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PLAYING VIRTUAL MUSICAL DRUMS BY MEMS 3D GENERATOR WITH MACHINE LEARNING MODELS

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ABSTRACT
In our life, music is one of the important tools of entertainment whose ingredients are musical instruments. For instance, acoustic drum is very important when a song is being sung. In the modern world, therefore, the style of the musical instruments is changing, yet retaining the same tune for instance an electronic drum. *Based on MEMS 3D accelerometersensor data and machine learning, we have created "Virtual Musical Drums" in this work. Machine learning is integrating in all fields of AI for solving problems and the MEMS sensor is transforming a large ph This study has shown that, in the specified simulation, there is a detection accuracy of 91.42%, and in the real-time scenario with 20% window overlapping, there is an accuracy of 88. 20%. The simulated drum sound seemed unreal, even if the accuracy of the system detection was adequate. Therefore, we selected the "virtual musical drums sound files" in line with the acoustic drum sound pattern and length, and we adopted the "multiple hit detection within a fixed interval, sound intensity calibration, and sound tune parallel processing." Finally, but just as importantly, we completed the "Playing Virtual Musical Drums" exercise and were able to simulate playing an acoustic drum. Another aspect of MEMS sensors and machine learning has been illustrated by this work. It illustrates how data,. It demonstrates how data, sensor, and machine learning can be applied in a different way in offering musical entertainment with enhanced precision.*
KEYWORDS—*Virtual musical drum, MEMS, SHIMMER, support vector machines (SVM) and k-Nearest Neighbors (kNN)*

I.INTRODUCTION

To freshen the mind, music is indispensable in our lives. Musical instruments that support songs are played with a set of musical instruments such as pitch, dynamics, rhythm and presenting performance. Guitar, piano, and drums Among the most widely used musical instruments are the accordion, clarinet, saxophone, violin, trumpet, and cello.The drum is classified under the percussion instrument category and it is one of the most important musical instruments. The acoustic drum involves the use of the stick in executing the musical instrument. The electronic drum kits, often also referred @ as silicon drums, computer drums or electronic drums, are currently in use as a substitute to the acoustic drum kit in regard to demand. This highly popular new generation electronic musical instrument has an acoustic drum-like sensation. These days, machine learning and micro electromechanical systems (MEMS) sensors are undergoing a paradigm change. All facets of AI problem-solving that help to improve our quality of life see a surge in the application of machine learning. But as a result, the MEMS sensor was reduced in size from a huge small physical system they have to establish a connection between a large physical system and a small physical system. accuracy. MEMS and machine learning both are modern day technologies Human-Computer Interaction (HCI) system we've worked on creating a music-based setup named "Playing Virtual Musical Drums where the user can play drum music without touching a single instrument just by mere hand posture (Figure 1).

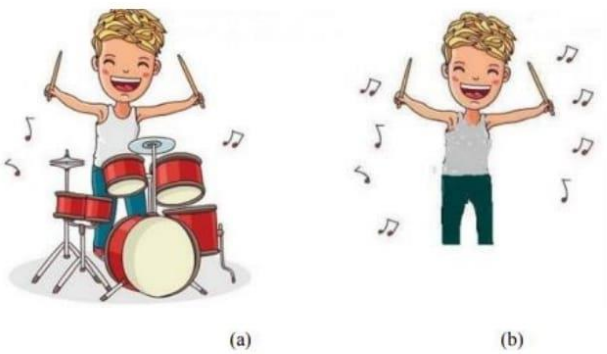

Fig. 1. (a). Real musical instruments (b). Virtual musical instruments playing

Big hurdles for 3D gesture control systems include

1. Data is collected from the sensors and then stored; as the stream of data is monitored for training and recognition.
2. The program searches for predefined patterns by comparing the specific pattern with the data vector
3. On the assessment of the 3D gesture recognizer algorithm
4. The reaction time or latency assessment during record monitoring in real time, whenever a match is found in the pattern.

