EE04-Digital Pen-Ideation Summary

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Introduction

Problem Statement:

The Digital Pen project aims at designing an electronic pen that stores text that is written manually on a surface automatically in a storage device. The text that is stored can be read and edited any time.
The basic functionality of the pen can be represented as follows,
Writing on surface → motion sensors of some form → data processing → storage device

Location of Sensors:

Sensors used for tracking the motion and determining whether the pen is stationary or not can be located inside the pen or outside the pen.

Sensors Inside the Pen

CMOS Optical Mouse sensor + IMU sensor:

Working:

The CMOS (complementary metal oxide semiconductor) sensor is used in optical mice to locate the (x,y) coordinates. The basic working is explained below:
➔ Light from a red LED bounces off the surface and falls on the CMOS sensor.
➔ Each image from the CMOS sensor is sent to a digital signal processor (DSP) for analysis.
➔ The DSP detects patterns in the image and compares how the current pattern has moved with respect to the previous one.
➔ Based on the change in patterns over a sequence of images, the DSP determines how far the mouse has moved and gives the coordinates in the form of a two wire serial port.
This sensor does not sense any data when it is not in contact with any surface. The sensor requires a surface for LED light to bounce back so that image capture and processing is possible.
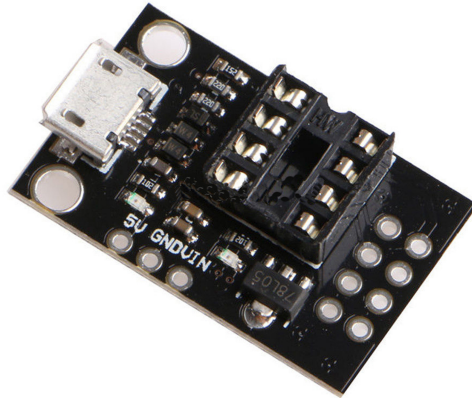

The movements made by the writer that are not intended to be text are tracked using the IMU (inertial measurement unit) sensor. The CMOS sensor will not sense data because the pen is

not in contact with the surface. These include actions like leaving spaces, moving to the next line etc.

The IMU helps to measure acceleration, velocity, orientation and displacement of the pen. Rapid motions of the pen can be sensed using the IMU.

Both, the IMU Sensor and the Optical Mouse Sensor can be connected to a microcontroller housed inside the Digital Pen. The data from both the sensors is processed by the microcontroller and is stored in a storage device like a SD card.

Since the design involves fitting the components inside the pen, a small microcontroller with I2C communication like ATTiny85 can be used.

Components ,disadvantages and improvements:

Optical Mouse sensor (CMOS sensor)	ADNS 2610 is available. The optical mouse sensor contains the CMOS sensor, Image acquisition system (IAS), Digital Signal Processor (DSP) and a two wire serial port. It is a small sized sensor (10 mm x 12.5 mm) and can be fitted inside the pen. In addition to this, we require a red LED and a good image capturing system.
IMU sensor	The MPU-6050 sensor is available easily. The size of this module is 2.12 x 1.64 x 0.013 cm. So it can be comfortably fitted inside a pen
Microcontroller	Any microcontroller like arduino nano or ATTiny85 can be used. However we prefer a small one with I2C communication to fit the design of the pen
All the components have I2C interfaces and hence inter-communication is easy.	

Storing text on a device like a SD card can make correcting the text difficult. Actions such as striking out will be recorded instead of deleting the word itself. So, the data can be stored on a computer using a bluetooth module like HC-05 and can be edited later.

All components are easily available and can be programmed with I2C communication.

Pressure and IMU sensors:

Working:

1. a IMU sensor can be used to keep track of the text written.
2. Also, a power ON button must be present and this must be switched on before writing. This ensures that no random data (caused due to movement of the pen in an inactive state) is saved and also saves power.
3. Further, a small pressure sensor can be attached near the nib of the pen to collect only the data generated due to genuine writing movements.

Pressure sensor used is BMPI80. It has dimensions of 4mm x 4mm x 1.5 mm and can be easily fit in the pen design.

Disadvantages:

If the user accidentally makes a mistake, he can't correct it by erasing or striking it off as the data is stored sequentially in the SD card. So any striking action will also be stored sequentially and hence, can't be used to correct the data. So, the data can be stored in a computer using a bluetooth module, where editing can be done.

<u>Sensors Outside the Pen</u>

The fundamental principle behind all techniques involving sensors outside the pen are similar: A transceiver sends a signal to locate the position of the nib of the pen on the paper. Upon obtaining the coordinates of the nib, some algorithm is implemented to figure out what is being written on the paper.
The different technologies that the transceiver operates with are IR sensing, Ultrasound and Time-of-Flight camera (ToF which is basically a more refined way of putting IR sensing).

IR and Ultrasound sensing are prone to false outputs and errors because they detect other objects in the vicinity of the nib. This is due to their wider vision and lower accuracy.

The ToF sensor is a better option. It has a lower vision range and is not affected by external factors such as temperature, humidity etc. A sensor used is the VL5310X which includes an IR emitter, ambient light sensor and a range sensor. This sensor communicates with arduino by using I2C communication method.

Another way of arranging sensors around the paper for the outside the pen ideation was suggested by Sharanesh. It is a very nice way of adjusting these sensors.
➢ High precision IR cameras are placed at 4 corners or any 2 corners of the paper to track the position of the nib.
➢ It employs the reflected IR rays from the nib to exactly determine the position of the pen.

Pen using EMR Technology

One of the pens that stood out among others in the list of smart pens in the market was the Wacom Bamboo Folio Smartpad Digital Notebook.
This pen uses a special tab to write upon. The pen need not be charged, only the tab needs to be powered.

Everything you write is captured by the folio, which you can sync with the desktop or mobile app, and can be shared with cloud services like OneDrive or Google docs.

It works based on electromagnetic Resonance technology. The pen contains a copper solenoid above its nib. When the tab is powered EM waves are generated in the coil. The tab records data like pressure, tilt angle and button presses on the pen.

Working - https://essentialpicks.com/emr-stylus-how-wacom-pens-work/

Other pen designs in the market:

1. NEWYES smartpen - it has an inbuilt camera to capture the text being written. These captured images are processed by a microcontroller and sent to a NEWYES app on the mobile. The app allows users to search for keywords or store voice memos in the document itself.
2. Livescribe Echo smartpen - this pen contains an audio recorder and a IR camera to record audio as well as text. The text is written on a special dotted paper. Based on the dots recorded, text is generated. This pen cannot be used on any ordinary paper.
3. There are few other pens similar to (2) that cannot function without the special paper for processing the text.