VIRTUAL MOUSE: AN ACCELEROMETER BASED MOTION TRACKING SYSTEM

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Abstract

This paper includes an accelerometer based 3-D motion tracking system which captures the human hand movement in 3-D and transform it into a 2-D plane where it acts as a wireless wearable PC mouse. This is developed as a general purpose device that would find many applications in various capacities such as Computer Games, Graphic designs, Toys and 3D object manipulations by simply redefining the communication protocols.

1. Introduction

Introducing new alternative input devices operating almost real time using various tracking systems have become a popular area of research. Methods using video tracking [1], accelerometers are being tested and various algorithms are also experimented to map the movements interfacing them to computers. It is proposed that this will be an initial opening of doors to various other applications such as, uses in Presentations, Computer Games, Toys, 3D Graphic Manipulations and certain Bio Medical Applications.

This will mainly be an accelerometer and magnetometer based tracking device which captures the 3-Dimentional hand movements from 3-D coordinates and process onboard at Digital domain with resolution of 10-bit A/D conversion. Digital data is processed in a micro controller & transmitted to the targeted PC using a wireless link. On the PC side, the device driver will be written for Bluetooth-HID access and receives the mouse data using a Bluetooth dongle to simulate the cursor.

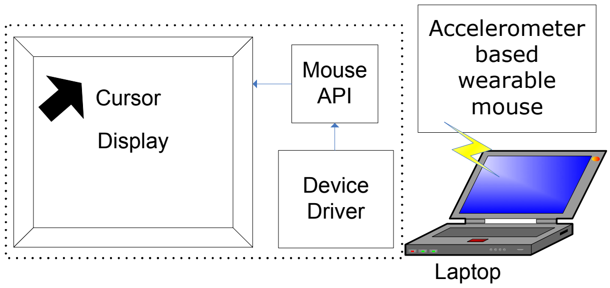

Figure 1: Overview of the system

The algorithms for filtering correct mouse movements and events from sensor inputs play a major role in this project. It is planned to minimize the size of the product as much as possible to fit well into any human hand.

2. Related work

To the knowledge of the authors, the area is still emerging since only a handful of researchers are experimenting in this area. Therefore it is challenging to come up with something that can go pass the current drawbacks of above mentioned researches, with difficulties specially in mapping pointer to movements and responsiveness. Due to this reason it is first required to research on the most suitable hand movements for mapping.

Simulating the mouse cursor with human hand movement can be done in several ways. Image processing technique is used by most researchers which uses an overhead camera to track different movements [2]. Here the mathematical processing for realization of mouse movements is also done inside the PC. The major disadvantage is whenever the device is used it is needed to mount the camera; also there should be adequate light intensity for recognition of the finger from other surrounding objects. Since the finger is not a point object, additional image processing techniques for reshaping the finger should be used. [3]

Accelerometer tilt calculations are used for simulation by most of the researchers that has used accelerometer based designs. [4] In this technique, users are not permitted to move the device freely. In other words user has some constrained area and several movements are predefined like when using any other ordinary mouse. If moved away from the constrained area, it is not possible for the device to move the cursor. Also clicking and double clicking are done using two press buttons.

Press buttons will not be used for Virtual Mouse since all control signals and movement tracking will be done based on acceleration data. It can be worn and moved by the user. Currently the first prototype is finished with accelerometer and the digitized data is fed into MATLAB® 6.5. By applying the most suitable coordinate mapping algorithm, it was implemented in Microsoft® C# where it drives the PC mouse cursor through standard mouse API. The mapping algorithm will convert them into a stationary coordinate system where it is hoped to define the movements and calculations. Currently the digital heading calculator is being designed using a magnetic field sensor. So far the accelerometer and magnetic field sensor data separately give a very good response. The final design will be tested after integration of the above two sections, and it will be followed by the implementation of wireless section and windows driver section.

3. Modularization

Overall system is a collection of different modules. Each module's specialization function depends on inputs for the module and inputs required for the proceeding module (that is the outputs required)

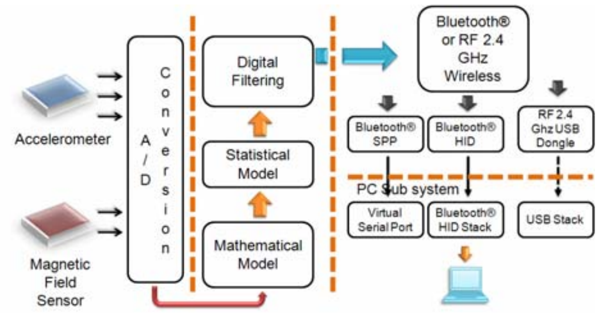

Figure 2: Modularization of the system

Pre conditioning accelerometer data and digital compass subsystem is responsible for pre-conditioned accelerometer raw analog voltage to interface with a micro-controller and design an azimuth calculator using 2-D magnetic field strength sensor. 3-Axis accelerations together with the angle w.r.t. a fixed direction will be driving the overall mathematical model in the next section. **Digital filtering and mathematical model subsystem** applies the Mathematical and statistical model to pre-conditioned digital data and derive mouse API inputs. **Wireless subsystem** creates the communication link between the wearable PC mouse and desktop PC or Laptop (wireless). **API and windows driver subsystem** derives the device driver for wearable PC mouse and guide the pre-conditioned data to the API.

4. Mathematical model

Digitized data from the A/D converter will drive the mathematical model and produces acceleration components w.r.t reference coordinate frame. The movements in the 3D space by the user should be mapped onto standard mouse movements. The manipulations are done with the triplet of data carrying the accelerations in the 3 mutually perpendicular directions. Orientations (not positions) are considered and they can be easily dealt with Euler's Angle Transformation.

The model is first tested in MATLAB® and other modeling tools like SIMULINK® Virtual reality tools. Data from the serial port (RS232) is directly read by MATLAB® and will be processed using a custom made Blockset which provides these necessary calculations within the block for simulation. Necessary mathematical essence will be applied to obtain the results wanted within the computer and simulate the mouse movement by directly communicating the Operating system (OS) through .NET platform.

Control inputs such as "Click", "Right Click" and "Double Click" will carry high acceleration values in the z-direction since those are the only intended movements in the direction. Once a predetermined threshold of acceleration is exceeded in the z-direction, z-axis acceleration data will start getting buffered for a specified time. By analyzing this buffered data the decision as to whether it is "Click Signal", "Right Click" or "Noise" is taken. The core mathematical model will need to be optimized using statistical data (large number of inputs from different users) due to reasons such as: Mouse holding and use by different users being different, human imperfections in the movements, filtering out unnecessary movements (such as movements of self expression by presenters)

5. Future work

In addition to the standard x and y coordinates, z coordinates will also be introduced to the system. The 3-D driver will expose some functions to higher level, so that the data received can be used to develop various applications. This involves in modifying the standard mouse API into a 3-D supported API which can be used in other 3-D applications. Improve the mathematical model to an artificial neural network base model so that the system can learn itself according to different user's movements upon initial training.

6. Conclusion

Concluding the project it is evident that the "minimal component" circuit has clearly met the strict requirements imposed. It has remarkably reduces the scale and limits the cost of the circuit around US$30. Minimal component may lead the circuit to fit into a very small package where the user can wear it and limiting the cost may affect the customers to attract to the new product.

7. References

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