This article chooses the second method, and through research, it is found that if the DC component is not removed during the filtering process, or a small DC component is added after removing the DC component of the original signal, its effect is the same as setting the zero threshold. . As shown in Figure 4, the DC component is very small, and not using the average filter is equivalent to setting the zero threshold T. However, as the signal-to-noise ratio decreases, the false zero-crossing rate caused by noise will make it impossible to distinguish the start and end points of the sound.

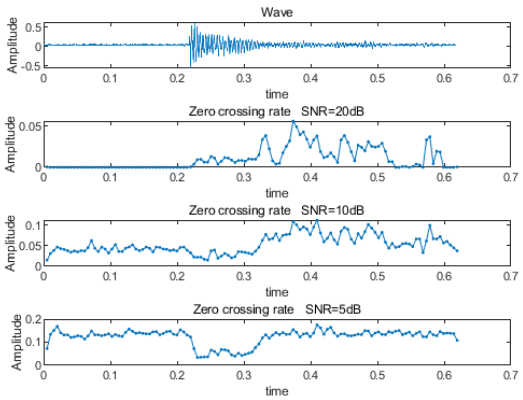

Figure 4. The effect of noise on the short-term zero-crossing rate

4.3 Information Entropy

For a discrete source, when it is composed of several random events, the uncertainty of the occurrence of a random event is described by the probability of its occurrence. The smaller the probability of an event, the smaller the probability and the greater the amount of information contained. On the contrary, the greater the likelihood of an event, the greater the probability and the smaller the amount of information

contained. Therefore, the short-term average amount of information provided by the source is expressed as:

$$H(X) = -\sum_{i=1}^{n} p_i \log_2 p_i \quad (11)$$

Since the amplitude of the sound signal has a large dynamic range relative to the amplitude of the background noise, it can be considered that the random event of the sound signal in the range (-M, M) is large, that is, the information entropy is large, and the invalid sound segment only contains the amplitude of the background noise Small, the distribution is relatively concentrated, so the information entropy is small. As shown in Figure 5, as the signal-to-noise ratio decreases, the short-term information entropy fluctuates to a certain extent, but the start and end points of the sound can still be distinguished. According to the above principles, after constructing the entropy function, the information entropy of each frame of signal can be calculated.

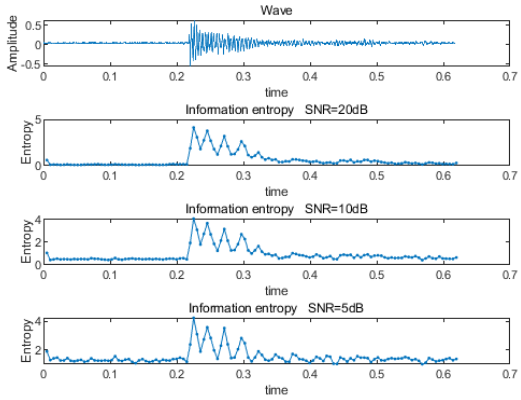

Figure .5 The effect of noise on short-term information entropy

4.4 Multi-element and Double threshold Detection

The multi-element double-threshold method is used to locate the sound source of the explosion point of the shadow bomb to find out the part of the speech that contains the explosion sound. The multi-element double-threshold method is realized by using the three-level judgment of the short-term energy of the sound, the short-term zero-crossing rate and the short-term information entropy.

The first level of judgment, as shown in Figure 6, a higher threshold TH1 is selected on the short-term energy envelope of the sound, and the one higher than the TH1 gate, that is, between the AB segments must be speech, and the start and end points of the speech should be located at this threshold Outside the time point corresponding to the point of intersection with the short-term energy envelope. Determine a lower threshold TH2 on the average energy, and search from point A to the left and from point B to the right to find the two points C and D where the short-term energy envelope intersects the threshold TH2, so the CD segment is used The double-threshold method determines the start and end positions of the sound segment based on the short-term energy.

The second level of judgment is based on short-term information entropy. Two thresholds TH3 and TH4 are set on the short-term information entropy envelope. Using the same judgment method as the short-term energy, the double-threshold method of short-term information entropy can be obtained. The starting and ending point positions of the obtained voice. The start and end points obtained by the short-term energy and short-term information entropy are weighted and averaged to obtain the dual-element dual-threshold speech start and end points.

The third level of judgment is based on the short-term average zero-crossing rate. From the weighted average starting and ending points, search from point C to the left and from point D to the right, and find two short-term average zero-crossing rates lower than the threshold TH5. Points M and N are the starting and ending points of the sound segment determined by the multi-element double-threshold algorithm.

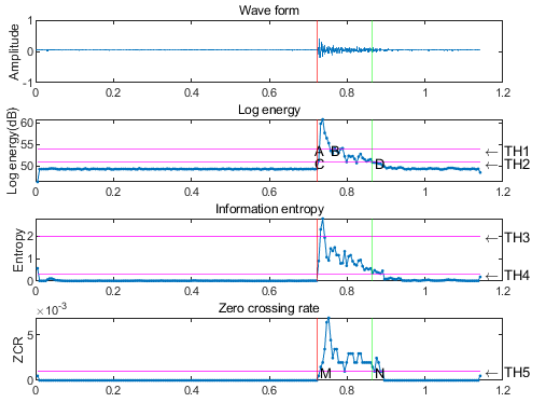

Figure .6 Voice endpoint detection diagram

5. EXPERIMENT ANALYSIS

5.1 Experimental Environment

The experimental environment was chosen in an empty playground to reduce the reflection and reverberation of sound. The sound source chooses cowhide drums to replace the explosion sound, the sound frequency is 200Hz~300Hz, and the sound source is 10m away from the center of the pickup array. Start at 0° and collect twice every 45°. In the first collection, hit the cowhide drum twice, and in the second collection, hit the cowhide drum once.

5.2 Data Collection and Analysis

The sampling rate of the data acquisition system is set to 100kHz, and the four channels are collected simultaneously. A total of sixteen sets of data are obtained, and each set of data has four channels.

Using a multi-element double-threshold sound endpoint detection algorithm in MATLAB, each set of data can be used to obtain the sound starting point and ending point of the signals received by the four sensors. The starting point is used as the starting point for the sensor array to receive the sound signal, and the largest ending point is used as the ending point of the sound. The starting point and ending point of the sound signal received by the sensor array can be obtained.

Table 1 compares the results of single-sound four-channel sound endpoint detection and manual marking of the start and end points of the sound, and the error is within one frame. When locating the sound source, you only need to know the starting point of the sound, and then take 5-10 frames of data from the starting point backwards, and then you can use generalized cross-correlation to get the time delay between each sensor for positioning. Moreover, the sound has a certain length of tail, and it is difficult to manually mark the end point, so the end point of the sound is not manually marked.

Table 1 Starting and ending point test results table

	Detection algorithm		Manual marking	
	Starting point	End point	Starting point	Error
Ch.1	123905	135680	123960	-55
Ch.2	123905	134656	123990	-90
Ch.3	123905	133632	124290	-385
Ch.4	123905	134656	124000	-95
Ch_All	123905	135680	123960	-55

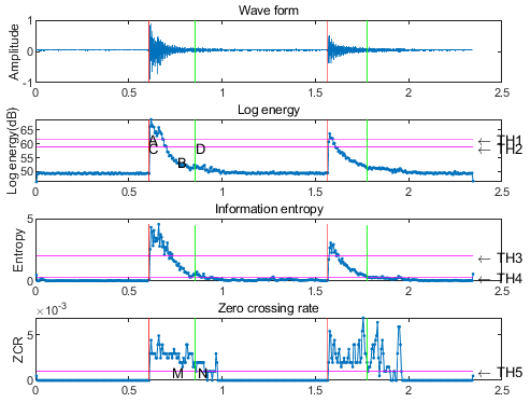

Figure 7. Voice endpoint detection diagram

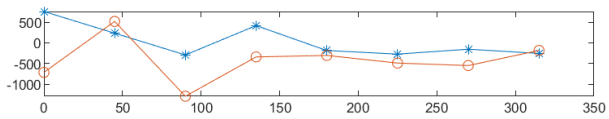

Figure 8. Sixteen data sets of sound starting point errors

Figure 7 Voice endpoint detection The picture shows the voice endpoint detection including two voices.It can be seen that the algorithm accurately marked the start and end points of the two speech signals. Figure 8 shows the error between the 16 sets of data voice endpoints detecting the start and end points of the marked voice and the start point of the manual marking. It can be seen that the multi-element double-threshold algorithm effectively marks the starting point of the speech, and the detection error meets the needs of the positioning algorithm.

6. CONCLUSIONS

This paper uses the short-term stability characteristics of the sound signal and proposes a multi-element double-threshold algorithm using short-term energy, short-term zero-crossing rate and short-term information entropy to determine the start and end points of the sound. Experimental results show that the algorithm can effectively mark the start and end points of the sound, and can provide effective speech fragments for the sound source localization algorithm. In this paper, the algorithm processing of adaptive threshold is not implemented. The threshold is only derived from a large amount of experimental data, and when the signal-to-noise ratio drops below 5dB, a large number of misjudgments will occur in the short-term zero-crossing rate and lead to errors in the results. In the next step, the adaptive threshold sound endpoint detection will be studied to achieve more accurate sound endpoint detection.

7. REFERENCES

[1] Huanbin Xu,Jinfang Yin. Key issues in developing numerical models for artificial weather modification[J]. Journal of Meteorological Research,2017,31(6).

[2] Nan Jiang,Ting Liu,Thomas Hanne. An Improved Speech Segmentation and Clustering Algorithm Based on SOM and K -Means[J]. Mathematical Problems in Engineering,2020,2020.

[3] Changqin Quan,Bin Zhang,Xiao Sun,Fuji Ren. A combined cepstral distance method for emotional speech recognition[J]. International Journal of Advanced Robotic Systems,2017,14(4).

[4] Jian Wang,Han Wang,Yan Song. Quantum Endpoint Detection Based on QRDA[J]. International Journal of Theoretical Physics,2017,56(10).

[5] Wang Huasong, Zhao Xin. An accurate time delay extraction method based on endpoint detection and its positioning accuracy analysis [J/OL]. Acoustic technology: 1-6 [2021-05-18].

[6] Li Xuezheng. Design of whistle vehicle identification and positioning system for car whistle monitoring [D]. Hebei University,

[7] Yao Lina, Lu Xutao, Sun Yunqiang, Chai Jinqiang. Research on Endpoint Detection Algorithms in the Positioning Technology of Rain Enhancement Bomb and Blast[J]. Foreign Electronic Measurement Technology, 2020, 39(01): 6-9.

[8] Ling Yu. Design and implementation of sound source positioning system [D]. Hebei University of Science and Technology, 2015.

[9] Xuan Zhangjian, Cai Xiaoxia, Chu Dingli. Research on a voice endpoint detection method based on improved information entropy[J]. Communication Technology, 2018, 51(06): 1302-1306.

[10]Danyang Cao,Xue Gao,Lei Gao. An Improved Endpoint Detection Algorithm Based on MFCC Cosine Value[J]. Wireless Personal Communications,2017,95(3).

[11]Yongwon Hwang,Mun-Ho Jeong,Sang-Rok Oh,Il-Hwan Kim. Applying the Bi-level HMM for Robust Voice-activity Detection[J]. Journal of Electrical Engineering & Technology,2017,12(1).

[12]Tanmoy Roy,Tshilidzi Marwala,Snehashish Chakraverty. Precise Detection of Speech Endpoints Dynamically: A Wavelet Convolution based approach[J]. Communications in Nonlinear Science and Numerical Simulation,2018,67.

[13]Hall J I , Lozano M , Estradapetrocelli L , et al. The present and future of cough counting tools[J]. Journal of Thoracic Disease, 2020, 12(9):5207-5223.

[14] Zhang Xiaoguang, Lu Haifeng, Lu Chuanmao, Wang Puhao, Han Dong, Chen Longhu. Research on the sound source localization algorithm of four-element cross microphone array [J]. China Test, 2020, 46(02): 96-102.

[15] Zhou Hefeng, Tian Zhangfu, Zeng Yang, Gong Changchao, Zeng Xinwu, Jiang Weikang. Improved time delay estimation based on generalized cross-correlation algorithm [A]. Editorial Department of Acoustic Technology, 2020: 3.

[16]Zeng Jianfei. Research on Speech Endpoint Detection Algorithm under Low SNR[D]. South China University of Technology, 2019.

[17] Xing Lizhao. Research on Speech Signal Endpoint Detection Algorithm [D]. Zhengzhou University, 2016.PiÃ±al Moctezuma Fernando,Delgado Prieto Miguel,Romeral MartÃnez Luis. An acoustic emission activity detection method based on short-term waveform features: Application to metallic components under uniaxial tensile test[J]. Mechanical Systems and Signal Processing,2019,142.

[18]X Zhang, Cheng D , Jia P , et al. An Efficient Android-Based Multimodal Biometric Authentication System with Face and Voice[J]. IEEE Access, 2020, PP(99):1-1.

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A Design of an RFID Based Microcontroller Integrating Real Time Media Auto-Stream for Vehicle Packing

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Abstract: Microcontrollers control the actions and features of a product. They are embedded controllers inside devices. Microcontroller based devices are dedicated to a single task that run one specific program at a time. It integrates with advanced peripherals like a graphics processing unit (GPU), a Wi-Fi module, or one or more coprocessors. A number of devices currently are taking advantage of minimal requirements for memory and program length, with no operating system, and low software complexity. Typical input and output devices include switches, relays, solenoids, LED's, small or custom liquid-crystal displays, radio frequency devices, and sensors for data such as temperature, humidity and light levels. In our discussion we are coming up with an architectural design of an RFID based microcontroller for car packing. The design is created using a Qemu system running Raspbian on Windows 10.Specifically focusing on how the components that relay data interface with each other. While discussing standard definitions, challenges, and benefits of this microcontroller based technologies, as well as some interesting players in this space.
Keywords: component; formatting; style; styling

1. INTRODUCTION

Automatic identification, or auto ID for short, is the broad term given to a host of technologies that are used to help machines identify objects. Auto identification is often coupled with automatic data capture (koh *et al*, 2003). That is, companies want to identify items, capture information about them and somehow get the data into a computer without having employees type it in. The aim of most auto-ID systems is to increment efficiency, reduce data ingress errors, and free up staff to perform more value-integrated functions. There are a host of technologies that fall under the auto-ID umbrella. These include bar codes, astute cards, voice apperception, some biometric technologies (retinal scans, for instance), optical character apperception, radio frequency identification (RFID) and others.

RFID (Radio Frequency Identification) is a means of identifying an item based on radio frequency transmission (Zumsteg and Qu., 2018). This technology can be utilized to identify, track and detect a wide variety of objects. Communication takes place between a reader and a transponder (derived from Transmitter/responder - Silicon Chip connected to an antenna), customarily called “tag”. Tags come in many forms, such as perspicacious labels that are stuck on boxes, keenly intellective cards and a box that you stick on your windshield to enable you to pay tolls without ceasing.

Tags can either be passive (powered by the reader field), semi-passive or active (powered by battery) (Somervell, *et al.*, 2019). Active RFID tags are powered by an onboard powering source and incline to be more extravagant than passive tags that harvest power from the RF energy of the reader. On board power sanctions the active tags to have more preponderant communication distance and more expeditious replication time. These tags are more multifarious and customarily have more sizably voluminous recollection capacity. Passive RFID tags have no internal power source and use external power to operate. These tags are powered by the electromagnetic signal received from a reader. The received electromagnetic signal charges an internal capacitor on the tags, which in turn, acts as a puissance source and supplies the potency to the chip (Ramos *et al*, 2020)

RFID systems differentiation criteria depend on operating reader frequency, physical coupling method and communication distance (read range) (Mbacke, Mitton and Rivano, 2018). The communication frequency used ranges from 135 KHz long wave to 5.8 GHz in the microwave range and are classified into four basic Ranges: LF (low frequency, 30 - 300 kHz), HF (high frequency, 3 - 30 MHz), UHF (ultra-high frequency, 300 MHz – 2 GHz) and Microwave (> 2 GHz). The physical coupling uses magnetic and electromagnetic fields. The communication distance varies from few millimeters to above 35 meters (close coupling: 0 - 1 cm, remote coupling: 0 - 1 m, long range: > 1 m) (Pichorim, Gomes and Batchelor. 2018).

