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Interactive Smart Writing Technology (ISWT): An Assistance to Paperless Documentation

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Abstract: With the latest inventions, human life standards have been changed dramatically. Intensive work can be seen to make the environment human-friendly. By keeping this view, this paper presents the future of advanced classroom/ meeting rooms, training areas, etc. by bringing down the count of paper used to make lecture notes. Our proposed system Interactive Smart Writing Technology (ISWT) which we claim as assistance to paperless documentation, is a pen/ marker sleeve that works on the mechanism of taking motion reading through the sensor that can work on any flat writing surface and whatever is written from it, will get digitalized on the application in real-time, making it easier to take notes and much more. You do not need to focus on writing, rather you can focus on the learning and understanding of the topics being discussed. The ISWT can also work as a liaison between industry and academia. The novelty of ISWT includes surface independence, portable, real-time and low cost.

Keywords: Classroom, Digitizing, Paper Usage, Sensors, Smart Writing.

I. INTRODUCTION

The digitizing of the written text has a huge impact on the daily life of an individual. The vision of Interactive Smart Writing Technology (ISWT) is to reduce paperwork to make lecture notes. The ISWT can also work as a liaison between industry and academia. It may help us remove the differences between the old physical notes taking to the automatic notes synchronizing by linking the handwritten input with the desktop application which is an incredibly convenient way of recording written content. We in this proposed system are digitizing the process of writing on one surface and getting it into the computer software in real-time. There are many advantages of ISWT, some of which are enhanced teaching/learning experience, can be used as a modern business advancement tool, increase engagement in collaborative productions, recorded lectures that can be used by substitute teacher/ junior teacher for their assistance, etc.

Since our proposed system aims to modernize the old methods of writing to the new technology of interactive smart writing. This is done by a marker or any befitting pen that can be placed in the shell (marker sleeve) and consisting of movement recognizable sensors (embedded in its circuit) that send its data to connected Arduino board [1]. Arduino board is responsible for the connection with the Bluetooth module [2], the desktop application is connected to that Bluetooth module. The Bluetooth module in this system aims to provide communication and synchronize the pen/ marker sleeve with the desktop application. The novelty of ISWT includes surface independence, low cost, portable, repairable, real-time and very economical for personal usage.

The remaining part of this paper is divided into seven parts. A literature review has been done in section two. Section three contains the design of the ISWT system. The methodology for the proposed system can be seen in section four. Results obtained from the proposed system can be seen in section five and finally, section six and seven are about future work and conclusion respectively.

II. LITERATURE REVIEW

The XAX [3] from XEROX PARC was one of the very early attempts to interlink paper and electronic world by introducing a paper user interface technology. The system retrieves and processes the documents written or printed on a paper form and faxed to/from a server. The XAX system uses conventional office equipment in conjunction with pencil & paper. The XAX-Form is a piece of paper with machine-readable marks on it. The marks are also human-readable. XAX-Server interprets the documents arriving from a scanner or fax.

The DigitalDesk [4], constructed on a physical desk. Downwards projection can be seen from a computer display on to a desk where a camera for video recording purposes is placed and uses image analysis technique to note down the movement of the user. The system through down electronic images that are collected onto the desk having a paper document on it. The system is intelligent enough to respond to figure gesture and on pen-based interaction and convert documents placed on the top of the desk into the digital version.

Designer's Output [5] was introduced by Berkeley form the University of California. It has the capability of combining paper and big physical workspace with the help of electronic media to support the information design of websites. Designer's Output is composed of touch-sensitive whiteboard containing sticky notes, electronic pens, a strong computer

vision system that uses one rear video camera for motion capturing and one front-mounted high-resolution camera for the ink capturing.

Post-It Notes [6] are the digitization of paper notes that users can access through their mobile phones to search and browse. The digital notes are also appended into the mobile calendar to search by date. It uses a Java phone application to access the notes, which are sent to the server from the mobile device as well. Users can post their notes to the server by taking a picture with the camera from their mobile phone and emailing it to a photo-blog server. This project was designed to address the issue of paper versus digital notes. Post-that Notes system does not recognize or interpret the text on the notes.

