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Article

Motion Tracking Pen

Chahak Tyagi[1], Anjali Yadav[2], Nirmal Singh[3]

[1,2,3]Department of Electronics and Communication Engineering, JSS Academy of Technical Education, Noida.

I N F O

Corresponding Author:
Chahak Tyagi, Department of Electronics and Communication Engineering, JSS Academy of Technical Education, Noida.
E-mail Id:
tyagi19chahak@gmail.com
Orcid Id:
https://orcid.org/0000-0002-7949-460X
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A B S T R A C T

This paper aims at creating a working prototype for a Smart Pen that can be used for storing handwritten text and display it on your computer screens. We have provided it in English language, but it is not language specific, you can customize it and train it according to your ease.

Using Machine Learning algorithms and arduino, the stores movement is analyzed and matched with the best suited trained model to give the desired result. The movement will be recorded and stored. With Python, the movement also can be displayed on your device's screen. With a small and convenient button, the recording function can start and finish very flexibly. Users also can attach our device on other things to track their movements, too. Therefore, our device provides a workable solution for handwriting tracking, movement tracking etc.

Keywords: Arduino, Machine Learning, PyGARL, Python, MPU 6050

Introduction

Human civilization has always used handwriting as a main channel of communication. Long before people could talk, they used to communicate to each other via symbols and marks. As computing technologies expanded beyond the confines of the desktop, the need for effective text entry on mobile devices has been increasingly felt over the last two decades. Such increasing need motivated researchers to work on better and effective method for data entry than just keyboard. This pen is an attempt to link physical and digital information media and combine the best of both worlds. We can also modify the pen to have wireless connectivity and then recognized information can be saved in cloud so that we can access the data to anywhere anytime. This makes data accessibility faster and at ease in such a way that the received data can be used for third party applications.

The goal of the paper is to design a separate module that can be put on a pen, robot or even people to track and record the object movement.

Users can use this module and attach it with their other devices, so when the object is moved, our device can restore and track their trajectory and display the movement in the horizontal plane in the world frame on the screen. A very classic application is that users can use it as a pen, so their writings will be recorded and saved as an image. A special feature about this paper is that the tracking does not reply on any specific plane and it can be applied on every plane, even in the air. The placement or tilt of the device also will not affect the result.

Nowadays, in order to gain the handwriting results, people often rely on the capacitive touch screen, stylus pen, or other similar devices. They are functional and precise, but not always flexible.[1,2]

Our paper combines Arduino with MPU to build a product that can keep tracking of the movement and generate the trajectory very quickly. We designed a system that does not need any specific surface or other input tools for support and it only reply on MPU and its sensors.

Literature Review

The recent growth in communication and technology brought a wide range of new applications which are advanced to upkeep several areas of education and learning. A Pen-based Computing or Pen Computing basically denotes to a User-Interface (UI) which works by using a pen, rather than traditional input devices such as a mouse or keyboard.[14] According to Ana Belén Lago Vilariño and Iván Pretel García,

an e-learning platform that combines work with printed and digital documents. It integrates pen-and-paper-based interaction techniques that enable users to manage their digitized documents. In addition, this platform integrates different e-learning platforms providing a single intuitive interface to manage them.[13]

LeapFrog[1], provides LeapReader which is a digital pen for the children aged between 4 to 8 that sounds out words, guides letter strokes, and helps them to build understand. Earlier, the company formed the Fly digital pen, it was a pen very similar to the Livescribe pen, but in the year of 2009 the company discontinued both the support and manufacturing of this pen. Benlloch etal. 2009, with their Classroom Presenter, discussed an approach which was a six steps based on a teaching system that provides active teaching and learning techniques and at the same time supports in class faculty/student and student/student collaboration. They implemented the method in first-year Computer.

The recent progress in communication and skill transported an extensive range of novel uses which are developed to sustenance numerous parts of education and learning. A Smart pen or Pen Computing simply refers to a user-interface (UI) which works by using a pen, rather than old-style input devices such as a mouse or keyboard.[14]

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Benlloch etal. 2009, planned the system to collect formative data and instead they were making instant response, doings by means of Classroom Presenter.[14] Investigators have examined the use of a smart pen to improve teaching and learning. In[2], pen-based writing and reading in combination with groupware was used to contribution interaction with computer science studies. However, there were no smart pen and paper but was a tablet and styluses were used for the writing. Miura et al. had performed a number of researches using the digital pen in a classroom.[3-5] In 2005, they were able to develop AirTransNote,[3] a learning system which uses digital pen based on an ultrasonic digital pen (Inklink) and PDAs which were used to pass on the student's notes from Inklink to the faculties PC by using wireless LAN. Later,[5] an improved and dependable system was on condition that using an Anoto-based digital pen. The system was responsible to examine the activities in class and also monitoring the inspiration of children when they were using it to write their notes, calculations and while drawings. According to the result produced by the research most of the children were more and more concentrated, motivated and were enjoying the lectures.

