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E322 - Homework 5

Enhanced Human Machine Interaction project

Section 1:

<u>Individual contributions:</u>
Alexander
- Researched references [1] and [2]

Jiaren
- Contributed to Sections 3 and 4 in formulating requirements and objectives
- Organized the structure and overall flow and format of the report

Shinji
- Researched reference [4]. Contributed to requirements and objectives.

Gwenn
- Researched reference [3]

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Percentage of effort toward this assignment	25 %	25 %	25 %	25%

Section 2:

If we decide to use accelerometers embedded in a glove to measure hand movement, this example shows how to interpret the data and translate it into 3D movement. Below shows the readings that result from movement in the positive X direction. The key data points here are how the X axis readings begin positive, then cross over to the negative direction. The point where it crosses zero “marks the point of maximum speed.” [1] The Z axis readings remain close to 1 because the accelerometer is being held horizontally and so the force of gravity remains constant in the Z direction. Since there is no movement and no effect of gravity in the Y direction, the readings are simply zero. With this understanding of accelerometer readings we can see movement happening in any direction. Additionally, a static measurement can be used to find tilt or rotation, another part of gesture recognition. [1]

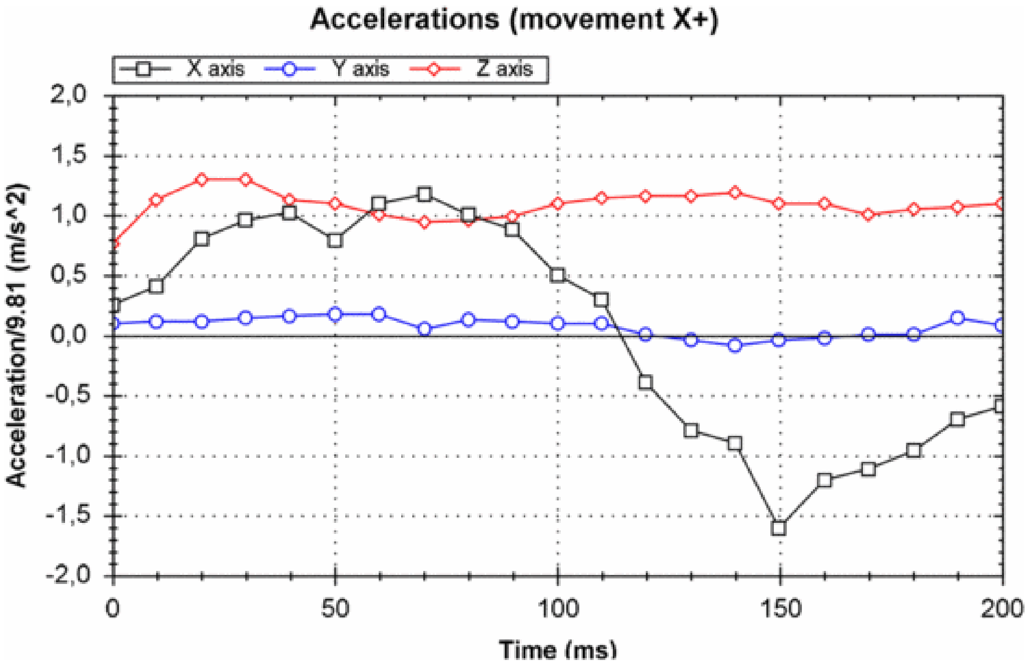


Fig. 1. Example readings from a 3-axis accelerometer [1]

In addition to accelerometers, gyroscopes can also be implemented into the glove design since they are useful for measuring the rate of rotation of the object on which they are mounted. They can detect angular velocities in three-axes, which can provide calculations of different glove angles in each direction. The example readings below depict the angle and the angular velocity of a gyroscope sensor that was turned 90° counter-clockwise and back, then turned 90° clockwise then back. The angular velocity was calculated from converting the ADC (analog to digital converter) resolution input of the sensor into radians per second. An integration was then determined to find angle vs. time of the gyroscope (Fig. 3).