Quickies [7] are the intelligent notes that are used for portability, sending reminders, connecting the physical world with the world of digital information and organize smart information. Quickies are introduced by Pranav Mistry. By using Quickies, hand-written sticky notes are linked with digital systems like digital calendar, email, mobile phone, etc. The basic idea behind Quickies is the working of a digital pen with an embedded camera. Artificial Intelligence (AI) [8], RFID tag and reader [9], Natural Language Processing (NLP) [10] and ink recognition technologies [11] are the essential elements for the development of stick notes. Smart sticky notes can be examined, traced, sending of messages, reminders and behaves as an input and output (I/O) interface to the digital world [12].

The Ebeam [13] is a type of interactive whiteboard which was introduced by Luidia, Inc. Ebeam smart-pen makes its self-interactive due to the collaboration of digital projectors and computers. By using this technology, any wall or whiteboard can be converted into an interactive whiteboard. Alteration of screen dimension size is also possible so that it can be visible to the user and viewer. By using Ebeam smart-pen, one can reduce the cost level and increase the interactive mode of the session to be conducted.

With the combination of hardware and software, a wide range of applications can be in use by using ebeam smart-pen. This includes the use of text and multimedia presentations on different surfaces. Interactive Marker (Stylus) is used to put notes, perform the task like a mouse in windows for accessing control menus and for drawing/manipulation diagrams on the surface which can, later on, save and email to participants present on different locations. Ultrasonic receivers and infrared technology are used behind the working of ebeam smart-pen.

The novelty of Interactive Smart Writing Technology (ISWT) includes surface independence, portable, real-time and low cost. Having these features, ISWT is the most economical system for personal usage

Table 1 shows the comparison of research works related to smart writing and handwriting recognition.

TABLE I. RESEARCH WORKS RELATED TO SMART WRITING RECOGNITION

Ref #	Name	Created By	Technology Used	Features	Surface Independent	Low Cost	Portable	Real-Time
[3]	XAX	XEROX PARC	Paper user interface	The XAX-Form is a piece of paper with machine-readable marks on it. The marks are also human-readable. XAX-Server interprets the documents arriving from a scanner or fax	No	No	No	No
[4]	Digital Desk	Pierre Wellner	Computer vision,	Constructed on a physical desk, downwards projection can be seen from computer display on to a desk where a camera for video recording purpose is placed and uses image analysis technique to note down the movement of the user	No	No	No	No
[5]	Designer's Outpost	University of California	The computer vision system, electronic pens, touch-sensitive whiteboard, and Java	The capability of combining paper and big physical workspace with the help of electronic media for the design of websites. Composed of touch-sensitive whiteboard, electronic pens, computer vision system with one rear video camera for the motion capturing and one front-mounted high-resolution camera for the ink capturing	No	No	No	Yes
[6]	Post-It Notes	Stanford University	Java phone application	Digitizing of paper notes that users can access through their mobile phones to search and browse,	Yes	No	Yes	No

				designed to address the issue of paper versus digital notes				
[7]	Quickies	Pranav Mistry	Artificial Intelligence (AI), RFID and Natural Language Processing (NLP)	Have an ability to be examined, traced, sending of messages and reminders	No	No	Yes	No
[13]	Ebeam	Luidia, Inc	Ultrasonic receiver and infrared	Alteration of screen dimension size, pen perform like a mouse in windows for accessing control menus and for drawing/manipulation diagrams on the surface which can, later on, save and email to participant present on different locations	No	Yes	Yes	Yes
-	ISWT	Hamdard University	Sensor FC-51, MPU-6050, Arduino, HC-05 Bluetooth	Assistance to paperless documentation, that works on the mechanism of taking motion reading through the sensor that can work on any flat writing surface and whatever is written from it, will get digitalized on the application in real-time, making it easier to take notes	Yes	Yes	Yes	Yes

III. DESIGN OF THE SYSTEM

The design opts for the implementation of the ISWT system can be seen in Figure 1 for the transmitting side. In which it can be seen that the flat surface is detected by the infrared (IR) sensor the FC-51 [14] placed inside the smart-pen (Controller Marker Sleeve). This smart-pen is also composed of (MPU-6050) [15], Arduino Nano [16] which is connected with the battery (5 Volts DC) through the support of mini USB to have power and HC-05 Bluetooth Module [17].