Thus, we have been able to solve the above mentioned major challenges while designing and implementing a system called "Playing Virtual Musical Drums" which will enable the drum lover to play the virtual drum while at the same time providing the feel of the above mentioned acoustic musical instruments. If one aims at buying a set for using in playing any musical instrument, then he or she has to spend a lot of money. Furthermore, large instruments are also difficult to transport from one place to the other. Now-a-days, Smart Phone music application is becoming limited to the user as it can be accessed only with a finger touch. Through these music application, the user don't develop the real interest from this application and cause the young generation feel boring. The musical instrument of this work is significantly different from the conventional musical instrument in several ways because by the use of advanced technology the drum player is provided with the right gesture tracking and recognition method. In the recent years, all aspects of people's lives are shifting to automation and virtual environment and music needs to adapt to it too.

II. RELATED WORKS

Joseph and his colleagues argue that Uses for 3D hand gesture and body natural posture with computer interface include musical instruments, training and simulation for video games, and movement-based disease detection. The raw data has also been analysed [2]. By Berman et al. created a GRS model with the following components: Sensor (Gesture Capture Device), Motion Capture/Tracking, Feature Extraction, and Classification Algorithm. This was accomplished by combining these two cutting-edge technologies with the Human computer accurately while learning the 3D movements [1].Consequently, he observes that the most crucial initial design factors are GRS's assessment of context utilization, a sensor's stimulus, and its platform.applying magnetic sensing technology to evaluate different movements from varied fingertips; Chen et al designed and implemented 'Finexus' system. Head-mounted displays in virtual reality is one area where this system becomes useful as well as human input like drawing in the air. He said that compared to an optical tracker, 'Finexus' system has higher average accuracy [3]. Proposed by Hoang, Truong et al (2018), this is a wristband system wherein a wireless communication module (BLE), capacitive sensors on flexible circuit board, and cheap microcontroller unit have been integrated into 3D printed wristband. To detect and locate the hand gestures of users, the wristband samples capacitance variations from several capacitive sensors [4]. The new OLE was developed and used for portable intra-hand multi-finger-motion capture wearable device by Kang Li and his team. In its nature, it is compact, power efficient and light in its composition. [5]. An efficient gestural music interface has been demonstrated in Brown et al. in relation to a Leap Motion optical sensor and a camera-based motion tracking system.. On the other hand, when looking at the interface it seems to be far more accurate since leap motion being placed on flat surface like table [6]The controller MYO was developed by Nymoen et al., which includes an inertial measurement unit (IMU) and measures muscle tension using eight electromyography (EMG) sensors, 3D accelerometer, 3D gyroscope. The primary objective of this wearable device is to design novel musical instruments,[7].Another example provided by Jeffrey et al. is for people wanting to play traditional musical instruments using virtual reality tools. The three major components in the system include: the instrument robot, webserver and user interface.This translates user hand gestures into playable instruments as a virtual environment in the user interface. After that HTTP server will deliver transformed data to the webserver [8].Caramiaux et al.'s article, "Analyzing Musical Gestures and Sound Control with Regression and Classification" shows how regression and classification analyses can be used to play virtual music through gesture controls [9]. This is "a live performance approach" – a concept created by Torre et al. that describes his latest invention - a new musical glove that is difficult technically as well as sociologically, musically,[10]. Consequently, with a particular focus on the elderly and patients who need to live independently, this has made MEMS sensor the most preferred medical sector [11]. This implies that a caregiver or a health attendant is responsible for his physical wellbeing, while he continues to live normally at home [12]. Currently, MEMS has wide applications. For instance, we have made another example of sensors where MEMS sensor and machine learning can be used to bring about innovative music playing devices in the future generations. Moreover, this article will show that data serves not only as information but also entertainment itself.

III. METHODOLOGY

This information section will discuss the step by step procedure which we follwed in order to complete "Playing Virtual Musical Drums".