2. .STATEMENT OF THE PROPLEM

Automatic car parking technologies are in different dimensions, nonetheless there are different approaches to design car parking solution. It can be noted that each of the existing solutions have different technological requirements in relation to all the components that are integrated to provision a working car park. Many types of research have influenced the ways in which the existing systems have been designed, measuring their performance and quality from the perspective of the designer, engineer, or developer, and not the stakeholders. The real time media auto stream model interfacing micro-controller and RFID towards coming up with a secure embedded car parking model, seeks to bridge the gap by minimizing challenges with an innovative approach of designing a car parking solution that interfaces all the components required using latest microcontroller and RFID technology.

3. RESEARCH OBJECTIVE

The main objective of the study is to come up with a design of an RFID embedded Micro-controller framework that aids in scheduling cars automatically into car park. The model interfaces all the components required for designing a working microcontroller and RFID while integrating real time media auto-stream.

4. SURVEY OF LITRATURE

The mainstream media in the last few years have increasingly begun to cover radio frequency identification (RFID) technology, it may seem as if this technology was invented recently. This is definitely not the case, on the contrary: one would be surprised to learn that it has been around for more than 60 years.

Even though RFID has been around for a while now, only recently it is getting more and more attention for application in different areas. The reasons for many companies not to implement or consider RFID technology earlier, were "the high costs of RFID hardware, software & services.

Also, the immaturity of technology and the lack of common standards"; as RFID components costs continue to decrease and the technology matures, it is assumed that more companies will become interested. Moreover, the mandates from two major players in the United States: Wal-Mart (the largest retailer in the world (Jones, 2018) and the Department of Defence (DOD) also have contributed to an increased interest in RFID.

It is a technology similar in theory to bar code identification. With RFID, the electromagnetic or electrostatic coupling in the RF portion of the electromagnetic spectrum is used to transmit signals. RFID is a technology belongs to the Automatic Identification (AUTO-ID) technologies which includes (amongst others): Bar Code, Optical Character Recognition and Magnetic Stripe.

The AUTO-ID technologies concept operates on the premise that, it is not necessary for humans to both read data and enter data manually into a computer system, because this all happens automatically and thus data entry is done efficiently and errors are minimized (RFID Journal, 200-). In an RFID system an object or person can be assigned a unique serial number (for instance, the identity) and this number is send out wirelessly by means of radio waves (Kuang and Xu, 2018).

4.1 Components of RFID

An RFID system is comprised of several components, they are: tag, reader, antenna, and middleware and enterprise applications. Imagine that a pallet has a RFID tag (a small plastic device which contains a unique identification) attached to it. This pallet is transported from location A (the pool manager) to B (the retailer). The pool manager can identify this particular pallet as follows: a reader will send out radio frequency signals via its antenna and then wait for a response from the tag. When the tag is in the neighbourhood of this reader it is activated (for example this only applies to passive tags (for example a type of tag)) and then sends back its data (via its own antenna) which is collected by the same antenna/reader that send out those signals. This data is then transported to software called middleware which filters data, and then (usually) sends it to an enterprise application (for example warehouse management system (WMS) or a database. This basically describes how RFID technology works. This process is summarized in figure 1. As shown in below, the RFID system is made up of different components and each serves a specific purpose in the system, hence they are only useful when used collectively

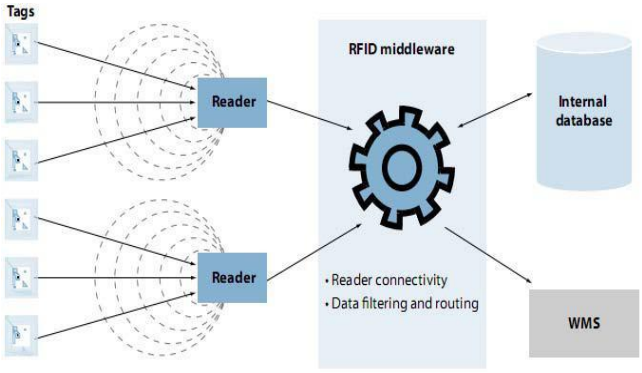

Figure 1.General RFID system overview (Source: Leaver *et al*. 2004)

5. MODEL DESIGN

The Design of an Architectural Model Based On RFID Microcontroller Integrating Real Time Media Auto-Streaming for Vehicle Packing followed the proof of concept research design. This phase involved validation of user needs, technical feasibility, identifying potential stumbling blocks, identifying what the RFID based microcontroller interfaced model for car packing would or would not provide. This helped determine the scope and level of customization necessary so as to complete deployment of the proposed model (makupi D., 2016).

The design was created using a Qemu system running Raspbian on Windows 10. The source code provided for this simulation deviated insignificantly with results even as much as there were various input sources and from real data. The figure below shows design of the carpark structure that was implemented on the Qemu system.

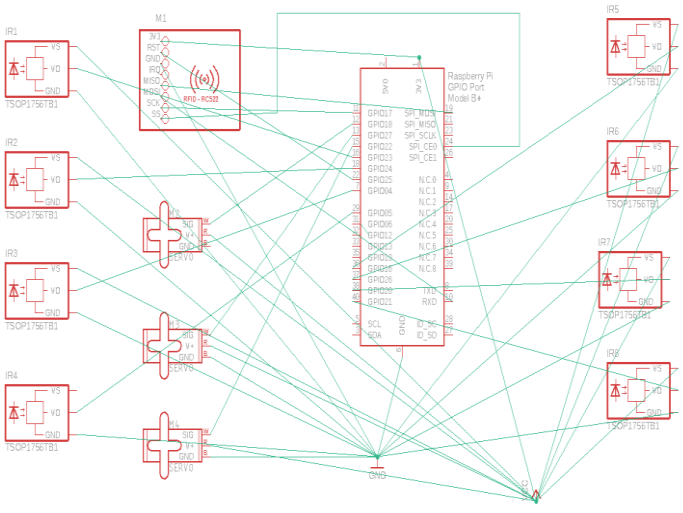

Figure 2: Design of the Car Park system later implemented on Qemu

Figure 2 shows the Qemu simulation for bus interconnection of car park structure and components. It illustrates the general overview on how the different components that make up the model interface with each other. The next section discusses how the simulation parameters were realized on Qemu.

5.1 Design of Simulation Parameters on Qemu

The simulation flow diagram involved a precise description of functionalities and data flow from inception of car entry into the car park area, entry/exit outputs, checking of vacant car spaces, capturing of multimedia into the data repository, RFID tagging and recording, below in figure 3 indicates the circuit components and the simulated circuit of the experiment.

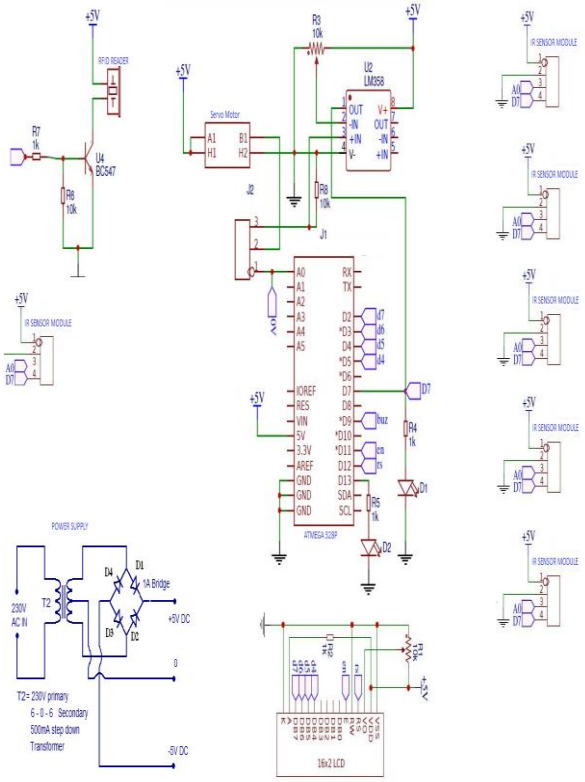

Figure 3: Qemu Circuit Diagram

The figure below shows design of the simulation flow which the experiment followed on the Qemu system.

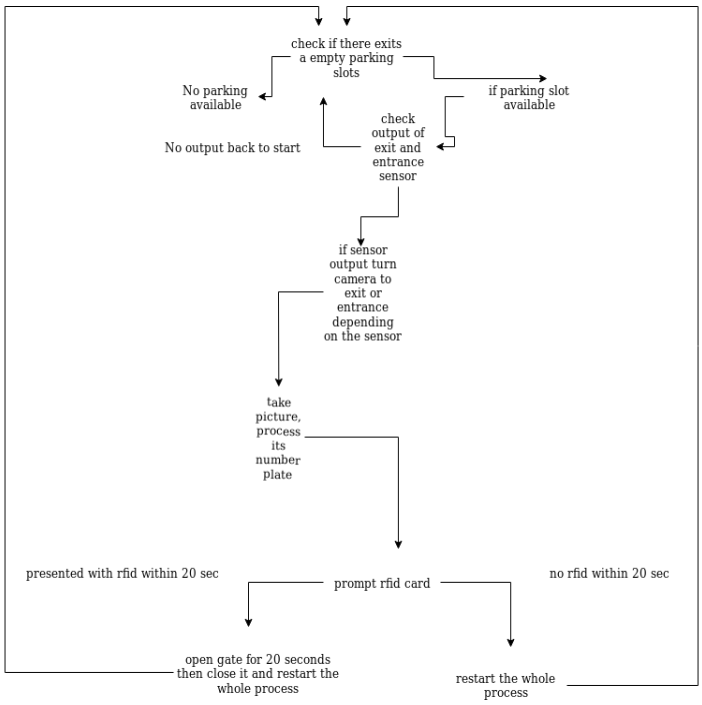

Figure 4: The Simulation Flow diagram

This was followed by selection of the simulation parameters on the Qemu system. Figure 5 below shows the selection process of the parameters for this study.

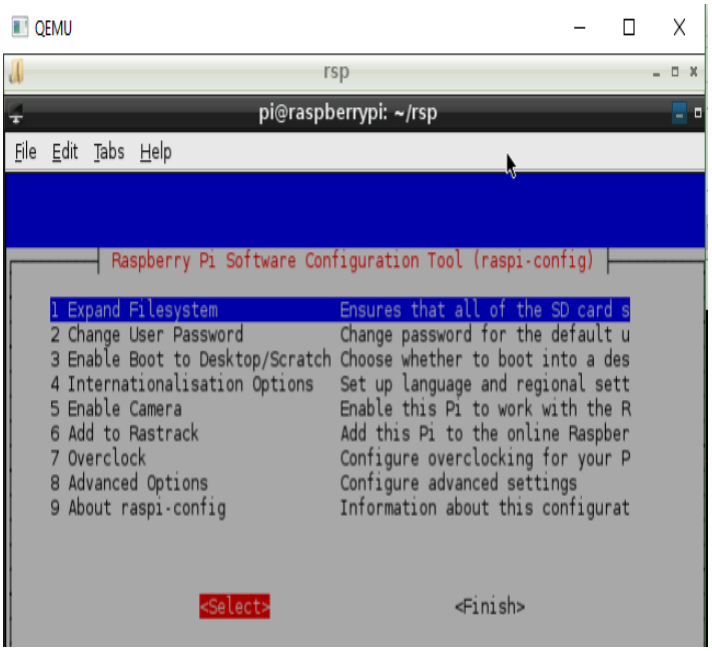

Figure 5: Simulation using Qemu system

Further, to enable negligible results deviation, there was need to align this simulation within real-time events that are experienced in a car-parking lot system. Thus in comparison and to be in tandem to the real raspi-config which could be used to configure the LCD, localization and interfacing options were configured to align the camera and the RFID as to be used in this project. The figure below shows

configuration and alignment of various options within the Raspberry Pi.

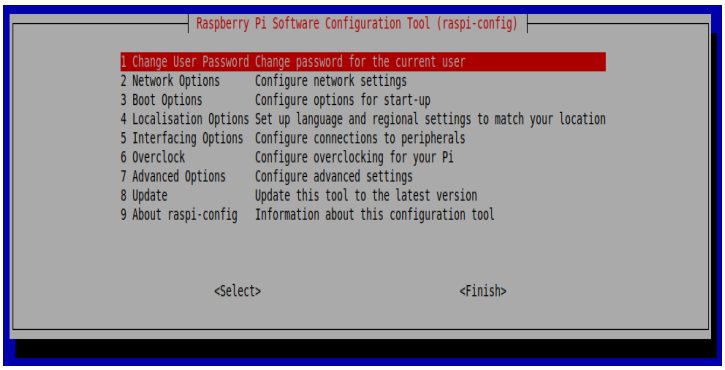

Figure 6: Simulation configuration and alignment on the Qemu system

5.2 The Logical Design of the RFID cameras and Sensors

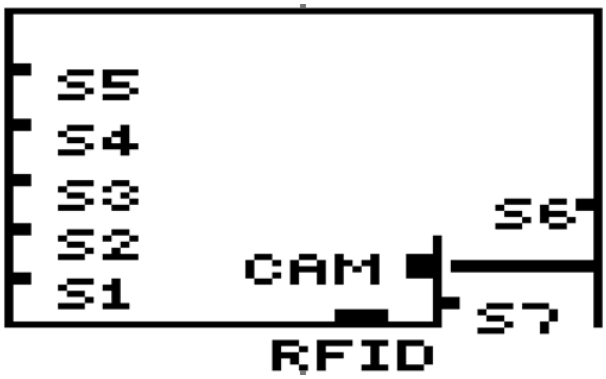

Figure 7: Logical design of the RFID

The above logical design composed of S1 - sensor1, S2 - sensor2, S3 - sensor3, S4 - sensor4, S5 - sensor5. S6 - sensor6, S7 - sensor7, G1 – gate, CAM – Camera & RFID - RFID tag

5.2.1 Operational Design

When a car approaches the gate, it turns sensor 7 on alerting the system on an incoming car. The system then checks if there are available slots by checking through sensor one to sensor five of any available cars. This is done by checking if any of the sensors if high which indicates a car presence or low which indicating the empty parking slots. If any parking slots available, the camera turns towards the incoming car, takes the picture of the incoming vehicle, processes the number plate as well as storing the encrypted car plate numbers. Then the system prompts the user to produce a RFID card for authentication.

i) The RFID Card Tag number is checked and if authenticated the gate opens and upon entrance the car will be guided towards the vacant slot by the system. The LCD will tell which slot is vacant.
ii) If the parking garage is full the systems outputs its parking slots are not available to the LCD and does not allow the vehicle owner to enter the parking garage.
iii) On arrival to its parking location and on sensor activation a time count is done which stops when the sensor turns low indication the car is on its exit way.
iv) On reaching the gate, sensor six is turned on and indicates to the system the car is on exit. This turns the camera to capture the exiting vehicle and stores it encrypted on the SQLite database, prompts the user for his or her RFID card for authentication.
v) If authenticated the gate opens for the outgoing car and a free slot is advertised on the LCD.

6. DESIGN CHALLENGES

Design challenges of realizing the model was on readjustment of parameters on Qemu. The following re-adjustments were done on the simulator since it failed to install RPi.GPIO pins as the module is only for real raspberry pi. It was also unable to connect sensors for example camera, RFID module and ir modules. There was also lack of open source free raspberry simulators. The following were the steps followed;

i) Scripts were modified so as to run on the simulator.
ii) Picamera, RPi.GPIO, MFRC522 modules were re-written to run on our simulated environment
iii) Qemu simulator was used running Raspbian

7. ASSUMPTIONS

According to already existing technological solutions, all of the sophisticated smart parking systems are proposed in academia (Bandyopadhyay, 2021). The solutions agreed mostly depend on the knowledge of real-time parking information, based on which the system makes and apportions allocations for drivers. Current sensing technologies provide several options to monitor parking spots. In general the design from this study provisions a guideline for designing any smart parking system that depends on sensors working either by sensors being deployed in each parking spot or by the construction of a network of wireless sensors with sink, which connects all sensors together and transmits sensing data to the gateway and then to the driver through GUI via the server. Typically, several Mesh networks supports multi-hop routing through which data packets can be relayed from one to another (Rashid & Rehmani, 2016). Thus, in this solution sensors provides a mechanism to relay signal's from a distance.

8. ASSUMPTIONS

Living in a world that is aspiring to reach the epitome of technological advancement in every field, but the question remains: Where to park the car at? As the progression in the vehicle industry is taking place, it is a dire need to find advance means to accommodate these vehicles. Over the years it has become a challenge for both the planners and builders to manage the parking spaces to curtail traffic congestion; it asks for a well-managed parking system that ensures efficiency and smart utilization of available space. This project aims to create a more assertive system for an automated parking lot that is time saving and more effective

as compared to the conventional manual system that is inefficient and prone to creating nuisance.