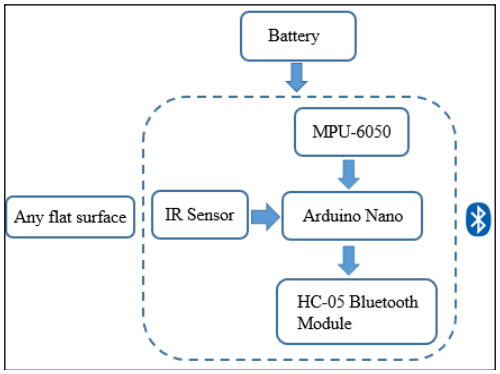

Figure 1. Block Diagram of ISWT Transmitting Side

The receiving side that can be seen in Figure 2 is composed of the HC-05 Bluetooth Module, Arduino UNO [18] and a workstation (containing desktop application) connected with the Arduino UNO through the serial port.

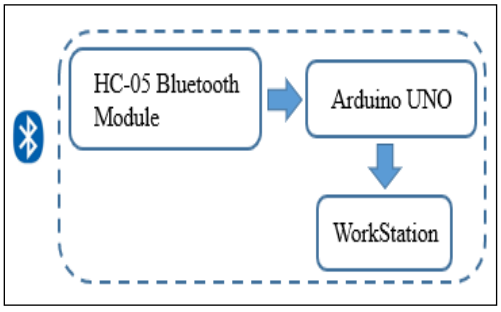

Figure 2. Block Diagram of ISWT Receiving Side

The Bluetooth module is used for the communication between the desktop application (which synchronized all the written content and save all the work) and the pen. Detail analysis regarding components used in ISWT system are as follows;

A. Controller Marker Sleeve

Controller Marker Sleeve is like a smart-pen that will be used to write on any flat surface. This sleeve contains a marker or any befitting pen along with the infrared (IR) sensor the FC-51, MPU-6050, Arduino Nano which is connected with the battery to have power and HC-05 Bluetooth Module (see Figure 3).

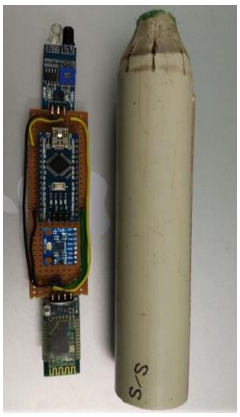

Figure 3. Controller Marker Sleeve

B. *Sensor FC-51*

The key idea behind the FC-51 (Figure 4) sensor works on the detection of an obstacle. Infrared radiation is transmitted from one sensor (transmitter) and when they bounced back, they are collected from another sensor (receiver). The power requirement of such a sensor is between 3-5V DC. FC-51 provides a digital output that can easily be connected with the digital pin of Arduino Nano.

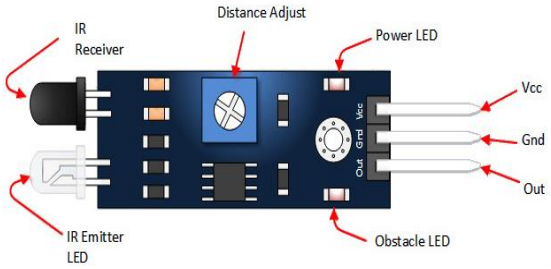

Figure 4. IR Infrared Sensor Module FC-5 [19]

C. *Sensor MPU-6050*

The MPU-6050 (Figure 5) sensor is embedded with three-dimensional Micro-Electro-Mechanical Systems (MEMS) gyroscope and accelerometer and used in motion detection. MPU-6050 sensor used I2C (Inter-Integrated Circuit) communication protocol [20] to interface with the Arduino. Moreover, MPU-6050 also includes a temperature sensor that has a digital output. Sleep mode of accelerometer and gyro sensor needs to be disabled to obtain the raw values.