Sellen and Harper (2003)[6] extensively deliberated advantages and disadvantages of a paperless working.

Though, skill has enhanced a ration but certain of the points given by them are still valid.

- Many people still like the traditional way of reading and writing. They just pick the paper and start reading or they can just use the pen to write. An electronic device doesn't provide the same feel while interpretation and writing.[8]
- An electronic device is always dependent on a power supply to start working. While paper does not require any power supply. There is possibility that pen could run out of ink, but this is a very low-cost replacement.
- Still the most commonly used method for information retrieval and exchange is the physical paper. These days' computers and PC's are on almost every desk, but a lot of papers are still being used.
- The speed of scrolling on physical paper is much faster than the scrolling on PC's.

Though the pen has varies challenges but it has several advantages as well and that is what makes it worth a try. It is bridge between the Physical and Digital world where the handwritten input is directly converted to the Digitized text with in no time or Real time. There are numerous advantages of the Smart Pen can be easily seen.[15,16]

Some of the Important Advantages are Listed Below

Easy To Use Customizable Multipurpose Pen

It is a Customizable Digital Device; it can be customizing according to the users. The trained data or beforehand stowed can differ individual to individual. Hence the user

can set or use his own Writing Style. It can replace the Mouse Peripheral to the computer, since the both devices do the same method to recognize the Coordinates.

Simple User Interface

The Smart Pen application has the Simple User Interface. Not much training required for user to familiarize the Application. Hence it is very easy to use.

Mobility

The size of the device is very small, as long as a pen. Hence it Can be used as standard pen and can carry anywhere without stressing mind to carry it. It provides greater mobility if the connectivity is wireless.

Third Party Application Can Be Hosted

Smart Pen Application supports the Third-party applications to use the Recognized text as their input. It is great advantage for the Businessmen, students etc. They're work can be directly saved in the desired format and applications.

Components Required

Hardware Used

- Arduino Uno
- MPU 6050
- Bluetooth Module (HC 06)

Software Used

- Arduino IDE
- Python IDE
- Scikitlearn
- pyGarl Library

Block Diagram

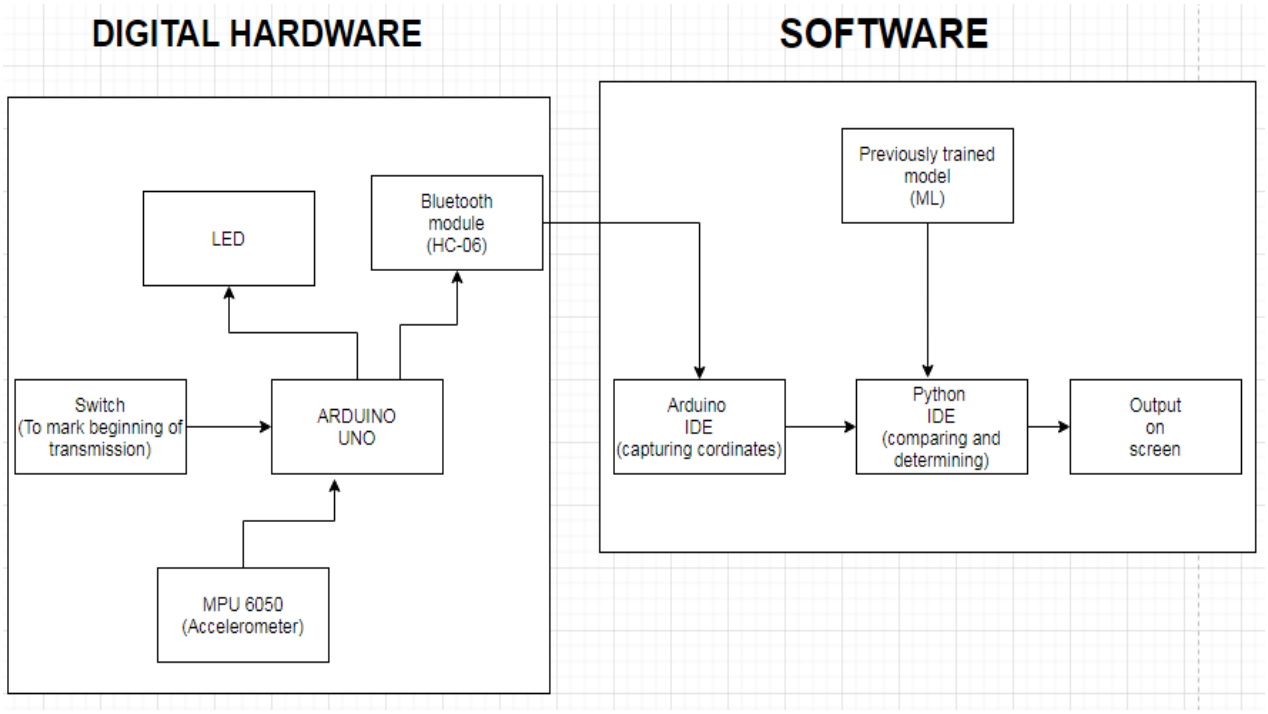
Block diagram for the model is described above. The Block diagram has 2 portions. First one is hardware part and the second is the Software part which is the Python plus Arduino software to convert the motion as input to the Digital Characters on the screen.