9. REFERENCES

[1] A. Juels, "Minimalistic Cryptography for Low-Cost RFID Tags", Security in Communication Networks 2004

[2] Bandyopadhyay, A., Misra, S., Nath, D., & Sarkar, V. (2021). Automatic Smart Parking One-Sided Free Slot Booking Using Internet of Things (IoT). In *Advances in Medical Physics and Healthcare Engineering* (pp. 463-472). Springer, Singapore.

[3] Landt, J., Catlin, B. (2001). Shrouds of time: The history of RFID. Pittsburg, Pennsylvania: AIM, Inc. Retrieved from http://www.aimglobal.org/technologies/ rfid/resources/shrouds_of_time.pdf.

[4] A Novel Chipless RFID System Based on Planar Multiresonators for Barcode Replacement Stevan Preradovic, Isaac Balbin, Nemai C. Karmakar and Gerry Swiegers2008

[5] Koh, Robin, Edmund W. Schuster, Nhat-So Lam and Mark Dinning. "Prediction, Detection and Proof: An Integrated Auto-ID Solution to Retail Theft." The MIT Auto-ID Center, 2003.

[6] Somervell, A. R. D., Alami, N., Cheung, D. C. L., Quill, C. S. J., & Payton, M. J. (2019). U.S. Patent Application No. 16/157,002.

[7] Mbacke, A. A., Mitton, N., & Rivano, H. (2018). A survey of RFID reader's anticollision protocols. *IEEE Journal of Radio Frequency Identification*, 2(1), 38-48.

[8] Pichorim, S., Gomes, N., & Batchelor, J. (2018). Two solutions of soil moisture sensing with RFID for landslide monitoring. Sensors, 18(2), 452.

[9] Jones, M. A., Jones, N. A., Vasgaard, A., & Wilkinson, B. W. (2018). U.S. Patent Application No. 15/878,807.

[10] Kuang, G., & Xu, H. (2018, October). Construction of Sports Competition Management System Based on Key Technologies of Internet of Things. In *8th International Conference on Management and Computer Science (ICMCS 2018).* Atlantis Press.

[11] Rashid, B., & Rehmani, M. H. (2016). Applications of wireless sensor networks for urban areas: A survey. *Journal of network and computer applications*, 60, 192-219.

[12] Makupi, D. (2016). *Reducing Road Carnage Using A Web Based Model For Monitoring Road Traffic Crime* (Masters Dissertation, Kabarak University).

[13] Ramos, Victoria, et al. "Electromagnetic Characterization for UHF-RFID Fixed Reader in Smart Healthcare Environments." *2020 International Symposium on Electromagnetic Compatibility-EMC EUROPE*. IEEE, 2020.

[14] Zumsteg, P., & Qu, H. (2018). U.S. Patent No. 9,892,289. Washington, DC: U.S. Patent and Trademark Office.

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Developing an Effective Employee Performance Appraisal System

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Abstract: This study focuses on developing an effective employee performance appraisal system and employees' perception of justice with the appraisal outcome. The study tries to identify the various techniques used in the appraisal process, the error(s) associated with each technique, all known metrics of performance measurement, and best ways of capturing appraisal data. This study is imperative in view of the fact that most existing appraisal system limit staff performance to competence only. The current system uses generic ratings for all workers irrespective of their job roles and do not employ biometrics in the appraisal process. Leveraging on the potentials of information and communications technology (ICT) helps to harmonize all issues embedded in the current appraisal system. Data was collected from both primary and secondary sources in order to elicit information from stakeholders. Some hypotheses were adopted. Questionnaires were also used to help in data collection from both stake holders and workers in general. Hypothesises were tested using chi-square with degree of freedom (d.f.) = (n-1) = 4 and level of significance (α) is 0.05. Pie chart was also use in the analysis. Results show that there is a high level of perception of injustice with the present appraisal system by stakeholders. Result also shows that existing appraisal systems limits workers performance to competence only. It was revealed that an effective appraisal system should be technology-driven. Technology-driven employee performance appraisal system utilizes all known matrices of performance measurement in the appraisal process. This approach to workers appraisal would bring about transparency and efficiency in the system. It would also bring about wide participation in the appraisal process. Furthermore, it would create room for increased productivity, proper monitoring of workers performance and increased workers satisfaction.

Keywords: Technology-driven, employee-performance, appraisal, effective, measurement appraisal outcome

1. INTRODUCTION

Performance appraisal has received the attention of several authors over the years. Palaiologos et al. [1] defined performance appraisal as a methodical process of identifying, observing, measuring, recording and developing the job-relevant strengths and weaknesses of employees. Performance appraisal can be describes as the procedures adopted by an organization in order to improve an individual's performance through evaluation, feedback, merit increments, and promotions [2]. Performance appraisal is the system used by an organization to assign a score indicating the performance of an individual or a group [3]. Performance appraisal is the process of evaluating or judging the way in which someone is functioning [4]. The practice of performance appraisal is a mandated process in which, for a specific period of time, all or a group of employees' work performance, behaviour, or traits are individually rated, judged, or described by a person other than the rated employee and the results are kept by the organization [4]. The practice of giving employees annual ratings or performance evaluation is widely accepted as an essential and valuable tool throughout the business world [5]. From the above definitions, performance appraisal suggests a system of measurement. If we believe that appraising means measuring, then we will try to improve our appraisal of performance by measuring more precisely [6]. Human performance, except in such terms as things produced per hour, cannot be measured precisely. On the other hand, an excuse that some jobs cannot be described objectively is either ill-informed or deliberate. Although some job performance cannot be "counted" in numeric terms, whether or not performance achieves expectations can be assessed [6]. However, the question still remains 'what should be measured?' put differently, 'what should be the source of appraisal data?' and 'how should it be measured and processed?' In an attempt to answer these knotty questions, several scholars and practitioners alike have suggested and adopted the use of the following appraisal systems: ***Comparison or ranking methods*** (includes: straight ranking, alternation ranking, paired comparisons, forced distribution), ***standards-based reviews*** (includes: critical incidents, essays and narrative appraisals, checklists, forced choice, rating scales, behaviourally anchored rating scales (BARS), behavioural observation scales (BORS)), ***result-oriented reviews*** (management by objectives (MBO), and ***competency-based methods.*** These systems are collectively called traditional systems of appraisal [7] and they are judgmental in nature and prone to psychometric errors - errors in measurement that occur because of the psychological predisposition or make-up of the assessor [8]. The unfortunate fact about psychometric errors is that most assessors are not aware that they are liable to such errors [8]. As a result of the psychometric errors inherent with the traditional systems, several researchers came up with automated systems of appraisal. These systems include but are not limited to Analytic Hierarchy Process (AHP)-based [9] evaluating process based on weighted criteria to combat such problems as favouritism and prejudice associated with the traditional system. This system remains partially manual and is heavily reliant on the Human Resource Department's willingness to cooperate; Internet of Things (IoT) based [10] systems that makes use of Internet of Things (IoT) based systems to automatically gather accurate data that feeds into an evaluation algorithm. However, there was no way of measuring employee's daily task output and competency skills. The system merely calculates employees' performance based on data from clock in and clock out registers; A Game Theoretic Appraisal for an IoT-Based Automatic Employee Evaluation [11] which proposes a game theoretic approach for

an Internet of things (IoT) based performance evaluation of the employees in industry. IoT is a new paradigm that interconnects the various "objects" through sensor devices, Radio-frequency identification (RFID) scanners, actuators, and other wireless and mobile devices. This system has some flaws, firstly, assessments of employees are not based on competency skills and the system also fails to capture employees' daily tasks outputs as part of performance appraisal, secondly, there is no discrete ranking of employees' work output and organizational behaviours as to determine the highest scored employee and the lowest scored employee within a given assessment period; and Fuzzy Based appraisal systems [12]. The fuzzy system has its own flaws which include but not limited to the fact that fussy systems are not based on measurable task outputs but on fuzzy or crisp qualitative employee appraisal skills and so do not measure a critical part of modern organizational performance criteria. Recently, more flexible online appraisal systems have emerged. These systems include but not limited to: Trakstar appraisal software, BambooHR software, Ultipro appraisal software and workday performance appraisal software. However, these online appraisal systems not only limited their performance measures to competencies only, they also used generic ratings for all workers irrespective of their roles or positions within their organizations. The online appraisal systems did not consider also the smart application of biometrics in securing appraisal data. This approach overlooked some important performance criteria that were relevant to particular jobs, and included other criteria that were irrelevant to others. In order to overcome the challenges associated with the current appraisal systems, there is a need: to develop a technology-driven appraisal system that can utilize an expanded range of performance tools to capture data from all known sources of appraisal information, and in quality time too; to develop a system that does not use generic rating across board but one that uses both core organizational competencies and job family competencies captured through the popular 360-degree appraisal method; to develop a system that employs smart application of biometrics in the appraisal process in order in order to give validity to the instrument of performance measurement and protect the integrity of the appraisal data.

2. METHODS

The study utilized survey research design to obtain relevant data. Three hypotheses were postulated to guide us in the work. The method of research involved administering of questionnaires and subsequent analysis of the results of the questionnaires using chi-squared goodness of fit tests. The results obtained from the chi-squared analysis were used to test the hypotheses.

2.1 Hypotheses

To guide our work in this study, the following hypotheses were posited.

i. There is significant relationship between use of traditional appraisal system and low level of employees' perception of organizational justice.

ii. There is significant relationship between technology-driven appraisal system with multi-sourced appraisal data and high level of employees' job satisfaction.

iii. Use of technology-driven appraisal system minimizes errors in the appraisal process.

2.2 Source of Data

We studied "Developing an Effective Employee Performance Appraisal System" with data from two main sources thus:

Primary Source: Questionnaires were used to obtain relevant data from stakeholders in three public sector agencies of Nigeria. A total of 152 questionnaires covering 5 questions were delivered by hand to the stakeholders in these agencies. Out of this number, 148 questionnaires were completed and returned. The questions sought, among others, the views of the respondents on the relationship between the use of traditional appraisal system and employees' perception of organizational justice.

Secondary Source: Relevant information was drawn from articles and books written by professionals in the Human Resource and IT industries.

3.0 RESULTS

3.1 Data Analysis and Result Presentation

Quantitative data obtained from primary source were analyzed using the chi-squared test. Table 2 and figure 3 both show the level categorizations of respondents. Table 1 shows the questions, responses and X^2 values from the chi-squared analysis of the questionnaires.

Table 1. Categorization of respondents

S/n	Respondents' category	Number	Percentage
1	Junior staff	**66**	48.33%
2	Senior staff	**60**	41.67%
3	Management staff	**22**	10.00%
	Total:	**148**	**100.00%**

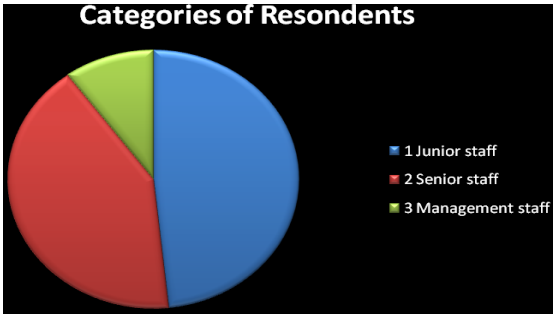

Figure 1. Pie Chart showing level categorization of employees

Table 2. Questions, responses and x^2 values from the chi-squared analysis

S/n	Question	O_i	E_i	$(O_i-E_i)^2/E_i$	$X^2 = \sum[O_i-E_i)^2/E_i]$
1.	The use of traditional appraisal system leads to low level of employees' perception of organizational justice				
	• **SA**	112	29.6	229.38	
	• **A**	24	29.6	1.06	
	• **U**	0	29.6	29.6	
	• **D**	8	29.6	15.76	
	• **SD**	4	29.6	22.14	**297.94**
2.	The use of technology-driven appraisal process minimizes errors in the appraisal process.				
	• **SA**	116	29.6	252.19	
	• **A**	28	29.6	0.09	
	• **U**	0	29.6	29.6	
	• **D**	2	29.6	25.74	
	• **SD**	2	29.6	25.74	**333.36**
3.	Employees are more satisfied with their job when technology-driven appraisal system is used				
	• **SA**	118	29.6	264.01	
	• **A**	12	29.6	10.46	
	• **U**	0	29.6	29.6	
	• **D**	10	29.6	13.5	
	• **SD**	8	29.6	16.67	**248.34**
4.	Appraisal data is more secured and reliable with computer-based online appraisal process				
	• **SA**	122	29.6	288.44	
	• **A**	14	29.6	8.22	
	• **U**	6	29.6	18.82	
	• **D**	4	29.6	22.14	
	• **SD**	2	29.6	25.74	**363.36**
5.	An effective appraisal system should be technology-based, multi-sourced data, multi-rated, secured and reliable.				
	• **SA**	114	29.6	240.65	
	• **A**	32	29.6	0.19	
	• **U**	0	29.6	29.6	
	• **D**	0	29.6	29.6	
	• **SD**	2	29.6	25.74	**325.78**

3.2 Test of Hypotheses

3.2.1 Hypothesis one

H_0: ***There is significant relationship between use of traditional appraisal system and low level of employees' perception of organizational justice.***

H_1: ***There is no significant relationship between use of traditional appraisal system and low level of employees' perception of organizational justice***

Relevant in testing hypothesis one is question 1 of the questionnaire.
From the chi-squared analysis in table 2, $X^2 = [(O_i - E_i)^2/E_i]$ for question 1 is **297.94**
Our degree of freedom (d.f.) = (n-1) = 4 and our level of significance (α) is 0.05
Decision
Tabulated value of X^2 (X^2Tab) at 4 d.f. and 0.05 level of significance = **9.488**
The Calculated value of X^2 (X^2Cal) = **297.94**
X^2Cal > X^2Tab

The decision rules states that if **X^2Cal** is greater than **X^2Tab**, we should reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

We therefore reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1)

3.2.2 Hypothesis two

H_0: ***There is significant relationship between technology-driven appraisal system with multi-sourced appraisal data and high level of employees' job satisfaction.***

H_1: There is no significant relationship between technology-driven appraisal system with multi-sourced appraisal data and high level of employees' job satisfaction.

Relevant in testing hypothesis two is question 3 of the questionnaire.
From the chi-squared analysis in table 4, $X^2 = [(O_i - E_i)^2/E^i]$ for question 2 is **248.34**
Our degree of freedom (d.f.) = (n-1) = 4 and our level of significance (α) is 0.05 **Decision**
Tabulated value of X^2 (X_2Tab) at 4 d.f. and 0.05 level of significance = **9.488**
The Calculated value of X^2 (X^2Cal) = **248.34**
X^2Cal > X^2Tab

The decision rules states that if **X^2Cal** is greater than **X^2Tab**, we should reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

We therefore reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

3.2.3 Hypothesis three

H_0: ***Use of technology-driven appraisal system minimizes errors in the appraisal process.***

H_1: ***Use of technology-driven appraisal system does not minimize errors in the appraisal process.***

Relevant in testing hypothesis three is question 3 of the questionnaire.
From the chi-squared analysis in table 4, $X^2 = [(O_i - E_i)2/E_i]$ for question 2 is **333.36**
Our degree of freedom (d.f.) = (n-1) = 4 and our level of significance (α) is 0.05

Decision

Tabulated value of X^2 (X^2Tab) at 4 d.f. and 0.05 level of significance = **9.488**
The Calculated value of X^2 (X^2Cal) = **333.36**
X^2Cal > X^2Tab

The decision rules states that if X^2Cal is greater than X^2Tab, we should reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).
We therefore reject the null hypothesis (H_0) and accept the alternative hypothesis (H_1).

4. DISCUSSION

4.1 Categorization of Existing Performance Systems

Previous attempts at conducting performance appraisal in organizations could be categorized into the following:

(1) Traditional systems.

As outlined by Rudman [8], some of the traditional appraisal methods include:

(a) Comparison or ranking method: Comparison or ranking methods require each person - or some characteristic of a person or a person's performance - to be compared with every other employee, with the results then being used to produce a rank order for all the employees. These methods are simple and easily understood, quick and inexpensive to implement and can achieve relatively high reliability, but they are not often used for performance planning and review. There are some major problems with this method. Comparisons are usually made on the basis of a single behavioural dimension (e.g. 'reliability') or job-related characteristic (e.g. 'product knowledge') or some overall assessment (e.g. 'value to the organization'). Unless these descriptors are given specific definitions, there is a risk that different reviewers will apply different standards in assessing relative worth, and the rank order will lack a defensible rationale. They are cumbersome when large numbers of employees are involved, or when more than one manager has to contribute to the ranking process, or when a number of characteristics need to be ranked. These methods are also subject to bias and discrimination on the part of those who decide the rankings. These would lead to employees' dissatisfaction and erode the intended gains of the appraisal process [8].