A .Sensor type, number and dimensions selection

There are a number of different types of IR,pressure, gyroscope, magnetometer, accelerometer, encompass, and other micro-electromechanical systems (MEMS) sensors etc. that can be found in the market. In order to pick an appropriate sensor for our particular purposes it is important to consider the functionality as well as application areas. From the outcome analysis and observational study it's seen that playing virtual drum using MEMS accelerometer has been very successful. It's also possible to play a virtual drum by using either gyroscopes or magnetometers individually or both in this When using a single sensor, such as aamagnetometer or gyroscope, the accuracy, precision, and recall for identifying virtual drums are reduced. Accuracy percentage,

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precision, and recall are high when accelerometer, gyroscope, or gyroscopes with magnetometer are combined.The angledetection requires a gyroscope, while motion velocity demands an accelerometer. This enhances virtual drum detection better than either sensor on its own but is slightly more expensive. Similarly, when we Use a three-dimensional accelerometer to get results similar to those of a gyroscope and accelerometer combined. Thus, instead of using resultant accelerometer plus gyroscope we can solely employ the three-dimensional accelerometer. The 3D accelerometer provides a three-axis value that resembles a gyroscope and meets both criteria for a resulting accelerometer. We decided to utilize a single MEMS 3D accelerometer for virtual drumming in this experiment (Figure 2).

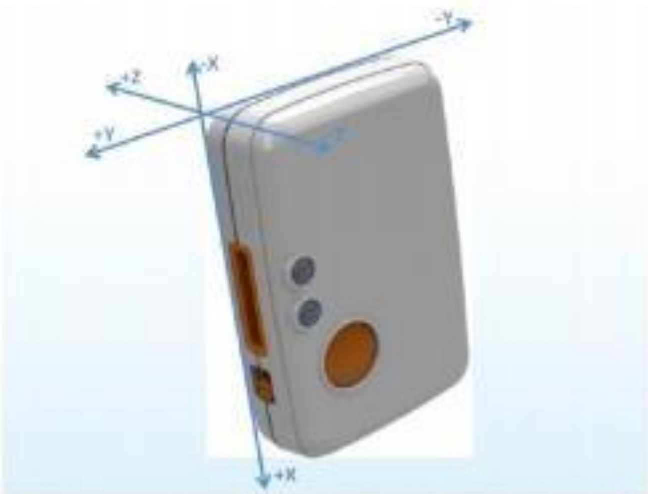

Fig. 2. Accelerometer and 3D coordinate systems

B. Selecting the number of samples and the frequency of sensor sampling

One of the primary goals of this study is to identify the virtual drum position and hand posture. Increased accuracy in posture recognition is achieved at the cost of increased computational expenditure and shorter sensor battery life when sampling frequency is high. The high frequency setting of the sensor in a real-time application can occasionally result in a delayed response. In this paper we have considered the use of the SHIMMER (Sensing Health with Intelligence, Modularity, Mobility and Experimental Reusability) brand sensor for the sensing activity [13]. SHIMMER's sampling frequency can be adjusted between 10 and 1000 Hz. Afterward,

C: Noise Filter of acceleration signal and calibrating of axis

The CPU in our experimental sensor has a A 12-bit digital-to- analog converter and a 16-channel integrated circuit. The sensor offers three configuration options: low-pass, high-pass, and band filter. It may be set up by Bluetooth or a conventional dock connection. The built-in SHIMMER function has been used to configure the low-pass filter. In an audio signal processing systemsignals over a specified cutoff frequency are attenuated and signals below it are passed through a low-pass filter (LPF). When recording accelerometer sensor data, low pass filter produces lower noise acceleration than band and high pass filters. For-windows platform, we have set 9 DoF calibration.which allows us to use commands to define the required x, y, and z axis. The tri-axial MEMS 3D accelerometer sensor can be calibrated and the configuration written using the formula below.

C=R-1.K-1.(u-b) In this equation:
C=3x1 calibrated signal vector
R=3x3 alignment matrix
K=3x3 sensitivity matrix u=3x1
Uncalibrated signal vector b=3x1 offset vector

D. Position of virtual drum and sensor wear

The top end of the drum stick, the wrist, just under the elbow, and the base of the stick are where you can wear the sensor. Putting the sensor on the top end of the stick works best for picking up the right drum sounds. The wrist is just as good. But, putting it under the elbow or at the stick's base doesn't work as well. Because it's more comfy and keeps the sensor safe, wearing it on the wrist is the best choice

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Fig. 3. Right side 1- 4 drums hand posture and left side 1-4 same hand posture

We have eight drum positions indicated in our system. The remaining four are on the left, and the final four are on the right.. For either sensor, they were referred to as "first drum position" (sensor in the right hand), "second drum position" (left hand sensor), "third drum position" (sensor in the right hand) and finally "fourth drum" (left sensor) In total we have two sensors for four positions and each of these sensors has four different Drum positions.