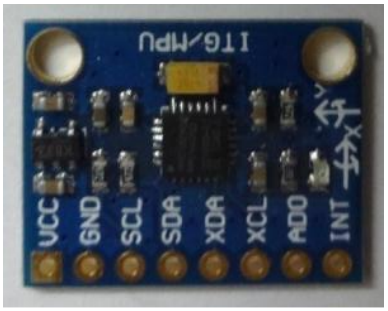

Figure 5. Sensor MPU-6050

D. *Arduino Nano*

Arduino Nano is based on ATmega328p and having identical working as of Arduino UNO but the difference is in size. It operates at the voltage level of 5V. Arduino Nano contains 32 pins in and contains 16 MHz frequency oscillator. The only problem with the Arduino Nano is the absence of DC power jack (see Figure 6). Arduino Nano comes with the mini USB support.

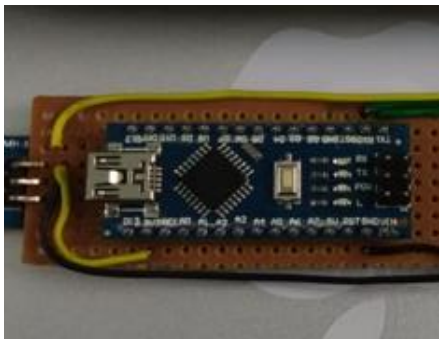

Figure 6. Arduino Nano

E. *HC-05 Bluetooth Module*

Typically, the HC-05 Bluetooth module has a sensitivity of 80dBm with the RF transmit power of +4dBm. It contains PIO (Programmable Input/Output) control with the voltage rating of 3.3 to 5Volts. This module comes with the integrated antenna along with the UART interface with a programmable baud rate. HC-05 Bluetooth module (see Figure 7) has a feature to auto-connect to the device and auto-reconnect if the device is out of range in 30 min [21].

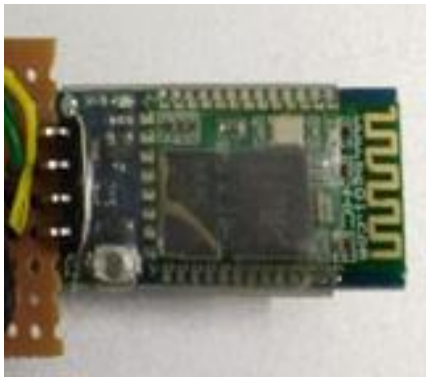

Figure 7. HC-05 Bluetooth Module

F. *Arduino UNO*

It is an open-source microcontroller that is widely used for many types of hardware designing and implementation. It is based on the microchip that is the microcontroller named ATmega328 and can be seen in Figure 8. The Arduino UNO board has input and output pins for both analog and digital that are interfaced with multiple shields and circuits. This board

consists of 14 digitals as well as 6 analog pins. This board can be programmed using the Arduino Integrated Development Environment known as Arduino IDE. It uses a B-Type USB cable [22] for a power supply and can also be powered by a 9-volt battery externally. The Arduino UNO can also be connected to the computer, there are many open source libraries available on internet form which different functions can be performed using Arduino UNO.

Figure 8. Arduino UNO Board [23]

IV. METHODOLOGY

Handwritten input from the movements of the pen tip will be sensed in real-time and gets synchronized with the desktop application. ISWT system has been divided into two parts i.e. transmitting part and the receiving part. Transmitting part is composed of four major components that are namely FC-05, MPU-6050, Arduino Nano is connected with the battery through mini USB to have power and HC-05 Bluetooth Module. The user needs to write the stuff on any flat surface, when a flat surface (obstacle) is within the range of 2-30 cm with the smart-pen (controller marker sleeve), the infrared (IR) sensor the FC-51 will give the digital input to Arduino Nano as the indication of surface detection. With the active logic, Arduino Nano will transmit the signal of marker/pen connectivity due to which MPU6050 will start performing its tasks. MPU-6050 is a motion sensor and senses the motion of the user's handwriting. MPU-6050 will send its data to Arduino Nano. Interfacing of MPU-6050 with Arduino Nano took place in the following manner.

Open Arduino IDE, then click Sketch -> Include Library -> Add ZIP Library, and select MPU6050.zip to include. After including successfully, you can see the example in File -> Examples ->MPU6050 ->Examples -> MPU6050_DMP6 (DMP= Digital Motion Processing) as shown in Figure 9.