(b) Standards-based Reviews: Like comparison or ranking methods, standards-based review methods concentrate on an employee's characteristics or traits, rather than the person's actual performance or behaviour. These methods include application of critical incidents interviews, essays and narrative appraisals, use of checklist in performance reviews, application of forced choice reviews, use of rating scales, behaviourally anchored ratings scales (BARS), behavioural observed scales (BOS). The obvious problems with narrative methods are questions of comprehensiveness and difficulties of bias. Rater error is a problem, especially the halo effect where one attribute or incident dominates the overall rating. Managers seem to find it difficult to spread their ratings across the entire scale, leading to the central tendency problem where ratings are bunched around the middle of the scale, or a skewed distribution where all the ratings are too high or too low. The traditional systems of appraisal [7 are judgmental in nature and prone to psychometric errors - errors in measurement that occur because of the psychological predisposition or make-up of the assessor [8]. The unfortunate fact about psychometric errors is that most assessors are not aware that they are liable to such errors [8]. Psychometric errors include but are not limited to ***halo effect*** - the tendency for ratings and assessments to be influenced by one or two positive attributes of the individual, resulting in an overall favourable assessment that would not necessarily be supported by a careful consideration of all relevant factors; ***horns effect*** - an overall unfavourable assessment resulting from the undue influence of one or two negative factors; ***central tendency error*** - caused by psychological bias against using extremes and as such assessors avoid both ends of a rating scale in making their assessments; ***leniency error*** - ratings that are too high or too low in terms of employees' actual performance and will produce an inaccurate or skewed distribution of assessments; ***recency error*** - a tendency to judge people on the basis of a recent incident or performance that might not be typical of the whole review period, or on the basis of a single factor or impression; ***contrast error*** – where an assessor gives an employee an unjustifiably high or low rating in contrast to a very low or high rating given to the previous employee assessed; ***bias/prejudice*** - a conscious or an unconscious discrimination set off by age, race, sex, cultural origins, appearance, marital status, social position or personal habits and/or personal judgments about an employee that have no relevance to job performance; ***logical error*** - occurs when characteristics or factors that appear to be logically related are given similar ratings, even though they are not actually linked; ***attributional error*** – where an assessor attributes an employee's lack of goal achievement to personal deficiencies and pays insufficient attention to other factors [8].

(c) Result-oriented Reviews or Management By Objectives: One way to approach measuring performance, popularized by management guru Peter Drucker, is Management by Objectives. Management by Objectives (MBO) is the best known of the results-oriented methods of performance planning and review and, in some form, probably the most frequently used approach to performance planning and review. MBO has been a feature of organizational life since it was popularized in the 1950s by Peter Drucker, John Humble and others as a replacement for the traditional bureaucratic or job-holding approach to employment [8]. In simple terms, MBO is a target-setting or results-oriented approach to performance management. It recognizes that employees perform better when they have targets, and even better when they have participated in setting those targets [8]. While this approach is readily applied to jobs in, say, production or sales - where specifying targets and measuring performance in quantifiable terms is relatively straightforward - it can be more difficult in roles where quality is more

important than quantity, or where the prime purpose is to provide support or service to others [8].

(d) Competency-based Reviews: Competency-based approaches to employee assessment have developed out of the growing use of competency-based approaches in many areas of human resources management, all of which are affected by the continuing lack of consensus over the 'competency' concept. If we accept that competency is 'the set of behaviour patterns that the incumbent needs to bring to a position in order to perform its tasks and functions with competence' [7], then it is clear that competency-based approaches to appraisal are concerned less with what employees achieve on the job than with what they have the capability or competency to do. In other words, these methods assess the individual's potential to perform rather than the actual performance [8]. Most competency based-reviews make use of general statements of competences which is applied across an occupation or an organization. Though less time and resources are needed to develop generic competences, this advantage is usually eroded if the descriptions are not sufficiently specific to a particular role or occupation. Competency statements can be used for the assessment of current performance but are better used to assess employees' abilities and development needs than the results they achieve. However, using competences to assess only the current situation seems to be a waste of significant amounts of analysis. Competency-based assessment, therefore, is most useful as a developmental tool - a kind of map that guides individuals from where they are at present to where they need to be in the future. But that map will need to change as individual employees make progress through their organizational and job careers [7].

(2) Automated systems

(a) Analytic hierarchy process (AHP)-based systems. Several researches have been done to tailor the existing traditional or manual appraisal process to be more accurate and objective. Islama and Rasad [9] created an AHP-based evaluating process based on weighted criteria to combat such problems as favouritism and prejudice. The criteria were structured around quantity/quality of work, planning/organization, team work/cooperation and more weighted by importance by the Human Resource Managers. Each employee was given a rating on their performance on each weighted criteria and an overall weighting score was calculated. This system remains partially manual and is heavily reliant on the Human Resource Department's willingness to cooperate.

(b) Application of time card system and Internet of things (IoT). To address the challenges encountered by the AHP-based systems, a system that is automatic and accurate was devised by Sharma and Hosein [10]. This was a time card system with a card reader that recorded employees' entries and exits. The difference in hours worked by an employee as well as their minutes was calculated and output as reports. The system makes use of IoT based systems to automatically gather accurate data that feeds into an evaluation algorithm. The attendance dataset used in their research was derived from radio-frequency identification (RFID) scanners for recording clock-in and clock-out times. While IoT and RFID devices do not eliminate all methods of data tampering, they discourage a variety of them. The use of this system created some challenges – the employee welfare challenges. For instance, it did not take into consideration days of approved absenteeism from work based on health or other human factor challenges. There was no way of measuring employee daily task output and competency skills. The system merely calculates employees' performance based on data from clock-in and clock-out registers.

(c) Application of game theory in appraisal systems. Kaur and Sood [11] in their work "A Game Theoretic Approach for an IoT-Based Automated Employee Performance Evaluation" proposes a game theoretic approach for an Internet of things based performance evaluation of the employees in industry. The ubiquity of the sensing capabilities of IoT devices enables continuous supervision of industrial employees due to which the proposed system is able to evaluate the performance of employees regularly. Moreover, the learning capabilities of the game model replace manual systems with an automated system. In their system, the data collected by IoT devices are used to detect the actions of every employee in industry. Based upon the employee actions, their performance is valuated. The game model is then used to take decisions for employees. The proposed system uses the pay-for-performance (pfp) system for decision making. The pfp, also known as gain sharing, rewards the employees who perform better. On the other hand, a penalty is imposed on the employee who works against the industry's policies. Figure 2 below shows the workflow of their proposed system in which, initially, various IoT devices collect data from the industrial infrastructure as well as from employees. Various employees activities were then detected from the sensor measurements of IoT devices to form activity sets. The participation of each employee in each activity was determined using collocation mining which gives the performance of employees in industry. Game-based automated decisions were then taken by the industry using performance information of the employees. The detailed description of their proposed system is as follows.

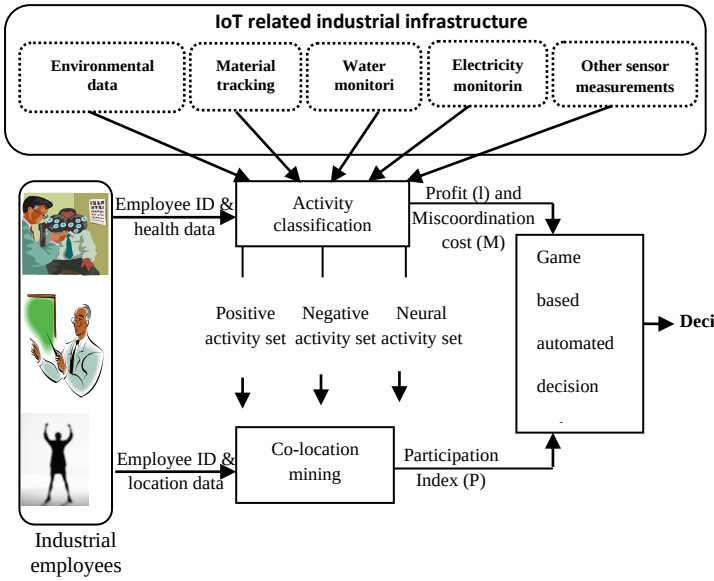

Figure 2. Workflow of Kaur and Sood proposed system

Source [11]

The data collected by sensor nodes and other IoT hardware devices are used to depict the employee activities in industry. The industrial activities of employees are classified into three types, namely, positive, negative, and neural activities. The positive activities are profitable to industry, while the negative activities lead to loss in industry. The neural activities are

necessary for proper working of an industry and are not associated with any profit or loss. The set consisting of all positive activities is termed as positive activity set. Similar is the case for negative and neural activity sets. The system groups employees' work performance into three extreme categories:

(a) A_P – employees with higher participation in positive work activities and who must be rewarded;

(b) A_N – employees with higher participation in negative work activities and who must be punished; and

(c) A_O – employees who neither participated in higher work activities nor participated in negative work activities and who must neither be rewarded nor punished.

This system has its own flaws. Assessments of employees are not based on competency skills and the system also fails to capture employees' daily task outputs as part of performance appraisal. There is no discrete ranking of employees' work output and organizational behaviour as to determine the highest scored employee and the lowest scored employee within a given assessment period.

(d) Application of fuzzy based methods

Several work were done on employee performance appraisal using fuzzy set theory. Moon et al. [12] proposed a methodology utilizing fuzzy set theory and electronic nominal group technology for multi-criteria assessment in the group decision-making of promotion screening; Researched have demonstrated [13] that fuzzy set theory could be successfully used to solve multiple criteria problems. This is because in many circumstances, appraiser tends to use vaguely defined qualitative criteria in evaluating the performance of their subordinates. Therefore, it creates difficulty for appraiser to precisely quantify the score of each candidate. The fuzzy system of appraisal emphasizes on the mapping of uncertainty data in performance measurement system into fuzzy values which consists of labels and confidence values. The mapping process is essential since if erroneous membership function and rules were chosen, it yields a flawed output. In the appraisal process using the fuzzy logic method, the performance of the appraisee usually involves the measurement of ability, competence, job behaviors, and skills, which are fuzzy concepts that may be captured during the performance appraisal process [15]. The Fuzzy appraisal evaluation system is usually made of the following components:

(a) The evaluation's criteria;
(b) Existing performance evaluation tool;
(c) Crisp input values;
(d) Fuzzy values; and
(e) Crisp output values.
The crisp input values are observed from existing evaluation tool. The input values, which are in the form crisp values, are processed through fuzzification phase, fuzzy inference phase, and defuzzification phase in order to convert fuzzy values into crisp output values for employees' performance assessment. The process is shown in the figure 3 below.

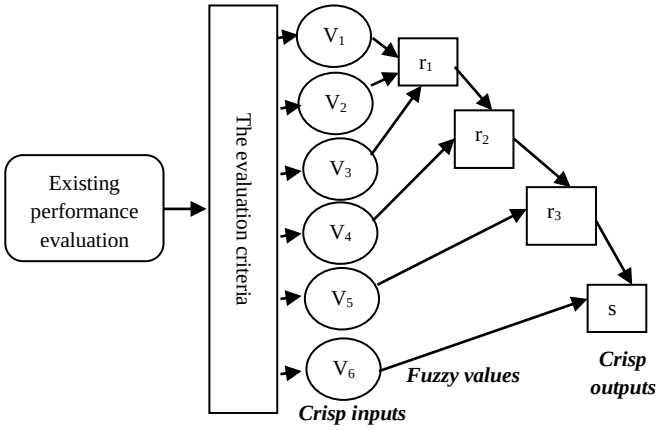

Figure 3. Fuzzy appraisal evaluation system

This system of appraisal has its own shortcomings. The validity of the performance data and the rating scale is not guaranteed by the fuzzy system. In fact the fuzzy system itself depends on the availability of the performance data and the rating scale which are fed as crisp inputs into the fuzzy system. The success of the Fuzzy system of performance appraisal is heavily reliant on the experience of selecting what constitutes membership functions and rules. If erroneous membership function and rules were chosen, it yields a flawed output. Setting exact fuzzy rules and membership functions is a difficult task. Validation and verification of a fuzzy knowledge based system needs extensive testing with hardware. Fussy systems are not based on measurable task outputs but on fuzzy or crisp qualitative employee appraisal skills and so do not measure a critical part of modern organizational performance criteria.

(e) Online performance appraisal software

Several recent software have also been developed to take care of employee performance appraisal processes. These software include but are not limited to the following: Trakstar performance appraisal software, Bamboo HR, Engagedly performance appraisal software, Ultipro performance appraisal and Workday performance appraisal. Most of the available online appraisal solutions limited their performance measures to competencies only- other performance metrics emphasized by literature were ignored. The existing online appraisal systems also made use of generic ratings for all workers irrespective of their roles or positions within their organizations. This approach overlooked some important performance criteria there were relevant to particular jobs, and included other criteria that were irrelevant to others. These systems also did not consider the smart application of biometrics in employee appraisals and therefore could not uniquely recall a personnel impersonating another or tampering with employee appraisal information.

4.1 Known metrics of performance appraisal process

Performance appraisal by its various definitions [1], [2], [3], [4], [5] suggests a system of measurement. The challenge of the appraisal process is in determining what exactly should be measured and how it should be measured in order to minimize error and increase employees' satisfaction with the outcome. Therefore, the creation of performance criteria is an important

requirement towards performance appraisal. Although, it is a well known fact that there are no perfect appraisal systems, it is nonetheless important to emphasize that appraisal is a process, and like any other process, it has inputs, outputs, objectives, and owner(s). Therefore the appraisal process should be measurable and should be applied to bring results to its owner(s). Better appraisal process yields better appraisal outcome, and vice versa. The danger of not having an effective process is that the outcome leads to employees' job dissatisfaction, reduces employees' organizational commitments, lowers employees' moral and reduces organizational citizenship behaviours amongst employees. This is shown in figure 4 below.

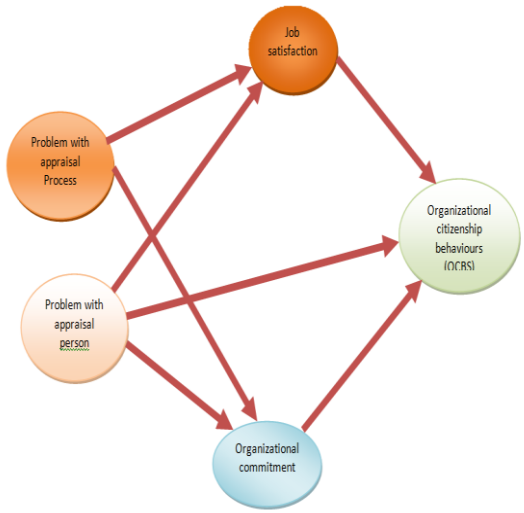

Figure 4. Relationship between appraisal outcome and OCB, and job commitment.
Source: [15]

To buttress the importance of performance measurement in organizations, [16] stated that rewards are indeed extremely powerful, and people will naturally tend to do the things for which they are rewarded, but no matter how important and powerful rewards are, they are no better than the measurement system they are based on. Organizations are conglomerations of many systems. Measurement is actually the most fundamental system of all. When the measurement system works well, management tends to manage (and reward) the right things- and the desired results will occur [16]. The wrong measures tend to trigger the wrong activities - because they represent what people see. Then these wrong activities generate the wrong results - no matter how well-executed the activities are. Most individuals and organizations do not get what they want because they do not measure what they really want [16].

Performance measures can be viewed as objective or subjective. The objective measures can be observed - for example, the number of items sold or the number of invoices processed can be counted. Objective performance measures include production data (e.g. units produced, number of errors, etc) and employment data (e.g. number of incidents, absences, tardiness, etc). Objective measures are usually, but not always result-based. These variables directly define the goals of the organization and, therefore, sometimes are outside the employee's control. Objective measures of job performance involve counts of various work-related behaviours. Some common objective job performance measures include [17]:

- Absenteeism (number of days absent)
- Accidents (number of accidents)
- Incidents at work (number of incidents / assaults /etc)
- Lateness (days late)
- Meeting deadlines.

Objective measures can be relatively quick and easy to obtain (given good organizational recordkeeping).