Apparently, there are two sensors with four separate positions each for a Drum that is shown below:

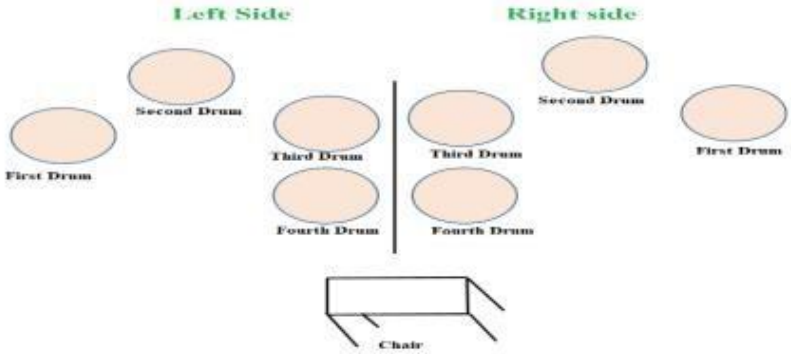

Fig. 4. Position of Virtual Drum

E. Train and test data preparation

In the above learning model, the nuber of training data sets from the subject, which provide good perlformance is optimum. is needed to achieve high detection accuracy system by any machine learning algorithm. The unexperienced subjects' data gives overfitting, leading to machine error detection and lowering overall performance. Furthermore, having more subjects than necessary does not always result into improved performance because in some cases it may even have a negative effect on the performance itself.we have chosen volunteer and their recorded data based upon We focused on capturing the natural hand posture of volunteers while playing the drums. Consequently, we disregarded certain data sets, and the remaining 1000 data sets were selected for further processing, as shown in Figure 5.However, to ensure the effectiveness of our model, we randomly split the entire dataset into two sections: one comprising 75% of the data, designated as the training dataset, and the other containing 25% of the data, designated as As can be observed in the above learning model, the number of training data sets from the subject which gives good performances is optimum.

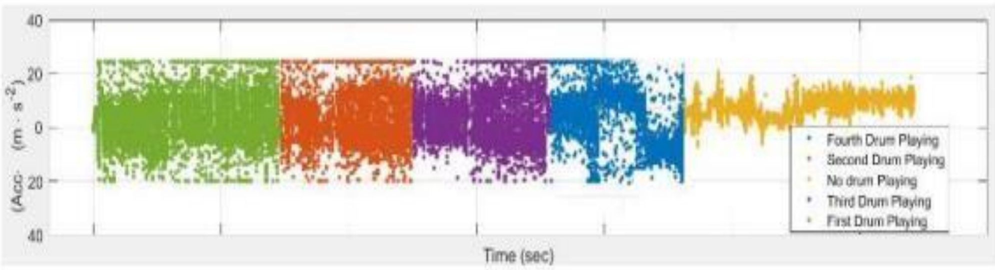

Fig. 5. Virtual drum training and testing dataset

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F:Drum musical selection
Drum music selection system Our system has eight virtual drums, set up like figure 2. We got over 500 drum audio files from "musicradar" website. First, we chose short audio files, less than one second, for drum play.

128 samples equals 1.28s of data saving time. It was done one after another. But for better sound, we changed to parallel processing (details are in the parallel processing section). Then, we picked the right audio files based on drum set and sound pattern.

IV. RESULT

SVM and KNN are used to check how well things work in a test and the outcomes are written down here. For
SVM: The mix-up grid and overall results for spotting virtual drums are seen in Tables I and II

Table I:SVM classifier's confusion matrix

True Class	Detection					
	First Drum	38		6	1	5
	Second Drum		42		2	6
	Third Drum	4	2	34	3	7
	Fourth Drum	1		7	39	3
	No Drum	1		1	4	44
		First Drum	Second Drum	Third Drum	Fourth Drum	No Drum
	Predicted Class					

Table II: a summary of the SVM results

Detection	Accuracy (%)	Precision (%)	Recall (%)
First Drum	92.28	76.00	86.36
Second Drum	96.00	84.00	95.45
Third Drum	88.00	68.00	70.83
Fourth Drum	91.60	78.00	79.59
No Drum	89.20	84.00	67.69

KNN Classifier: The confusion matrix and the summary of the virtual drum recognition using KNN classifier are displayed in Tables III and IV.