The construction and working of the paper are divided into 3 part:

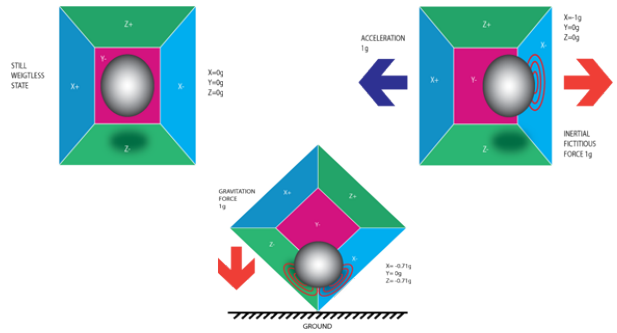
Creating A Motion Tracking Device

The MPU6050 IMU has both 3-Axis accelerometer and 3-Axis gyroscope integrated on a single chip. The gyroscope measures rotational velocity or rate of change of the angular position over time, along the X, Y and Z axis. It uses MEMS technology and the Coriolis Effect. The outputs of the gyroscope are in degrees per second, so in order to get the angular position we just need to integrate the angular velocity. Briefly, it can measure gravitational acceleration along the 3 axes and using some trigonometry math we can calculate the angle at which the sensor is positioned. So, if we fuse, or combine the accelerometer and gyroscope data we can get very accurate information about the sensor orientation. The MPU6050 IMU is also called six-axis motion tracking device or 6 DoF (six Degrees of Freedom) devices, because of its 6 outputs, or the 3 accelerometer outputs and the 3 gyroscope outputs.

An accelerometer works on the principle of the piezoelectric effect. Imagine a cuboidal box with a small ball intimate it, like in the picture above. The walls of this box are made with piezoelectric crystals. When you tilt the box, the ball



is forced to move in the direction of the leaning due to gravity. The wall that the ball collides with creates tiny piezoelectric currents. There are three pairs of opposite walls in a cuboid. Each pair corresponds to an axis in 3D space: X, Y, and Z axes. Depending on the current produced from the piezoelectric walls, we can determine the direction of inclination and its magnitude.



To create a motion tracking device, first we must configure our accelerometer (MPU 6050) with our microcontroller (in this case Arduino Uno). The program we will be running here also takes advantage of the Arduino's interrupt pin. After the connections are intact, we need to program the Arduino to get access to the values of acceleration and gyroscope from the sensor as it moves. We can observe the value for the coordinates on serial monitor.

Creating Movement Recognition Software

For the purpose of creating recognition, we need to use Machine Learning Algorithm. We have to train a model in such a way that every time the device encounters such motion, it can relate back to the recognized pattern. For this, we will use external Python library known as PyGARL-Python's Gesture and Recognition Library. To train the model we will be using SVM technique (Support Vector Machine) of Machine Learning Algorithm.