However, it can be unwise to place too much emphasis on these types of objective measures. An exclusive focus on results/outcomes may mask factors that impact on workers' performance that are beyond their control (e.g., client workload) [19]. Subjective measures require judgment on the part of the evaluator and are more difficult to determine. They are also prone to biases and errors. One example of a subjective measure is a supervisor's ratings of an employee's "attitude," which cannot be seen directly. Subjective measures rely on the judgment of an appraiser (self, co-workers, or supervisor). Subjective assessments are commonly used in performance appraisals and often involve the use of rating scales. Subjective assessments are more likely to provide accurate performance appraisals when: the behaviours and outcomes being assessed are stated in clear behavioural terms; the worker understands the measures (e.g., rating scales) being used to evaluate their performance, and agree that the measures are fair and accurate (i.e., measures what it is supposed to); and measurement is as brief as possible whilst addressing essential behaviours and outcomes (frustration with long and unwieldy questionnaires may introduce error in responses)[18]. Consequently, both objective and subjective measures should be used carefully. Sources of performance appraisal data are shown in figure 5 below.

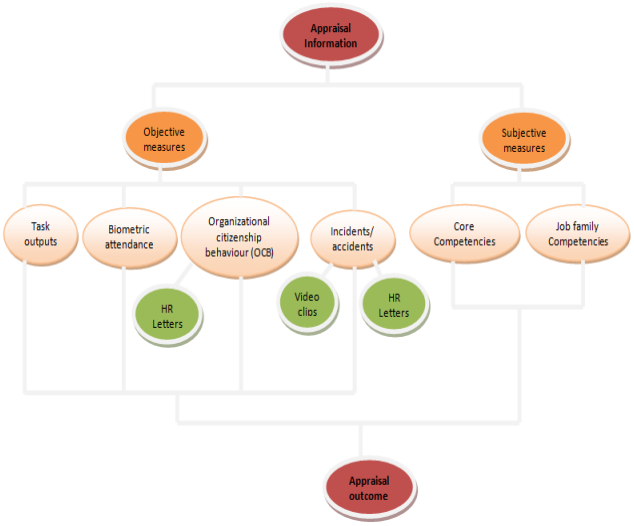

Figure 5. Sources of appraisal information

Measurement provides the basis for providing and generating feedback, and thus can build the platform for further success or identify why things are going less well so that corrective

actions can be taken. Therefore what gets measured in the appraisal process? Measure the wrong things perhaps because they are easy to measure, and an entire appraisal system can fall into disrepute. In making overall performance assessments, we should ensure that all aspects of performance are taken into account and not just those areas where targets for improvement or development were set [8] As Drucker [16] puts it the measurements which give us productivity for the manual worker, such as the number of pieces turned out per hour or per dollar of wage, are irrelevant if applied to the knowledge worker. Drucker [16] goes on to further state that a productivity measurement is the best yardstick for comparing managements of different units within an enterprise, and for comparing managements of different enterprises. This is because productivity includes all the efforts the enterprise contributes; it excludes everything it does not control. According to Drucker [16], productivity is the first test of management's competence. According to Drucker [16], measurement should be used to make self-control possible and should not be abused to control people from the outside and above - that is, to dominate them. Drucker [16] further stated that as long measurements are abused as a tool of control, measuring will remain the weakest area in the manager's performance. In furtherance to his argument, Drucker [16] stated that for a manager to be able to control his own performance, he needs to know more than what his goals are. He must be able to measure his performance and results against the goals. The measurements need not be rigidly quantitative; nor need they be exact, but they have to be clear, simple, rational, relevant and direct attention and efforts where they should go.

Performance measures that leave out some important job duties are considered deficient. For example, measurement of an employment interviewer's performance is likely to be deficient if it evaluates only the number of applicants hired and not the quality of those hired or how long those hired stay at the company. On the other hand, including irrelevant criteria in performance measures contaminates the measures. For example, appearance might be a contaminating criterion in measuring the performance of a telemarketing sales representative whom customers never see. Managers need to guard against using deficient or contaminated performance measures. Overemphasis on one or two criteria also can lead to problems as other important areas may be ignored. In addition, cheating can become an issue when goals are set to support such criteria because individuals might act unethically to reach objectives, especially when the objectives are linked to specific rewards [18]. As shown in figure 5 above, utilizing all know sources of appraisal data in measuring appraisal outcome is ideal. To solve the problem of what should be measured; Rudman [8] suggested that organizations combine various methods and techniques in developing performance appraisal systems. For example, a system might usefully combine MBO, which is a way to determine what an employee is expected to do, with behavioural rating concerned with how an employee carries out job requirements or behave on the job [8]. Some scholars argue that perceived justice appears to be an essential mechanism through which appraisals affect employees' reactions (e.g., Erdogan [27] Greenberg [23]) and such argument has received considerable attention in the performance appraisal literature [18]. There are two types of justice described in the literature of justice and fairness that are involved in the performance appraisal process: distributive justice and procedural justice [18].

Levels of perceived procedural justice are positively related to important organizational outcomes such as organizational citizenship behaviour [24], [22], [25], [26], [41], [27]; trust in leadership [28], [29], [27]); organizational commitment; job satisfaction; and performance [30], [31]. Folger et al. [41] argue that a comprehensive model for a procedurally just performance appraisal systems should include fair hearing and judgment based on evidence among other variables. Support for this model has been found in other studies [27], [33], [34]. These studies found that characteristics of the due process appraisal (fair hearing and evidence-based criteria) were associated with perceived procedural justice. In addition, Poon [33] found that when employees perceived the performance appraisal process as manipulative and skewed by the political interests of the raters (as opposed to the due process), they demonstrated less satisfaction and higher intention to quit their jobs.

4.2 Design of an effective employee performance appraisal system

Van and Schodl [21] states that if the main purpose of a performance appraisal process is to increase performance, then an effective performance appraisal system would be one that achieves this purpose. An effective appraisal system is dependent on a number of factors and these include: accuracy of ratings, source of appraisal data and perceived justice in the process. An effective appraisal system as described by Skinner et al. [18], involves among others: the appraisal instrument, the job analysis conducted to identify the appropriate criteria against which to establish standards for evaluating performance, and establishing the validity and reliability of the methods used. Regular monitoring of performance is another essential element of an effective appraisal process. Performance monitoring is a term applied to a variety of workplace practices that concern the collection of employee work performance data [18]. An effective performance appraisal should not be limited to a formal event occurring once or twice a year but should be a continuous process of day-to-day monitoring, feedback and review that provides first hand information to help identify performances shortfall so as to correct them promptly [18]. An effective appraisal system should be technology-driven. The use of technology in performance management has the potential to increase productivity, and enhance competitiveness. A performance appraisal system that uses technology to automate processes can provide many advantages to organizations, so human resource professionals should consider utilizing electronic methods to facilitate the manner in which appraisal procedures are administered and managed [18]. It is believed that appraisal satisfaction is a key concept that is central to any discussion of technology to be adopted in the appraisal process. Technology contributes to performance management and thus to appraisal satisfaction in two primary ways: technology facilitates measuring an individual's performance via computer monitoring activities and two, technology becomes a tool to facilitate the process of capturing appraisal data and generating performance feedback. An effective appraisal system should utilize multi-source appraisal data in rating employees' performance. To enhance perception of system fairness, practitioners should find a way to balance quantitative performance data with

qualitative performance data. Key performance job criteria should be as outlined in table 3 below [18].

Table 3. Key performance job criteria

Competencies	Knowledge, skills, and abilities relevant to performance
Behaviours	Related to individual productivity such as leadership styles, analytical skills, etc. Specific actions conducted/or tasks performed.
	Organizational citizenship behaviour (OCB) - actions that are over and above usual job responsibilities.
	Counterproductive work behaviours such as assaults, abuse of customers, etc.
Traits	Relating to individual's way of life such as "a good attitude", showing "confidence", being "dependable", etc.
Results / outcomes	Outputs, quantifiable results, measurable outcomes and achievements, objectives attained, incidents, absences, etc.

Source: [18]

Other scholars argue that: ***an effective appraisal system*** should ensure that the appraisal *data is highly secured and that the source data is validly collected.* These can be achieved through the use of password secured systems and the application of biometrics in capturing attendance data; an effective appraisal system should permit greater span of control by facilitating accurate collection of performance data without requiring managers to spend significant time observing each individual worker's actual job performance; ***an effective appraisal syste***m should be *multi-rater based*. The 360-degree feedback system should be part of the appraisal system. There are several advantages to using this system compared to a single source of performance information [26]. First, 360-degree feedback systems result in improved reliability of performance information because it originates from multiple sources and not just one source. Second, they consider a broader range of performance information, which is particularly useful in terms of minimizing criterion deficiency. Third, they usually include information not only on task performance but also on contextual performance and counterproductive work behaviours, which are all important given the multidimensional nature of performance. Finally, because multiple sources and individuals are involved, 360-degree feedback systems have great potential to decrease biases - particularly compared to a system involving a single source of information.

Acknowledging the fact that a performance appraisal system should be automatic and data-driven, what we propose in this study is a system that uses expanded range of performance tools to capture data that involves employees task outputs (quantity of work/period, quality of work/period), number of organizational citizenship behaviours (OCBs), number of incidents at work, number of errors, number of accidents at work, accurate data on staff attendance, absenteeism, hours worked and competencies in order to balance employees quantitative-qualitative performance data or put differently in order to give validity to the instrument of performance measurement; a system that does not use a generic rating form for all workers irrespective of their roles or positions within the organization but uses job family competencies applicable and relevant to employees' roles and positions in the organization; and a system that provides a convenient way in which fingerprint authentication can be applied in employee appraisal system to avoid unwanted tampering with the system's data. The proposed is system design is shown in figure 6 below.

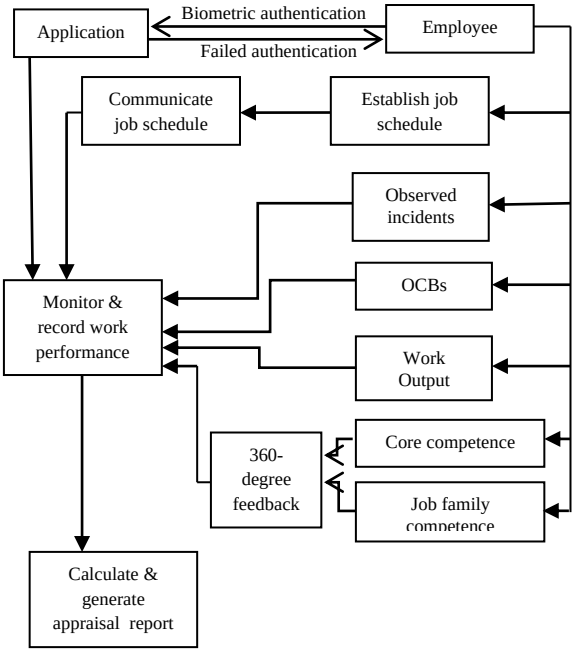

Figure 6. Employee performance appraisal system design

5. CONCLUSION

The study revealed that an effective performance appraisal system depends heavily on perceived organizational justice, the accuracy of the instruments of rating used, the sources of the appraisal data, the content of job performance criteria, and the type of technology that drives the process. It further reveals that an effective appraisal system should be technologically-driven, it should have large span of control as data-capture is automated, it should be multi-rated, appraisal information should be multi-sourced, it should be evidence-based, it should be accurate, reliable and should promote organizational justice and it should be able to utilize all known metrics of performance measurement in the appraisal process.

REFERENCES

[1] Palaiologos, A., Papazekos, P. and Panayotopoulou, L. 2011. "Organizational justice and employee satisfaction in performance appraisal", Journal of European Industrial Training, Vol. 35 No. 8, pp. 826-840.

[2] DeNisi A. and Smith C. E. 2014 "A. Performance Appraisal, Performance Management, and Firm-level Performance: A Review, a Proposed Model, and new Directions for Future Research". *The Academy of Management Annals*, 8(1), 127-179.

[3] DeNisi A. S. 2000. *Performance Appraisal and Performance Management. Multilevel Theory, Research, and Methods in Organizations: Foundations, Extensions and new Directions.* San Francisco, CA: Jossey-Bass, 121-156.

[4] Coens T. and Jenkins M.. 00. *Abolishing Performance Appraisal. Why they Backfire and what to do Instead.* San Francisco: Berrett-Koehler Publishers.

[5] Boachie-Mensah F. O. and Seidu P. A. 12. "Employees' Perception of Performance Appraisal System: A Case Study". *International Journal of Business and Management*, 7(2), 73.

[6] Ellington J. K and Wilson M. A. 16. "The performance appraisal milieu: a multilevel analysis of context effects in performance ratings". *Journal of Business and Psychology*, 1-14.

[7] Vicky G., Performance Appraisal.. 02. Loss Control Services, Texas Association of Counties.

[8] Rudman R., *Performance planning and review. Making employee appraisal work (2nd Edition).* New Zealand: Allen & Unwin Publishing, 03.

[9] Islama R. and Rasad S. 06 "Employee Performance Evaluation by the AHP: A Case Study. *Asia Pacific Management Review,* Vol. 11, pp. 163–176, 01.

[10] Sharma N. and Hosein P. . "A Comparison of Data-driven and traditional approaches to employee performance assessment. International Conference on Intelligent Data Science Technologies and Applications (IDSTA)", , pp. 34-41.

[11] Kaur N. and Sood S. K.. 17. "A game theoretic approach for an iot-based automated employee performance evaluation". *IEEE Systems Journal,* Vol. 11, no. 3, pp. 1385–1394.

[12] Moon C., Lee J., Jeong C., Lee J., Park S. and Lim S. 07. "An Implementation Case for the Performance Appraisal and Promotion Ranking, in Proceedings of the", *IEEE International Conference on Systems,* Man and Cybernetics, Montréal, Canada, 7-10.

[13] Jing R.C, Cheng C. H. and Chen L. S. 07. "A Fuzzy-based Military Officer Performance Appraisal System". *Applied Soft Computing, Vol. 7, Issue 3*
.

[14] Shaout, A., & Yousif, M., K. 14. Employee performance appraisal system using fuzzy logic. *International Journal of Computer Science and*

Information Technology, Vol 6, No 4, pp 1-19, August 14

[15] Na-Nan K., Kanthong S., Joungtrakul J. and Smith I. D. . "Mediating Effects of Job Satisfaction and Organizational Commitment between Problems with Performance Appraisal and Organizational Citizenship Behaviour". *Journal of Open Innovation: Technology, Market and Complexity,* Vol. 6, issue 3.

[16] Drucker P. F. 1986. Management: Tasks, Responsibilities, Practices. New York: Truman Talley Books/E.P. Dulton.

[17] Spector P. E. 00. *Industrial and Organizational Psychology: Research and Practice (2nd ed.).* New York: Wiley.

[18] Skinner N., Roche A., O'Connor J., Polland Y. and Todd C. 05. *Workforce Development TIPS (Theory into Practice Strategies):A Resource Kit for the Alcohol and other Drug Field.,* S..A.: National Centre for Education and Training in Addiction.

[19] Mathis R. L. And Jackson J. H. 10. *Human Resource Management (13th edition).* Ohio: South-Western Cengage Learning.

[20] Mullins L.J. 05. "Management and Organizational Behaviour". London: *Financial Times Management.*

[21] Van D. D. and Schodl M. M. 2015. "Performance Appraisal and Evaluation, In James D. Wright (editor-in-chief)", *International Encyclopaedia of the Social & Behavioural Scieces, 2nd edition*, Vol. 17, pp. 716-721. Oxford: Elsevier Ltd.

[22] Moorman R. H., Balkely G. L., Neihoff B. P. 1998. "Does Perceived Organizational Support Mediate the Relationship between Procedural Justice and Organizational Citizenship Behavior?"*Academy of Mana gement Journal* 41 (3), 351–357.

[23] Greenberg J. 1986. "Determinants of Perceived Fairness of Performance Evaluation". *Journal of Applied Psychology* 71 (2), 340–342.

[24] Ball G. A., Trevino L. K., Sims Jr. H. P. 1994. "Just and Unjust Punishment: Influences on Subordinate Performance and Citizenship". *Academy of Management Journal* 37 (2), 299–322.

[25] Organ D. W., Podsakoff P. M., Mackenzie S. B. 2006.Organizational Citizenship Behaviour: Its Nature, Antecedents and Consequences. Thousand Oaks, CA: Sage.

[26] Skarlicki D. P. and Latham G. P. 1996. "Increasing Citizenship within a Union: A Test of Organizational Justice Theory". *Journal of Applied Psychology* 81 (2), 161–169.

[27] Whiting S. W., Posdakoff P., and Pierce J. R. 2008. "Effects of Task , Helping, Voice and Organizational Loyalty on Performance Appraisal Ratings". *Journal of Applied Psychology* 93 (1), 125–139.

[28] Barling J. and Phillips M. 1993. "Interactional, Formal and Distributive Justice in the Workplace: An Exploratory Study". *Journal of Psychology* 127 (6), 649–656.