Table III:KNN Classifier's Confusion Matrix

True Class	Detection					
	First Drum	33	1	9	3	4
	Second Drum		37	1	5	7
	Third Drum	7	3	29	5	6
	Fourth Drum	3	3	7	32	5
	No Drum	2	1	7	4	36
		First Drum	Second Drum	Third Drum	Fourth Drum	No Drum
	Predicted Class					

Table IV: Summary results of KNN

Detection	Accuracy (%)	Precision (%)	Recall (%)
First Drum	87.20	66.00	73.33
Second Drum	91.60	74.00	82.22
Third Drum	80.00	58.00	54.71
Fourth Drum	86.20	64.00	65.30
No Drum	85.60	72.00	62.06

When comparing the results obtained from table2 and table 4,we are able to see that SVM has a higher accuracy, precision and recall than that of KNN. Therefore for the identification of the real-time drum,the SVM is selected and implemented
The real-time and simulated detection tests are as follows:

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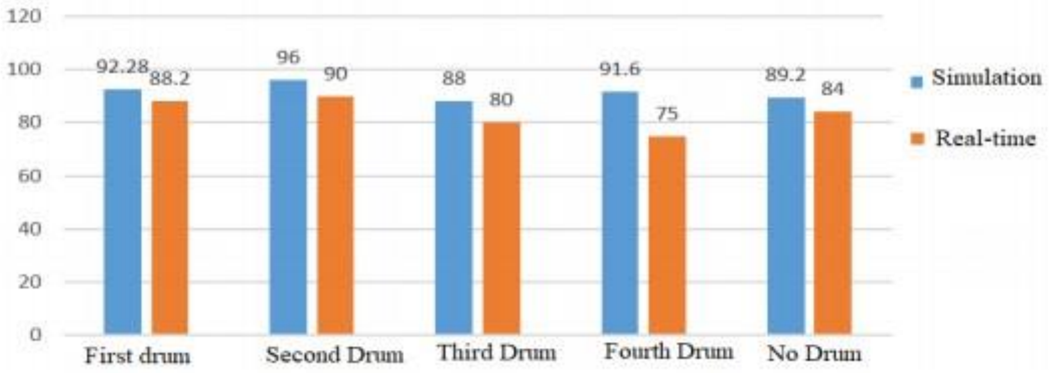
Last but not the least , we compared real-time testing with simulation. when we finished the real-time video experiment we tested its effectiveness by comparing the content of the vedio with that calculated by the computers. Through the random selection of data segments in real time, there was an improvement in the number of "no detection" cases as depicted in figure 12.



We fixed the "no finding" issue and improved the accuracy in the simulation and real-time. We used 20% windows overlapping for this. Now, we have almost achieved the simulation and real-time accuracy

V. CONCLUSION

In this work, we show a different use of data for fun in the world of music. Step by step, we solved the start-up issue through using numbers smartly and making the best choices. In the "Playing Virtual Musical Drums" task, we picked things carefully: the sensor type is an accelerometer with 3D ability; the make is SHIMMER; it checks data 100 times a second; it looks at 1.28 seconds of data, totaling 128 samples; it cuts down noise with a low pass filter; you wear it on your wrist; it tracks 4 hand shapes; it knows 8 drum spots; we got skilled people to help; we checked average values, how spread out the numbers are, and PCA; we sorted data with SVM; and we let data overlap by 20%. We ran a live test by first training and testing our data, and we also made a video of it. We spotted drum beats over time, their music patterns, and how long they played. We used tech to spot many drum hits at once, adjust the sound, and handle multiple sounds at the same time. After doing all these steps and getting 88.20% right in picking up drum sounds, we could play the virtual drum just like a real one. In Picture 14, we show a user playing this virtual drum.

Fig. 14Using MEMS 3D accelerometer sensors to play a virtual drum

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