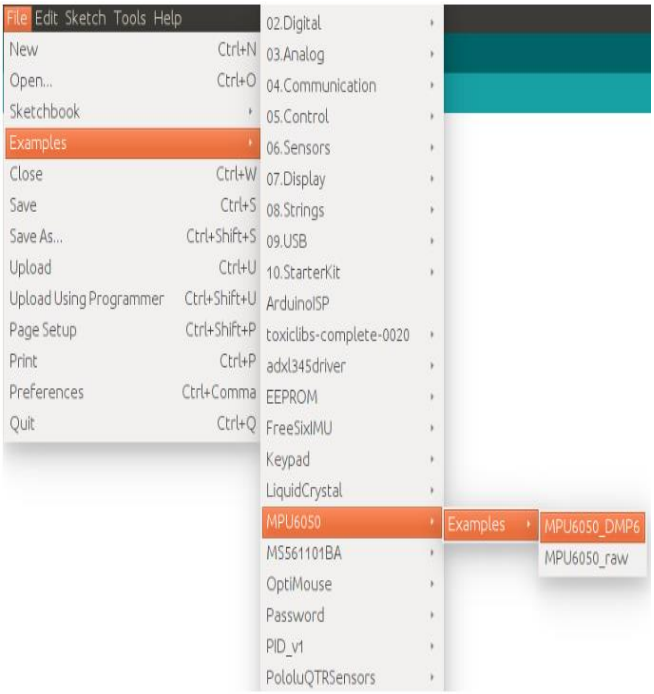

Figure 9. Sensor MPU-6050 interface with Arduino

After the interfacing in-between MPU-6050 and Arduino Nano, interfacing Bluetooth HC-05 with Arduino was performed (see Figure 10). In this HC-05 module PINCODE "123" was set as default for Auto pairing. Data collected from the MPU-6050 will now be sent to the receiving side by using the HC-05 Bluetooth module.

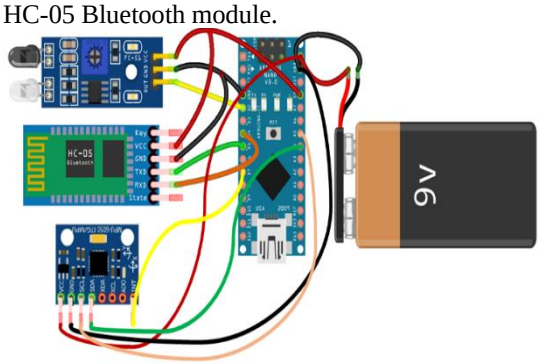

Figure 10. Transmitting side pin configuration of the ISWT system

The receiving side is composed of two major components that are namely the HC-05 Bluetooth module and Arduino UNO (see Figure 11). HC-05 Bluetooth module here at the receiver side establishes the connection between the sender and receiver.

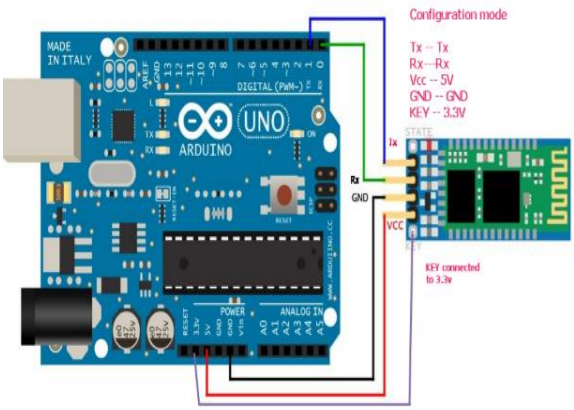

Figure 11. Connections of HC-05 Bluetooth Module with Arduino UNO [24]

The program code has been uploaded to the Arduino UNO board by using a USB cable from the workstation as can be seen in Figure 12. After the successful upload of the code, unplug the USB from the Arduino and provide the external power adapter (12V DC) to power the UNO board.