[29] Folger R. and Konovsky M. A. 1989. "Effects of Procedural and Distributive Justice on Reactions to Pay Raise Decisions". *Academy of Management Journal* 32, 115–130.

[30] Colquitt J. A., Conlon D. E., Wesson M. J., Porter C. O. L .H., and Ng K. Y. 2001. "Justice at the Millennium: A Meta-analytic Review of 25 years of Organizational Justice Research". *of Applied Psychology* 86 (3), 425–445.

[31] Korsgaard M. A., Schweiger D. M., Sapienza H. J.1995. "Building Commitment, Attachment and Trust in Strategic Decision-making Teams: The Role of Procedural Justice". *Academy of Management Journal,* 38(1), 60-84.

[32] Folger R., Konovsky M. A., and Cropanzano R. 1992. "A Due Process Metaphor for Performance Appraisal. In: Staw, B. M., Cummings, L. L. (Eds.)", *Research in Organizational Behaviour,* vol. 14. JAI press, pp. 129–177.

[33] Poon J. M. L. 2004. "Effects of Performance Appraisal Politics on Job Satisfaction and Turnover Intention". *Personnel Review* 33 (3), 322–334.

[34] Taylor M. S., Masterson S. S., Renard M. K., and Tracy K. B. 1998. "Managers' Reactions to Procedurally Just Performance Management Systems". *Academy of Management Journal* 41 (5), 568–579.

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ThamRobot: An Automated Robotic System to Play Thammattama

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Abstract: Sri Lanka has a precious traditional drum music culture that is mainly based on traditional drums. At present, this drum culture is in decline due to a lack of talented drum players. As a result, many Buddhist temples are facing a serious and tragic problem. This article presents the design and implementation of a robotic system named ThamRobot contains two robotic arms that were designed to play pre-programmed three drum tunes of the Thammattama correctly and efficiently like a drum player without any intervention of a human. In the research, nine major characteristics factors of the Thammattama such as music notes, drum locations, approximate stress, frequencies, pitch, drum type, number of sticks, playing technique, distance from stick to drum face were identified. The entire system is comprised of four main modules named motion module, user-operation module, processing module, power supply module. Finally, the system has been tested in a laboratory environment and encouraging results were obtained.

Keywords: Robotic Arms, Musical Robots, Traditional Drums, Thammattama, Automated Systems, Microcontrollers, Robots

1. INTRODUCTION

Sri Lanka has a unique, beautiful, and great traditional music culture that has a long history of over 2,500 years [1]. The traditional music culture of Sri Lanka is mainly based on traditional musical instruments that are endemic to the country. The ancient violin that was created by the great King Ravana, “Hakgediya” (the conch), “pantheruwa” (the tambourine), and different types of drums are considered the oldest musical instruments in Sri Lanka. Traditional musical instruments are an invaluable and inseparable part of the music culture of Sri Lanka and traditional drums are considered the king of local music instruments [2]. Ancient Sri Lanka had more than sixty types of traditional drums and at present, about ten drums are currently using for religious, cultural, ritualistic, and aesthetic performances. Accordingly, people often use traditional drums such as “Getaberaya”, “Yakberaya”, “Dawula”, “Thammattama”, “Rabana”, “Bummadiya”, “Udekkiya”, “Dandu-Beraya” for various purposes and among them, “Getaberaya”, “Yakberaya”, “Dawula” and “Thammattama” are considered as the four major drums in Sri Lanka [3]. These drums are mostly used by the Buddhist people in Sri Lanka for their religious activities. Therefore, this tradition has been become an integral part of the culture of the country and also a pride in Sri Lanka [4].

The drum culture of Sri Lanka is mainly classified into three categories as “Udarata Bera Wadana Kalawa” (The art of the up-country drumming), “Pahatharata Bera Wadana Kalawa” (The art of the low-country drumming), and “Sabaragamu Bera Wadana Kalawa” (The art of the Sabaragamuwa province drumming) [5]. The art of the up-country drumming deals with three drums such as “Getaberaya”, “Dawula” and “Thammattama” while the art of the low-country drumming deals with “Yakberaya” and “Dawula”. The art of the Sabaragamuwa province drumming uses “Dawula” and “Thammattama” as main drums [6].

These traditional drums have a unique vibrant beat of the rhythm and a unique style of drumming [7]. Not only that but also, these drum rhythm beats and drumming styles are not included in the source material and are transmitted from generation to generation. Accordingly, there are traditional families that are dedicated to play drums from ancient times. These families carry playing techniques, drum notes from generation to generation.

Ancient Sri Lanka had more than sixty traditional drums that are endemic to the country but ten of them are currently in use [8]. This is because this precious traditional drum music culture is gradually dying out as it faces a lot of problems unfortunately due to a lack of talented performers. The situation escalated very quickly due to the modern social transformation and their profession is not properly recognized. Besides, there is no formal recognition, proper appreciation for these drummers and they face a lot of problems financially. Although this art is a source of great pride to Sri Lanka, there is no state patronage has been received for this worthy cause. As a tragic consequence of these causes, these traditional drummers are standing back from their traditional occupation and seeking other employment.

In the face of the current unfortunate situation, another tragic thing is happening gradually. That is, the number of talented drummers who play Thammattama is gradually decreasing [9]. The main reason for this situation is that the drumming of the Thammattama is extremely complex compared to other drums. There is an opinion of the ancients that the ability to play this drum comes from birth as its playing technique is very complex. The importance of the Thammattama is that it is used for all the three drum cultures in Sri Lanka and it has become an indispensable drum in Buddhist temples. Therefore, the decline of Thammattama, one of the foremost

traditional drums in Sri Lanka is finally coming to an end very unfortunately and as the current solution, many Buddhist temples are using recorded music. This method is not a successful substitution as it does not produce the natural and the real sound of the Thammattama and there is a huge difference between the real sound and the recorded sound. While there are no advanced tools in the country to process this recorded music and this method has become a very unsuccessful alternative.

Many issues can be solved in a practicable way using new technologies and the article is going to discuss an automated robotic system named ThamRobot that was designed to play the Thammattama. This robotic system has two robotic arms that are holding the two playing sticks of the Thammattama and play three types of standard drum tunes very accurately, correctly, and efficiently without any intervention of a human-like a drum player. The advantage of this system is, this has been programmed to play three common drum tunes that are very frequently play at Buddhist temples where there is a shortage of Thammattama drummers.

2. THAMMATTAMA: A TRADITIONAL DRUM IN SRI LANKA

Thammattama is an extremely exceptional traditional drum that is endemic to Sri Lanka [10]. It is one of the four major drums in Sri Lanka and a very special drum due to various reasons. This drum performs a great service in Buddhist religious occasions, traditional occasions as well as in communication. This drum has been become very special as it belongs to all the three cultures in Sri Lanka named upcountry music tradition, low-country music tradition, and Sabaragamuwa music tradition. Unlike other drums in the country, this drum has two plane drum faces that are clasped together. Accordingly, older writers have called this drum "Pokuru-Beraya" or "Twin-Drum". However, these drums are different in size and one drum is larger than the other drum. The larger drum is named "Mandama" which produces low sounds while the smaller drum is named "Handabeya" which produces high sounds.

The drum bodies of the Thammattama are widely made using very strong wood such as "Ehela", "Kohomba", Jak and "Gansooriya". But today due to the scarcity of these woods, well-matured coconut wood is also used to make the drum bodies. The heights of the drum bodies are approximately 7 inches. The face diameter of the Mandama is 10.5 inches while the diameter of the Handabeya is 7 inches [11]. Drum membranes are used to cover the faces of the drums, and they are made of tempered animal skins. The types of animal skins used to cover the drum faces vary from drum to drum, and beef skins are used as the drum membrane of the Thammattama. The drum face of the Mandama is covered with a thick beef while the drum face of the Handabeya is covered with a less thickened beef skin. The thickness of the animal skin, the area of the drum faces mainly affect the difference in sounds. Thammattama is played with the use of two special sticks named "Kadippu" that are made of well-matured wood such as "Kirindi" or "Rathmal" [12]. Figure 1 and 2 show the measurements and parts of the Thammattama respectively.

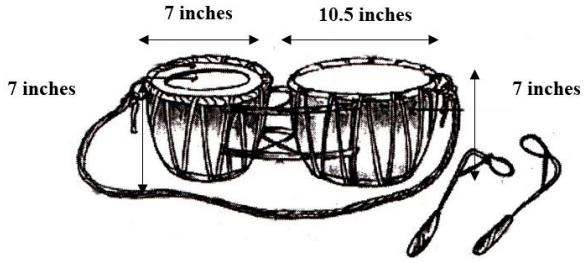


Figure 1. Measurements of the Thammattama

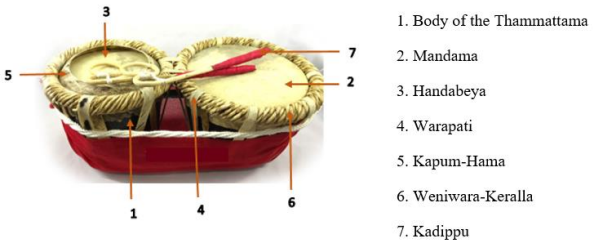


Figure 2. Parts of the Thammattama

Thammattama mainly produces ten music notes using Handabeya, Mandama, and also using both drums. The Mandama produces three notes such as "Don", "Thon" and "Kun" while Handabeya produces four notes such as "Kita", "Kruu" "Thari" and "Thath". The three music notes such as "Jen", "Raj" and "Digi" are produced using both drums. However, the playing technique, music patterns, sound variations of the Thammattama is complex compared with other drums in the country. Table 1 shows the details of the playing techniques of the Thammattama

At the first step of the research, characteristic factors of the Thammattama have been identified with the help of two talented Thammattama players and frequency counter. Table 2 shows the basic characteristic factors of the Thammattama. These basic characteristics include the drum type, number of sticks, and playing technique. When consider the drum type, the notes can be produced either using one of the two drums of the Thammattama or both drums. The notes such as "Don", "Thon" and "Kun" are produced using the Mandama (larger drum). In addition, all of these three notes are produced by hitting on the drum face of the Mandama only one time. The Handabeya produces four notes as "Kita", "Kruu" "Thari" and "Thath". The notes "Kita", "Kruu" "Thari" are produced by hitting the drum face of the Handabeya by using two sticks one after the other very quickly. The note "Thath" is produced by hitting the face of the Handabeya by using one stick at one time. The notes "Jen", "Raj" and "Digi" are produced by using both of the drums. Among them, "Jen", "Raj" sounds are produced by hitting the both drum faces by two sticks

simultaneously while "Digi" sound is produced by hitting the two drum faces by two sticks one after the other.

Table 1. Playing Techniques of the Thammattama

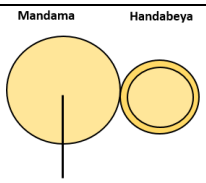
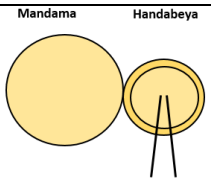
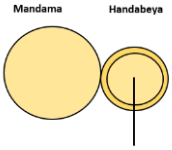
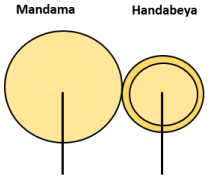
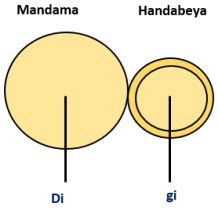
Music Note	Playing Technique Number	Playing Technique of the Thammattama
Don Thon Kun	1	
Kita (Ki-ta) Kruu (K-ruu) Thari (Tha-ri)	2	
Thath	3	
Jen Raj	4	
Digi (Di-gi)	5	

Table 2. Basic Characteristic Factors of the Thammattama

Music Note	Drum	Number of Sticks	Playing Technique
Don	Mandama	One	Once
Thon	Mandama	One	Once
Kun	Mandama	One	Once
Kita	Handabeya	Two	One after other
Kruu	Handabeya	Two	One after other
Thari	Handabeya	Two	One after other
Thath	Handabeya	One	Once
Gen	Both	Two	Simulataneous
Raj	Both	Two	Simulataneous
Digi	Both	Two	One after other

Table 3 shows the advanced characteristic factors of the Thammattama including the distance between the stick and drum face (d_{sd}), frequency of the notes, pitch, drum location and approximate amount of stress applied on the drum face.

Table 3. Advanced Characteristic Factors of the Thammattama

Music Note	Distance between drum face and stick	Frequency	Pitch	Drum Location	Appriximate amount of stress
Don	30cm	80Hz	Very Low (Bass)	Middle	Very High
Thon	20cm	92Hz	Low (Bass)	Middle	High
Kun	10cm	100Hz	Low (Tenor)	Middle	Low
Kita	20cm	130Hz	High (Alto)	Middle	High
Kruu	5cm	110Hz	Low (Tenor)	Middle	Low
Thari	15cm	112Hz	High (Alto)	Middle	High
Thath	30cm	157Hz	Very High (Soprano)	Middle	Very High
Gen	15cm	95Hz	High (Alto)	Middle	Very High
Raj	10cm	91Hz	Low (Tenor)	Middle	Low
Digi	10cm	122Hz	High (Alto)	Middle	High

3. RELATED WORKS

Robotics is an interdisciplinary branch of the engineering and science industry that covers mechanical, electronic, information, computer science, and other sectors [13]. Robotic technology is used to build machines that can replace people to perform human activities. Robots are used in many different environments and for many different applications [14]. Although they differ in application and form, they all share three fundamental fields as mechanical engineering, electrical engineering, and computer science [15].

Robotic arms are considered as one of the major and the most popular mechanical parts in robotic systems. It can be further explained as a mechanical product or a set of rigid jointed bodies able to take different configurations [16]. Robotic arms have been become very valuable and popular interim due to some common reasons. They are widely used in situations and places where humans are not able to work such as polluted air zones, high temperatures, heavy weight lifting, etc.

Therefore, there are different types of robotic arms available in the market that can be used for specific purposes. They have been very famous because of increased efficiency, higher quality, improved working environment, increased profitability, longer working hours, and prestige [17]. The robotic arms have some common parameters such as the number of axes, degree of freedom, working envelope and working space covering the arm, kinematics, payload, speed and acceleration, accuracy and repeatability, movement control and arm drive, etc [18].

The robotic arms can be developed using several technologies and wireless technology is one of them [19]. MR-999-E is a wireless robotic arm that can perform five separate movements such as grab or release, lift or lower, rotate wrist, and pivot sideways using five servo-motors [20]. The architecture of this robotic arm system has been comprised of three main components such as a transmitter, receiver, computer, and robotic arm. The transmitter has been connected to the computer and the receiver has been connected to the robotic arm interface. The graphical user interface (GUI) of the arm has been modeled using SolidWorks 2005 software and implemented using Visual Basic environment.

Automation technology is also a very common and a rapidly growing technology in the field of industries and robotics that is a type of technology by which a process or a procedure is performed with minimal human assistance [21]. Aparnathi and Rajendra have developed a six axes robotic arms to perform various actions in industry. The architecture of the arm consists of manipulator with end effecter, controller as commander, power supply, feedback mechanism, and sensor feedback [22].

Combination of wireless technology and automation technology can lead to invent better robotic arms and high-performance robotic systems. These types of practical arms are very essential to perform actions in warehouses. Nobutaka Kimura and others have developed an automated mobile dual-arm robot to pick and place objects in warehouses [23]. It is an Epson 6-axis robot arm that has a long reach of about 90 cm. It can lift and pick 2kg products and uses 200V power source. The arms have an RGBD camera and an RGB camera to recognize the kind, position, the orientation of the products.

Niranjan and other have designed a robotic arm to perform tasks by its physical strength using Arduino-Uno, flex sensor, Wi-Fi module and also servo-motor [24]. Basically, inputs are taken from the outside environment by the flex sensor and then a controller calculate how much the fingers of the arm have to be moved to grab a particular object. As the next step, the servo-motors perform the task with the help of the controller.

There many robotic arms have been designed for various applications such as agriculture, military, medical field and etc. “Animator” is a robotic arm that was designed by rahman and others to overcome from many challenges in daily life [25]. This arm generates a realistic velocity distributions to manilpulate several types of motions. and uses the mechanism and the mechanical structure of ASR K-250 to perform human-like manipulation motions. This arm has been implemented and tested successfully for the 4 degrees of freedom (DOF). Besides, Many robotic arms have been designed for agriculture field and Megalingam and others have developed a robotic arm to support agriculture industry that is controlled by depth sensors [26]. This robotic system has five main blocks such as Microsoft Kinect sensor, portable computer, API (Microsoft Kinect SDK), microcontroller and actuators and the operations that are performed by the robotic arm are controlled by these five blocks. Basically, the input to the system is entered from the physical world through the sensors and as the next step, these data are processed by portable computer, API and microcontroller. As the final step, the processed data will be given as the output in the form of motion of the actuators of the robotic arm.