Support Vector Machine

A Support Vector Machine (SVM) is a supervised machine learning model that uses classification algorithms for two-group classification problems. It aims at finding a hyper plane in N dimensional space that can most accurately divide the data set into suited categories.

Methodology

- Select an optimal hyperplane.
- Use the above classification for non-linearly separable problems.
- Now map the data for the N dimensions where is can be more easily classifiable with linear decision surface.

To define an optimal hyperplane, we need to maximize the width of the margin (w).

27 lines (27 sloc) | 1.19 KB — Raw | Blame | History

```
START 2544 6760 3996 5131 1277 -5211 END
START -9348 956 8628 5959 -3307 -3566 END
START -13768 1504 10692 2903 -2576 -1539 END
START -13408 600 12560 319 200 160 END
START -7764 716 9048 -1231 2793 2122 END
START -7248 940 10236 -1681 665 2681 END
START -7716 1332 11636 -2053 -860 1914 END
START -6904 1532 11052 -2331 -1412 154 END
START -8860 1352 10880 -3074 -1586 -1149 END
START -11600 1368 10468 -4775 -656 -748 END
START -13788 264 11552 -8026 2133 713 END
START -16460 -2052 14092 -9895 4455 2527 END
START -21248 -5308 17616 -8980 4200 5129 END
START -25088 -8020 19164 -5368 959 8861 END
START -26636 -10652 17364 -2957 715 13283 END
START -30532 -14020 15424 -3360 4372 19785 END
START -32768 -18160 13816 -4948 6485 29103 END
START -32768 -22520 11932 -7710 7818 32767 END
START -32768 -27840 11424 -11656 11367 32767 END
START -32768 -32768 12084 -15820 11671 32767 END
START -28820 -32768 14264 -20236 11855 32767 END
START -19744 -32768 19476 -22319 13476 32767 END
START -11248 -32768 22852 -23146 14140 32767 END
START -184 -32768 27952 -21947 13293 32767 END
START 13136 -32768 30936 -19216 18843 32767 END
START 25268 -32768 28316 -19135 24639 32767 END
START 32767 -32768 32767 -21270 30789 32767 END
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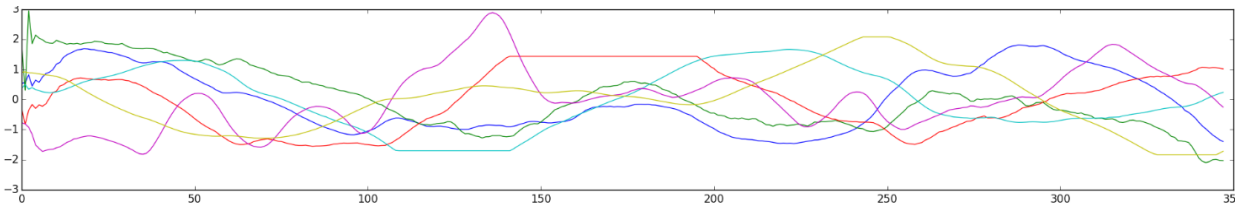
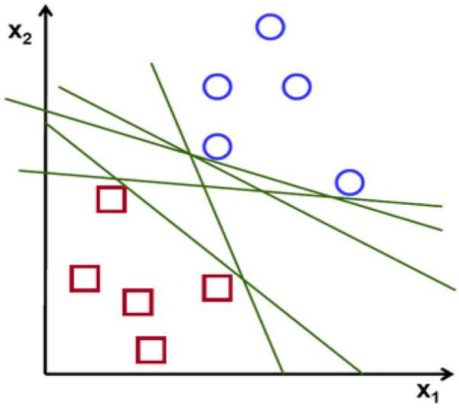
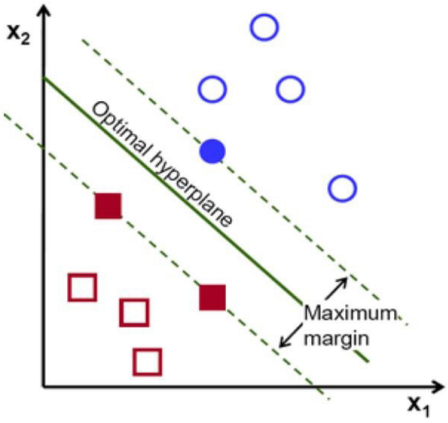
For more dynamic evaluation, we can observe the 6 output of the MPU changing with the motion of devic graphically.



In order to find value of b and w, we need to use Quadratic Programming.



Possible Hyper Planes



Optimal Hyper Plane

Support vectors are data points that are closer to the hyper plane and influence the position and orientation of the hyper plane. Using these support vectors, we maximize the margin of the classifier.

The data obtained via several observation is recorded and divided into 2 sets, Training set and Testing set. The model is then trained using training set corresponding to various letter in alphabet language using the above SVM model and accuracy is calculated.