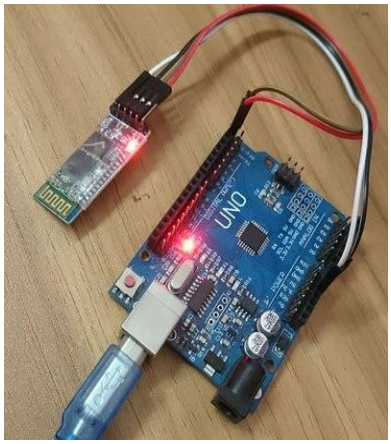

Figure 12. HC-05 Bluetooth Module with Arduino UNO

A desktop application (named as ISWT) has been created by using .net and c# which synchronize the handwritten content from the movement of marker sleeve and present it on the computer's user interface application through which a user will be able to save the contents (in image format). The default location of the master sleeve's tip at the time of initialization is at the center of the application's workspace.

V. RESULTS

Board marker will be first inserted in the marker sleeve and power of 9V DC has been applied to it. The application (ISWT) is then launched which will sense the connectivity of the marker/pen which can be seen in Figure 13 and Figure 14.

Figure 13. ISWT Loading Screen

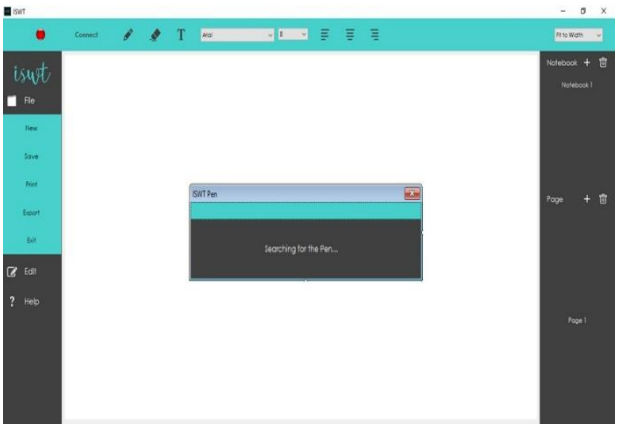

Figure 14. ISWT Searching Pen Screen

A message is prompt in a window with the comment "The Sensor cannot be found" if there is any connectivity issue with the pen (see Figure 15). This prompt window also contains certain possible issues that can be the cause of connection failure.

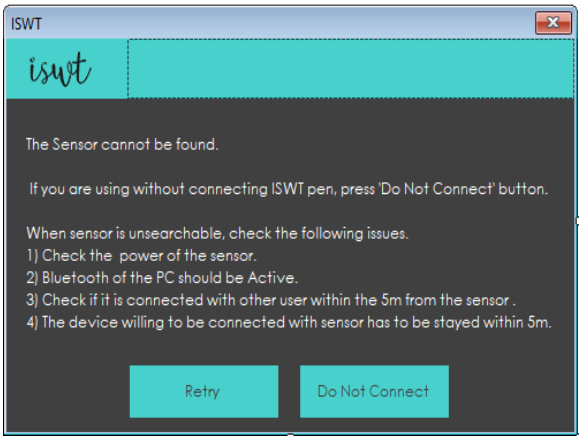

Figure 15. ISWT Sensor Not Found Screen

If the pen is found attached it will proceed further and a file option screen will appear which contains different options on the top menu bar like text, font size, add, connect and the light for the connection status with the pen which can be seen in Figure 16.

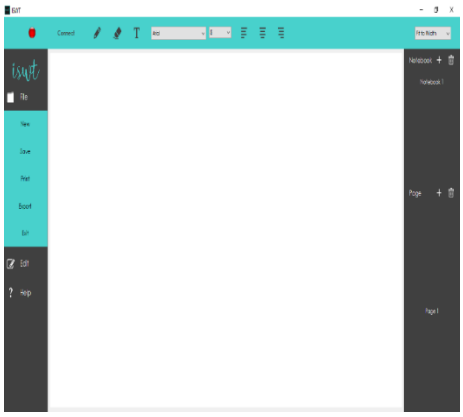

Figure 16. ISWT File Option Screen

One can create a new book by giving any name to it and pressing ok to confirm the name of the new book. There is also an option to cancel the creation of a new book by pressing cancel as can be seen in Figure 17.