At present, robotics is created based on the application area and musical robots are evolving day by day. Musical robots can now be used to play musical instruments very well and easily without any players. As a starting point Kapur has done a review on the history of robotic musical instruments [27]. Most of the robots in the past have been designed with the use of motors, gears and solenoids. Besides, he has discussed several musical robots and their technologies such as piano robots, percussion robots, woodwind robots and strings robots. Piano robot is one of the examples for an automatic musical instrument. Designers have designed these robots by using punched cards that give commands to the hammers in the piano to create chords, melodies and harmonies. A French innovator, Fourneaux, invented the first piano player named “Pianista” in 1863. After that, in 1896, Edwin Scott Votey invented the “Pianola”, a device that is similar to the piano and performed pressing keys using wooden fingers. Then, in 1897, Edwin Welte designed a piano player using loom technology. In 1980 Trimpin designed “Contraption Instant Prepared Piano 71512” that has mechanically bowing, plucking, and other manipulations of the strings. This system has been controlled through a remote-controlled MIDI device.

Sobh and Wang have developed a robot musician band that was established at the Bubble Theatre of the Arnold Bernhardt Center of University of Bridgeport [28]. The significance of this band is, each one who plays an instrument is a robot. Accordingly, they play real musical instruments through the usage of several mechanical devices like servo-motors and solenoids. The research has been linked with three main areas such as; robotic technology, computer science and music and each robot in the band has been constructed with hardware and software design and adopted a three-module architecture consists of a software module, a control module and a motion module.

“A Comparison of Solenoid-Based Strategies for Robotic Drumming” is a research done by Kapur and others that was related to a robot named “MahaDeviBot” [29]. This musical robot is a custom-built 12-armed MIDI-controlled mechanical device that plays a variety of Indian folk instruments. Besides, it includes some other instruments like bells, shakers and frame-drums to decorate music. “MahaDeviBot” has been designed with the use of solenoids and finally, it has been evaluated using a haptic feedback system.

Thambot is a robotic approach that was proposed for the drum named Thammattama which is one of the traditional drum in Sri Lanka. Accordingly, the authors have done a research to find four characteristic factors of the Thammattama [30]. As the next step of the research, they have developed a robotic system to play one standard drum beat using two robotic arms [31]. The overall system consisted of six modules named power module, a processing module, solenoid control module, servo-motor controller module, input module and display module. Finally, the developed system has been successfully tested with human players.

4. METHODOLOGY

ThamRobot is an automated robotic system that was designed to play the Thammattama which is one of the traditional drums in Sri Lanka. Mainly, the system has two robotic arms that are used to play the Thammattama. These two robotic

arms are made of Aluminium metal. At the end of the each arm the stick of the Thammattama named Kadippu have been attached and invented using solenoids, servo-motors. These two arms are capable of working along two axis such as X axis and Y axis. The system has been programed using the PIC 16F877A microcontroller and microchip technology [32]. The entire system of the ThamRobot is a combination of main four modules such as power supply module, processing module, motion module and user operation module. The system has been designed to play three pre-programmed standard drum tunes correctly, efficiently and accurately without any intervention of a human like a drum player and depicts the behavior of the open loop control system. The figure 3 shows the overall architecture of the ThamRobot system and brief introduction of each module is given below.

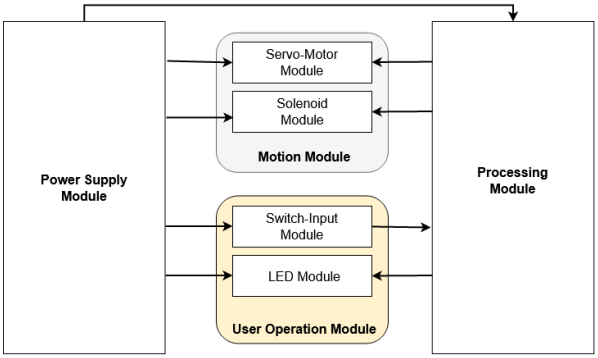


Figure 3. Overall Architecture of the ThamRobot System

A. User Operation Module

The user operation module of the system is a combination of two modules named switch-input module and LED module. This module is the only module that directly interacts with the user. The switch-input module represents two switches of the system such as ON/OFF switch and mode change switch. The first switch or the ON/OFF switch is used to switch ON and OFF the system while mode change switch is used to change the three drum tunes. Secondly, the LED module consists of three colored LEDs that represent three drum tunes. This module has been established for the user's convenience. This user operation module is very important module in this system as it takes the inputs or switch inputs from the user.

B. Processing Module

The processing module of the system can be defined as the heart of the system which is a PIC 16F877A microcontroller. This module uses microchip technology and contained the program of the system. Basically, this system has been programmed to play three drum tunes which are commonly played using the Thammattama. In addition, the hidden process of the processing module is shown by the figure 4.

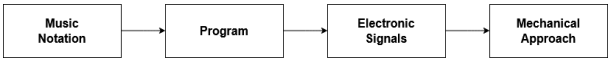


Figure 4. Process Flow the Processing Module

The significance of this system is, these two robotic arms are designed to play music. Music is a time-based, time-dependent subject and accordingly, designing robotic arms that play music rather than other robotic arms is a challenging task. As the first step of the development, important characteristics factors such as the music notes of the Thammattama, drum type among two drums, number of drum sticks, drum locations, approximate amount of stress applied on the drum face to produce notes, playing technique, distance between the Thammattama stick (kadippu) and the drum face, frequency and pitch were identified. These characteristics factors are shown in the table 2 and 3. Secondly, using the processing module, these notes were declared by its solenoid values, servo-motor values and delays. These three values were different for each music note of the Thammattama. As the third step of the process, these notes were arranged according to a particular drum tune using a trial and error approach. Finally, these values were transmitted to the motion module as the output as a source of electronic signals.

C. Motion Module

The motion module of the system contains two modules such as solenoid module and the servo-motor module. This module is the module that performs approprite motions along Y and X axis. In the solenoid module there are two solenoids that one is connected to each arm. The internal solenoids of the contactor named LC1D180 has been used to move arms up and down direction along the Y axis. Similarly, system has two servo-motors named SM-166M that one is connected to each arm to move arms along X axis. The motion module takes the output of the processing module as the input to perform a mechanical approach to play a particular drum tune. Figure 5 shows the construction of the robotic arm.

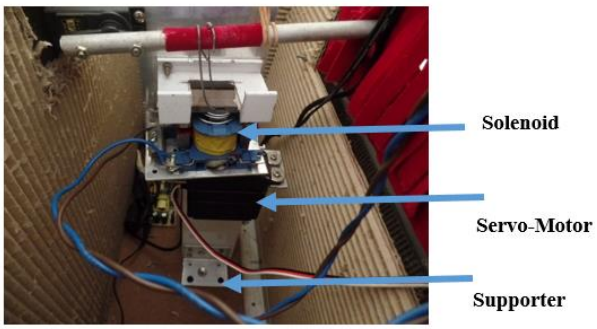


Figure 5. Construction of a Single Arm

The figure 6 and 7 shows the behavior of robotic arms along Y axis and X axis respectively.

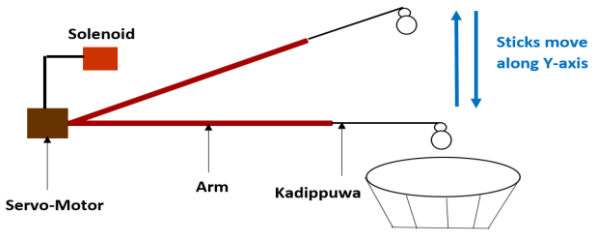


Figure 6. Behavior of Arms using Solenoids

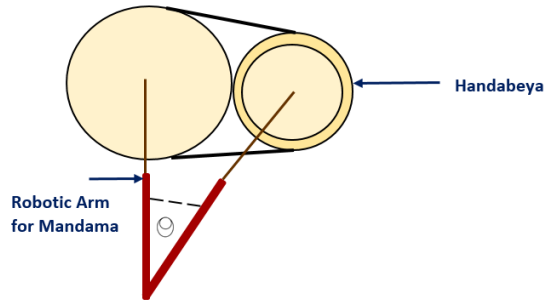


Figure 7. Behavior of Arms using Servo-Motors

According to the Table 3 that represents playing technique of notes of the Thammattama, it is clearly mentioned there are five different playing techniques. To achieve this task, the ThamRobot has been designed with all these five playing techniques as well as two other techniques. Figure 8. Shows the different combination position of arms.

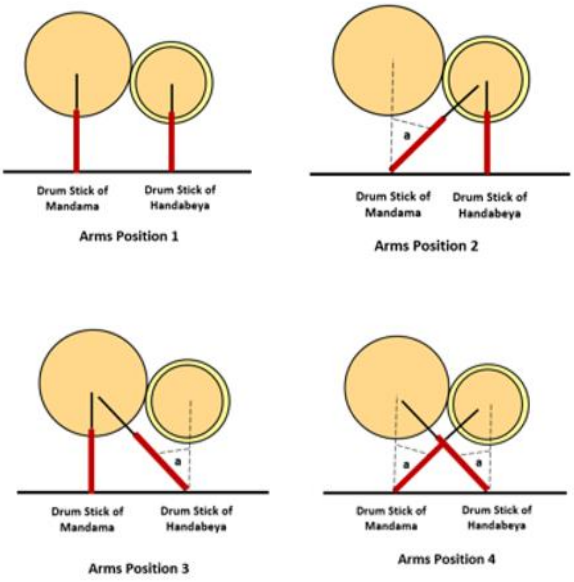


Figure 8. Different Combination Positions of Arms

D. Power Supply Module

The power supply module is the module that is connected with every module and component of the system to fulfil the power requirement. The power supply module is a combination of different components such as switch-mode power supplies (SMPS), voltage converters, linear regulators, diode bridges, connectors, and etc. At first, the system has been connected to a 230V AC voltage and it will be converted into a 12V AC voltage using a switch-mode power supply (SMPS). The output of the SMPS has been connected to a diode bridge that it a bridge of four diodes and the output coming from the diode bridge has been smoothed by two capacitors. This smoothened output will be then entered into a voltage regulator named LM317 and will be gone across a diode. After that, this ouput will be enetered into a LM7805 linear regulator that gives 5V DC voltage. Mainly, it gives 5V and 12V DC voltages to operate components in the system.

The system works according to the user's input. At first, the user has to switch ON the system. When he switch ON, the default mode of the system is drum tune 1. But after switch ON the system, the user can change the mode or change the drum tune. Then this input will be taken by the processing module and it sends the electronic signals to the solenoids and servo-motors to play the drum tune correctly, accurately and efficeintly. Advantage of this system is it plays a particular drum tune of the Thammattama until the user switch OFF the system or change the mode like a drum player without any intevention of a human being. In addition, this system plays drum tunes correctlty, efficiently by moving it arms very accurately with the time. The figure 9 and 10 shows the circuit board and developed system respectively.

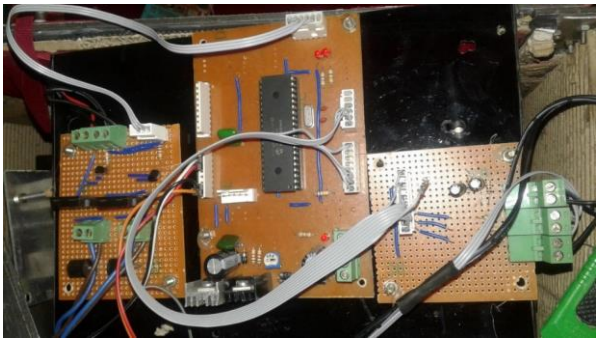
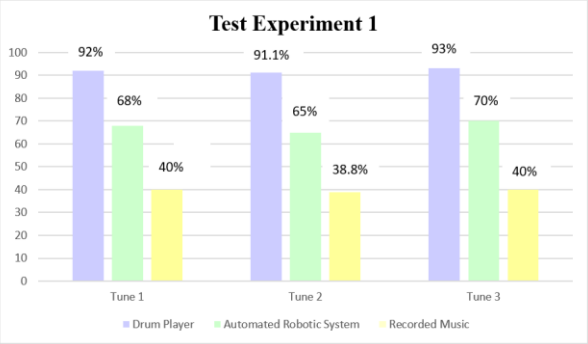


Figure 9. Circuit Board of the System

Figure 10. Automated Robotic System

5. RESULTS AND DISCUSSION

The ThamRobot system has been evaluated by using two different tests in a laboratory environment. The first test has been done using human evaluators as this robotic system is an alternative for a traditional drum and people of Sri Lanka are extremely sensitive to this traditional music. Accordingly, the test experiment 1 was conducted using twenty-five people. As the testing components, the developed robotic system, recorded music and a drum player were used. Then, a same drum tune was played separately by recorded music, drum player and robotic system. As the restriction, these people were not able to see anything and the only thing left to do was to listen to this music and give marks for each of these drum tunes. The marks that were given by people were collected and the final evaluation graph is represents using graph 1.



Graph 1. Evaluation Results of Test 1

The test experiment 1 was conducted using people in Sri Lanka and they have recognized the music differences of the music of drum player, automated robotic system and recorded music only hearing the music. Accordingly, the developed system is placed in between the drum player and the recorded music and have obtained an encouraging result for three drum tunes.

In music, there are four main attributes that are related with music notes of an any instrument. They are frequency, dynamics, timbre and texture. Among those four attributes, the test experiment 2 was carried out to check the correctness of the frequencies of the ten notes that can be played using the ThamRobot system. At the first step of the research, the standard frequencies of the notes have been identified and the data are mentioned in the table 2. Accordingly, in the test experiment 2, a frequency counter has been used to measure the frequencies of the notes that can be played using the developed robotic system and the comparisson between the real frequency of the notes of the Thammattama and the frequencies detected by the frequency counter of the developed system are mentioned in the table 4.

Table 4. Comparison between Frequencies

Music Note	Real Frequency	Detected Frequency
Don	80Hz	78Hz
Thon	92Hz	91Hz
Kun	100Hz	100Hz
Kita	130Hz	127Hz
Kruu	110Hz	112Hz
Thari	112Hz	114Hz
Thath	157Hz	150Hz
Gen	95Hz	90Hz
Raj	91Hz	89Hz
Digi	122Hz	120Hz

6. CONCLUSION AND FURTHER WORKS

The article presented the design and implementation of a robotic system that has two robotic arms that were designed to play the Thammattama which is one of the four major traditional drums in Sri Lanka. The system has been programmed to play three different drum tunes correctly and efficiently which are commonly played using the Thammattama without any intervention of a drummer. The system has been designed with the help of PIC 16F877A and microchip technology. In addition, to perform actuations along two axis such as X and Y, solenoid and servo-motor technology have been used. The system tested and evaluated by carrying out two experiments using human evaluators and also detecting the correctness of the frequencies of the ten main notes of the drum. As further works of the research, it is proposed to develop the current automated system into a closed loop control system containing sensors that can detect faults of the sounds of the notes and automatically correct them. The current system has been only tested to evaluate the frequencies of the notes. The further testing will be carried out to test and compare the other remaining three attributes such as dynamics, timbre and texture.

7. REFERENCES

[1] K. Bandara, "Udarata Bera Wadana Kalawa", *Sarasavi*, 2017. [Online]. Available: https://www.sarasavi.lk/udarata-bera-wadana-kalawa-9553008534.

[2] N. Dassenaike, "Sinhala folk music : its vocal traditions and stylistic nuances", *ResearchGate*, 2012. [Online]. Available: https://www.researchgate.net/publication/320923633_Sinhala_folk_music_its_vocal_traditions_and_stylistic_nuances.

[3] S. Daniel, "Traditional Beats: Ten Uniquely Sri Lankan Drums", *Roar.media*, 2018. [Online]. Available: https://roar.media/english/life/history/traditional-beats-ten-uniquely-sri-lankan-drums.

[4] N. Jasentuliyana, "The Unique Sights & Sounds of Sri Lanka Come Alive in America - IDN-InDepthNews | Analysis That Matters", *Indepthnews.net*, 2019. [Online]. Available: https://www.indepthnews.net/index.php/the-world/usa-and-canada/2903-the-unique-sights-sounds-of-sri-lanka-come-alive-in-america.