Displaying The Output on The Screen (Tkinter)

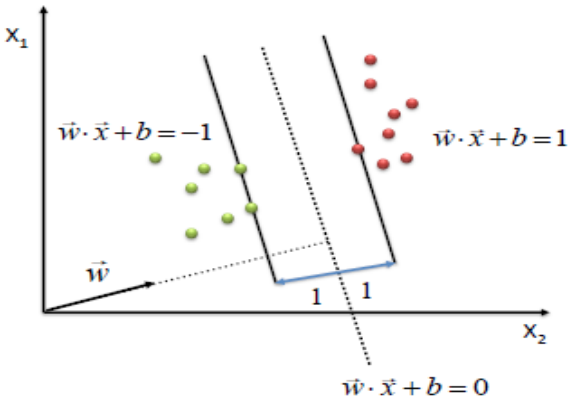
Once the values are obtained according to the movement of our sensor in space and the obtained values are passed into our Machine Learning model. The model makes predictions based on the trained sets and the output is then displayed as the result.

To Display the Output, We Make use of Python's Most Eminent Application – Tkinter

Python provides various options for developing graphical user interfaces (GUIs). Tkinter is the standard GUI library for Python. Python when combined with Tkinter provides a fast and easy way to create GUI applications.

Result and Conclusion

In this thesis we have presented and implemented a motion tracking pen that can be used to store handwriting and does not require any surface to work on. The motion by

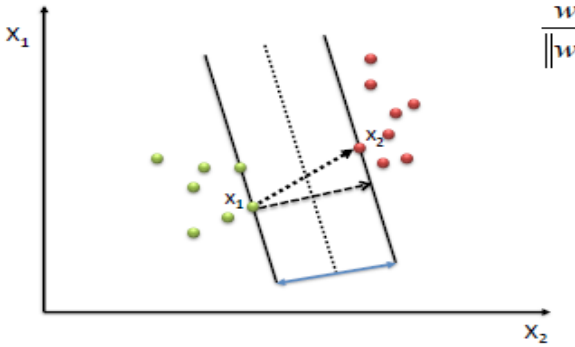


$$\max \frac{2}{\|w\|}$$

s.t.

$(w\cdot x+b)\geq 1, \forall x$ of class 1

$(w\cdot x+b)\leq -1, \forall x$ of class 2



$$\frac{w}{\|w\|}\cdot(x_2-x_1)=\text{width}=\frac{2}{\|w\|}$$

$$w\cdot x_2+b=1$$

$$w\cdot x_1+b=-1$$

$$w\cdot x_2+b-w\cdot x_1-b=1-(-1)$$

$$w\cdot x_2-w\cdot x_1=2$$

$$\frac{w}{\|w\|}(x_2-x_1)=\frac{2}{\|w\|}$$

the accelerometer is recorded and feed to a Machine Learning model which is trained using SVM (Support vector machine). Based on the feed coordinates of sensor, the model predicts the letters of the word. The output is displayed on your computer screen using Python's GUI (Graphic User Interface) known as Tkinter. Two LEDs are also attached with the module that indicates the start and end of the transmission.

Further we have 2 button switches to reset or stop the transmission at any time.

Future Scope

The Future scope of this thesis or the areas where the work can be expanded are listed below:

- More Connectivity option can be incorporated with device, which enables the user to connect various Devices wirelessly and even the recognized text can be made to store in the Cloud Storage. This helps to access the Texts anywhere anytime.
- Numerous Language and Script Recognition can be implemented, hence user can write in any language
- By implementing 3D Graphics in to the PEN, instead of using Complex software, the designer can put his heart down in to the computer. It saves a lot of time and No compromise required in the creativity.

And there are so many fields where smart pens applications can be extended can be used in classroom for easier and interactive learning, immersive gaming, interacting with virtual objects on screen. It will become more effective if merged with completely developed hologram technology. We will be able to interact with virtual 3D objects in the physical world in real time.

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