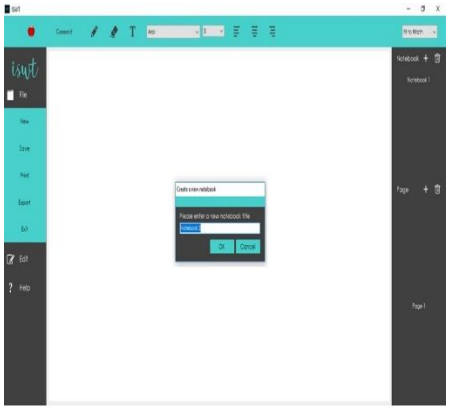

Figure 17. ISWT Create New Book Screen

Motion sensing will be done through MPU-6050 at the transmitting side and MPU-6050 sends data to the Arduino Nano board. Arduino Nano board sends its data to HC-05. The HC-05 is also connected to the system at the receiver side and it transfers the data to the application. Figure 18 shows the real working of ISWT in which one can see the physical movement of the pen on the screen with the option of save, view and delete the note.

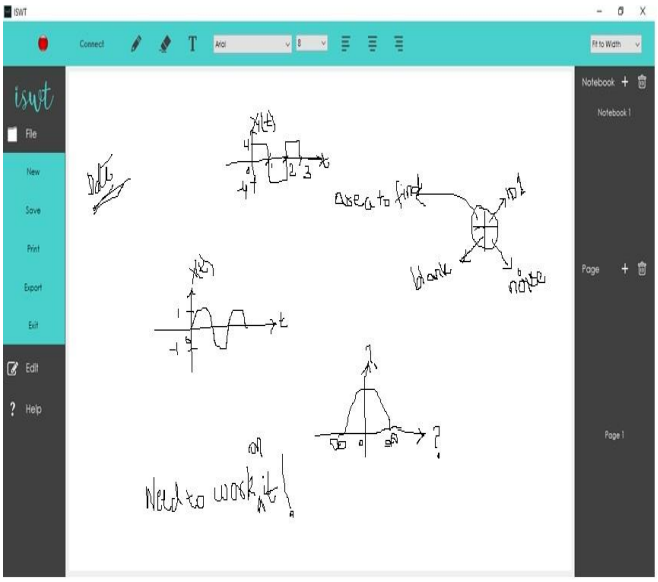

Figure 18. ISWT Running Application

It has been noted that the continuity of writing was an issue. If the pen was moved away from the flat surface with the distance out of the range for Infrared sensor and after some gap, the IR sensor detected the flat surface again, the writing will start from the center of the same workspace which creates an overlapping of handwriting.

VI. Future Work

The vision of Interactive Smart Writing Technology is to help reduce physical notes taking by digitizing the procedure of taking notes. Some of the possible future enhancements for this system can be on increasing the power efficiency of the embedded circuit (on transmitting and receiving side). Handwriting recognition for the written data to be converted into digital form and working on smooth edges for the better digital outcome. Moreover, an approach is required to resolve the overlapping issue of handwriting and enable autosave function in the software. For further editing, there is no option for it since the file saved as an image file. Therefore, some coding needs to be performed at the application's level to provide an editing option.

VII. Conclusion

By using this proposed system (ISWT), one can bring down the count of paper usage, saves efforts and brainstorming time which is used to convert the handwritten work to a printable form. The setup to the ISWT device is easy with a simple Bluetooth connection. It provides a more economical, factual and real-time substitute to Optical Character Recognition. The novelty of ISWT includes surface independence, low cost, portable, repairable, real-time and very economical for personal usage.

In the proposed system, the marker or any befitting pen can be placed in the shell (marker sleeve) which consist of movement recognizable sensors, microcontroller, and Bluetooth transmitting component. Anything written on the flat surface by using this marker sleeve will be detected by a

motion sensor and the data generated by movement recognizable sensors will be transmitted to the receiving end. Bluetooth transmitting component of the same standard places at the receiver side who is responsible to catch the data sent from the transmitting side and push it toward the microcontroller. The microcontroller will process the data toward the workstation where an application has been installed. A software application program will synchronize the handwritten content from the movement of marker sleeve and finally into the computer's user interface application through which a user will be able to save the contents.

There is a big room of improvement present in this system to resolve issues like overlapping of handwriting, auto-saving, and editing option.

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