[5] "Kandyan Drumming cultural features", *Insightguides.com*, 2021. [Online]. Available: https://www.insightguides.com/destinations/asia-pacific/sri-lanka/cultural-features/kandyan-drumming.

[6] "Traditional Drums", *Lakpura*, 2021. [Online]. Available: https://lakpura.com/traditional-drums.

[7] G. Ranathunga, "Art and tradition of Sri Lanka - Volume 01: Music of Sri Lanka", *Dl.lib.uom.lk*, 2021. [Online]. Available: http://dl.lib.uom.lk/handle/123/14436.

[8] C. Meddegoda, "The Story of a Failed Business Concept: Intensifying a Drum Production in Sri Lanka", *ResearchGate*, 2017. [Online]. Available: https://www.researchgate.net/publication/339913738_The_Story_of_a_Failed_Business_Concept_Intensifying_a_Drum_Production_in_Sri_Lanka.

[9] "Rhythm and Moves with Sri Lankan drumming", *Daily News*, 2017. [Online]. Available: http://www.dailynews.lk/2017/06/09/features/118360/rhythm-and-moves-sri-lankan-drumming.

[10] G. Peiris, "Beraya : Sri Lankawe Saha Lokaye Bera Pilibadha Wimasumak", *Expographic Books*, 2012. [Online]. Available: https://www.expo-graphic.com/books/Beraya---Sri-Lankawe-Saha-Lokaye-Bera-Pilibadha-Wimasumak-9789552900099/view.

[11] "Dankutu Dankutu: The Making Of The Traditional Drum", *Explore Sri Lanka - Once discovered, you must explore.....*, 2012. [Online]. Available: http://exploresrilanka.lk/2012/08/dankutu-dankutu-the-making-of-the-traditional-drum/.

[12] D. Blacker, "Traditional Drum Making In Sri Lanka: Beats down the Ages", *Thuppahi's Blog*, 2016. [Online]. Available: https://thuppahis.com/2016/12/30/traditional-drum-making-in-sri-lanka-beats-down-the-ages/.

[13] O. Koç, G. Maeda, and J. Peters, "Online optimal trajectory generation for robot table tennis," *Rob. Auton. Syst.*, vol. 105, pp. 121–137, Jul. 2018, doi: 10.1016/j.robot.2018.03.012.

[14] B. Haugaløkken, M. Skaldebø and I. Schjølberg, "Monocular vision-based gripping of objects", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/342129668_Monocular_vision-based_gripping_of_objects.

[15] W. Takano, H. Kanayama and T. Takahashi, "A data-driven approach to probabilistic impedance control for humanoid robots", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/337056023_A_data-driven_approach_to_probabilistic_impedance_control_for_humanoid_robots.

[16] A. SANCHETI, "Gesture Actuated Robotic Arm", *Ijsrp.org*, 2021. [Online]. Available: http://www.ijsrp.org/research-paper-1212/ijsrp-p1261.pdf.

[17] M. Raj and R. Seamans, "Primer on artificial intelligence and robotics", *Springer*, 2021. [Online]. Available: https://link.springer.com/article/10.1186/s41469-019-0050-0.

[18] V. Patidar and R. Tiwari, "Survey of Robotic Arm and Parameters", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/303749615_Survey_of_Robotic_Arm_and_Parameters.

[19] A. Verma and A. Sharma, "Wireless Robotic ARM", *Iosrjournals.org*, 2021. [Online]. Available: https://www.iosrjournals.org/iosr-jece/papers/Vol.%209%20Issue%206/Version-2/H09625053.pdf.

[20] M. Muhammed, M. Muji and M. Jenu, "MR 999-E Wireless Robotic Arm", *Semantic Scholar*, 2021. [Online]. Available: https://www.semanticscholar.org/paper/MR-999-E-Wireless-Robotic-Arm-Muhammed-Muji/c7fc8eeac08d42772d0f01b5abd38139de90212b.

[21] U. Mamodiya and P. Sharma, "Review in Industrial Automation", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/314720788_Review_in_Industrial_Automation.

[22] R. Aparnathi, "The Novel of Six axes Robotic Arm for Industrial Applications", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/270723528_The_Novel_of_Six_axes_Robotic_Arm_for_Industrial_Applications\.

[23] N. Kimura, K. Ito, T. Fuji and K. Fujimoto, "Mobile dual-arm robot for automated order picking system in warehouse containing various kinds of products", *Ieeexplore.ieee.org*, 2021. [Online]. Available: https://ieeexplore.ieee.org/document/7404942.

[24] S. AR, "DESIGN AND IMPLEMENTATION OF ROBOTIC ARM USING PROTEUS DESIGN TOOL AND ARDUINO-UNO", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/322790523_DESIGN_AND_IMPLEMENTATION_OF_ROBOTIC_ARM_USING_PROTEUS_DESIGN_TOOL_AND_ARDUINO-UNO.

[25] A. Rahman, A. Khan, T. Ahmed and M. Sajjad, "Design, Analysis and Implementation of a Robotic Arm-The Animator", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/269690255_Design_Analysis_and_Implementation_of_a_Robotic_Arm-The_Animator.

[26] R. Megalingam, G. Vivek, S. Bandyopadhyay and M. Rahi, "Robotic arm design, development and control for agriculture applications", *Ieeexplore.ieee.org*, 2021. [Online]. Available: https://ieeexplore.ieee.org/document/8014623.

[27] A. Kapur, "A HISTORY OF ROBOTIC MUSICAL INSTRUMENTS", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/260387943_A_HISTORY_OF_ROBOTIC_MUSICAL_INSTRUMENTS.

[28] T. Sobh and B. Wang, "Experimental Robot Musicians", *Sci.utah.edu*, 2021. [Online]. Available: https://www.sci.utah.edu/~beiwang/publications/Musician_BeiWang_2003.pdf.

[29] A. Kapur, T. Singer, A. Suleman and G. Tzanetakis, "A comparison of solenoid-based strategies for robotic drumming", *ResearchGate*, 2021. [Online]. Available: https://www.researchgate.net/publication/249874471_A_comparison_of_solenoid-based_strategies_for_robotic_drumming.

[30] S. Goonatilleke and B. Hettige, "Thambot: A Robotic Approach for Thammattama", *Ir.kdu.ac.lk*, 2021. [Online]. Available: http://ir.kdu.ac.lk/bitstream/handle/345/2288/Abstract%20Book%20Final%20Version_158.pdf?sequence=1&isAllowed=y.

[31] S. Goonatilleke and B. Hettige, "A Robotic Solution for Traditional Drums in Sri Lanka- Thammattama", *Slaai.lk*, 2021. [Online]. Available: https://slaai.lk/wp-content/uploads/2021/03/2019-Proceedings/A-Robotic-Solution-for-Traditional-Drums-in-Sri-Lanka-Thammattama.pdf.

[32] "PIC16F87XA Data Sheet", *Ww1.microchip.com*, 2021. [Online]. Available: https://ww1.microchip.com/downloads/en/devicedoc/39582b.pdf.

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Tech Trends of COVID-19 Pandemic

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Abstract: With the current outbreak of the novel coronavirus called several acute Respiratory Syndrome Coronavirus (SARS-COV-2) was first selected in Wuhan (Hubei, China) in December 2019. This disease has spread to almost all the countries in the world with hundreds of thousands of deaths. This study aims to review the tech trends topping the chart in the COVID-19 pandemic. It intends to highlight the impact of Information and Communication Technology (ICT) and how it has improved the quality of human lives by increasing business operations, economic and social activities in the world.

Keywords: COVID-19; Tech trend; ICT; Pandemic; SARS-COV-2

1. INTRODUCTION

Amid COVID-19 Pandemic, it is pertinent to have a closer look at the impact of technology and how it has been maximized to improve the quality of human lives by increasing the business operation, economic and social activities throughout the world.

2. TECH TRENDS IN COVID-19

2.1 Smart Office

This is one of the IoT applications that turns office equipment into connected things by using Sensor technology. This fulfills the overall environmental objective by lowering energy consumption protecting equipment and resource conservation, also improving the economy. It does this by reducing the cost of using the devices and improving the overall quality of life. Official meetings like weekly meetings, conferences during the COVID-19 pandemic are now been done via zoom applications and Virtual Reality applications[3].

2.2 Delivery Drones

This also uses IoT technology to render automated delivery services of medical materials and blood during lockdown[4]. It is also used to make food deliveries to COVID-19 patients to reduce physical contact with the patient, making it timely, efficient and thereby reducing the spread of this life-threatening infection. For instance, JD.com, Pudu Technologies uses robots and drones to deliver medical supplies within the hospital and supply food to patients during lockdown periods. Companies like Walmart, Amazon, Domino pizzas have started testing their drones in accordance to the standards set by the US government and will soon deploy theirs for retail items and food deliveries. In Rwanda, Zipline medical drone company has been in operation since October 2016 for

transporting blood and medical supplies within the country and is set to move its services to the US government later this year thereby solving global problem rural health care at this crucial period[5].

2.3 Robot Workers

Due to lockdown, robot workers are now being used in most manufacturing companies to do a larger percentage of the workforce in factories for economic sustenance. It is pertinent for manufacturing companies to use robot workers during COVID-19 lockdown to ensure the sustainability of the company and eventually save lives[6].

2.4 Voice Technology and Smart Home

This is one of Artificial Intelligence-powered technology also known as Speech Recognition[7]. In [8] severe active respiratory syndrome coronavirus(SARS-COV-2) can stay on surfaces like mobile phones, plastic, stainless steel for 48-72hrs, this prompted phone makers to develop apps that use voice tech thereby reducing physical contact with phones like Google voice, Alexa, Youversion rest. In December 2019, a survey from Comscore Mobilemart speakers that allows the owners to stream music, ask general questions, make weather forecast and listen to sports updates with just voice tech[9].

2.5 Telemedicine /Asynchronous Healthcare

This technology uses autonomous Robots to treat patients with confirmed cases of COVID-19[10]. This is done to create a social distance between them and the patients thereby reducing the COVID19 spread among Frontline Workers. Most Hospitals, Clinics, and Private health. The US government has expanded the Telehealth consultation for Diabetics. The US government has granted telehealth consultation to 50% of Medicare beneficiaries that allow Patients to get treated via videoconferencing and phone calls[11]. Asynchronous Healthcare is the process of giving virtual care in the treatment of chronic disease or life-threatening disease. In[12], One drop health management treats diabetic patients via self-tracking mobile app by offering services directly to their consumers like medical counseling, blood sugar monitoring device, glucose monitoring with the use of Bible app. Patients also have online access to online counseling thereby reduce hospital readmission, eliminates transportation cost and most importantly, relieving Front line workers for COVID-19 related medical issues[13].

2.6 Instant Messaging and Social Media

World Health Organization (WHO) in collaboration with Nigeria Center for Disease Control (NCDC) deploys a dedicated messaging service in English, Arabic, French and Spanish language to educate people on COVID-19 symptoms and how to stay safe. the use of Instant messaging via Twitter handles, Whatsapp and Facebook can reach nearly 2billion people, to update the general public on important global epidemic prevention and strategic information on COVID-19[14].

2.7 Social Virtual Reality (VR)

Due to the COVID-19 pandemic, where human interaction and social gatherings have been banned, sharing personal items with strangers like VR Headsets to play games in parks, explore travel destinations becomes a difficult task [15]. People can download social VR apps like Altspace VR, Rec room, IVR chat to communicate with their families and friends thereby eliminating social imbalance

and loneliness during this lockdown period[16]. Now, Businesses are exploring VR platforms to conduct training their employers, hold scheduled conferences, conduct meetings with their partners all over the world thereby increase sales continuity and sustaining the economy[17].

2.8 5G Connectivity

As demand for higher network bandwidth increases during COVID-19 Pandemic, to avoid a total shutdown of the economy, a worker needs an effective network for telecommuting. This has forced the 5G market to launch it earlier than the expected which will, in turn, increase the Internet of things(IoT) applications for a time like this with 5GIoT technologies[18].

2.9 Biometrics and Computer vision

In [19]Security sector uses Sensor technology like Biometrics companies like Baidu, Dermalog, and Tempo to apply the use of Biometrics technology to identify suspected cases of COVID-19 by combining facial recognition via Real-time CCTV cameras and temperature sensing technology. It makes use of RFID sensor and raises alarm if the temperature exceeds 99 F.SuperCOM Biometrics tracking technology uses ankle bracelets, fingerprint, a smartphone app to monitor quarantined COVID-19 Patients to reduce the careless spread of this severe respiratory infection.

2.10 E-Learning/ Online Education

The Educational sector has taken a quantum leap during this COVID19 pandemic by introducing E-learning which stands for Electronic, Electronic, Enhanced, and Easy-to-use. It makes use of cheap and affordable technology like smartphones, personal computer and apps like Youtube, whatsapp, zoom making it easy-to-use for students to access across the globe. In [20], the Leading Group of the Ministry of Education of China to respond to the COVID-19 epidemic has issued the "About Guiding Opinions on Online Teaching Organization and Management of General Colleges and Universities during the Period, Notice on Supporting Education and Teaching with Information Technology during Epidemic Prevention and Control, and Several Suggestions on Targeted Teacher Work during Epidemic Prevention and Control Notice" on February 4, 2020. This has also increased the popularity of Massive Open Online Courses (MOOC), making different courses to be globally recognized. This has accelerated the integration of online education into the educational sector thereby reforming the teaching methods and improving the overall quality of education[21].

3. SUMMARY AND CONCLUSION

This paper has reviewed the technology trends topping the chart during COVID-19 Pandemic. This has touched virtually every aspect of human lives from managing businesses via AI technologies to improving our state of mind through Social VR and most importantly, continuity in learning with MOOCs. It has revealed the highs embedded in this pandemic. It has also informed us about the relevant technologies we can take up in other to survive this dark phase of our lives and not put our lives on hold.

4. REFERENCES

[1] F. Zhou et al., "Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study," The Lancet, 2020.

[2] M. Roser, H. Ritchie, and E. Ortiz-Ospina, "Coronavirus Disease (COVID-19)–Statistics and Research," Our World in data, 2020.

[3] M. Giacobbe, G. Pellegrino, M. Scarpa, and A. Puliafito, "An approach to implement the “Smart Office” idea: the# SmartMe Energy system," Journal of Ambient Intelligence and Humanized Computing, pp. 1-19, 2018.

[4] J. Scott and C. Scott, "Drone delivery models for healthcare," in Proceedings of the 50th Hawaii international conference on system sciences, 2017.

[5] E. Ackerman and E. Strickland, "Medical delivery drones take flight in east africa," IEEE Spectrum, vol. 55, no. 1, pp. 34-35, 2018.

[6] H. Liu and L. Wang, "Gesture recognition for human-robot collaboration: A review," International Journal of Industrial Ergonomics, vol. 68, pp. 355-367, 2018.

[7] A. Aucella, R. Kinkead, A. Wichansky, and C. Shmandt, "Voice: technology searching for communication needs," ACM SIGCHI Bulletin, vol. 17, no. SI, pp. 41-44, 1986.

[8] D. Jakhar, I. Kaur, and S. Kaul, "Art of performing dermoscopy during the times of coronavirus disease (COVID-19): Simple change in approach can save the day!," Journal of the European Academy of Dermatology and Venereology, 2020.

[9] G. Pattillo, "Fast Facts," College & Research Libraries News, vol. 81, no. 4, p. 216, 2020.

[10] J. E. Hollander and B. G. Carr, "Virtually perfect? Telemedicine for covid-19," New England Journal of Medicine, 2020.

[11] O. J. Mechanic and A. B. Kimball, "Telehealth systems," in StatPearls [Internet]: StatPearls Publishing, 2019.

[12] C. Y. Osborn, J. R. van Ginkel, D. G. Marrero, D. Rodbard, B. Huddleston, and J. Dachis, "One drop| mobile on iPhone and Apple Watch: an evaluation of HbA1c improvement associated with tracking self-care," JMIR mHealth and uHealth, vol. 5, no. 11, p. e179, 2017.

[13] A. C. Smith et al., "Telehealth for global emergencies: Implications for coronavirus disease 2019 (COVID-19)," Journal of Telemedicine and Telecare, p. 1357633X20916567, 2020.

[14] K. Jahanbin and V. Rahmanian, "Using twitter and web news mining to predict COVID-19 outbreak," Asian Pacific Journal of Tropical Medicine, p. 13, 2020.

[15] E. Bastug, M. Bennis, M. Médard, and M. Debbah, "Toward interconnected virtual reality: Opportunities, challenges, and enablers," IEEE Communications Magazine, vol. 55, no. 6, pp. 110-117, 2017.

[16] G. Bernal and P. Maes, "Emotional beasts: visually expressing emotions