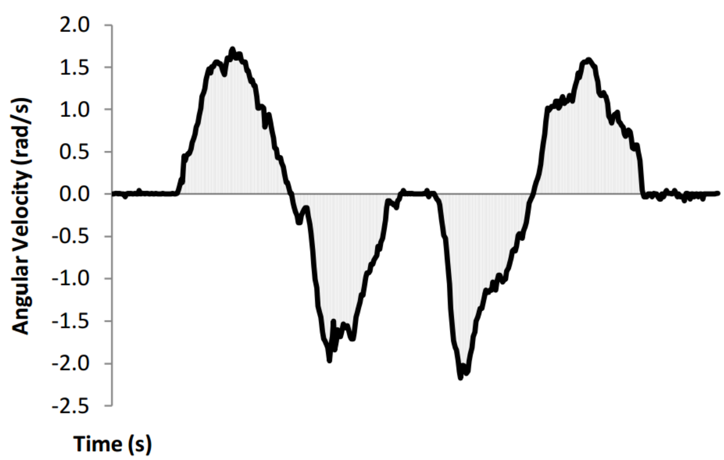


Fig 2. Example Gyroscope Readings of Angular Velocity vs. Time [3]

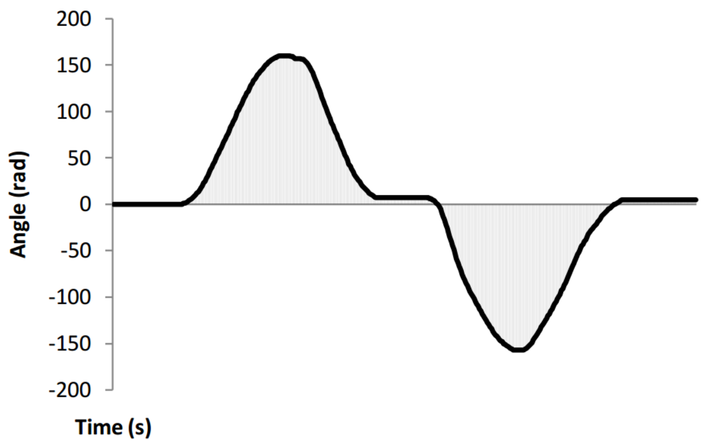


Fig 3. Example Gyroscope Readings of Angle vs. Time [3]

In the project from article [3], a wearable glove was equipped with a multi-axis accelerometer and gyroscope and data was sent from the sensors to a microcontroller. An algorithm that was programmed in the microcontroller translated the angular acceleration and velocity of the glove into relative orientation and position. A wired communication interface was then established with a computer and the desired information on orientation and position was sent to a computer for a visual output [3]. A similar system may be taken into account and implemented when carrying out our project.

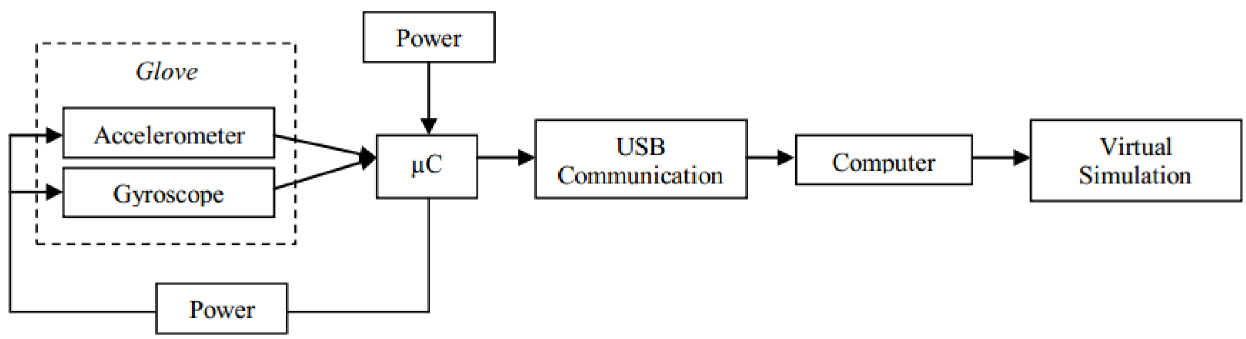


Fig 4. Example System Block Diagram

Additionally, when implementing accelerometers and gyroscopes into the project, digital low pass filters may be used on the outputs of the sensors in order to provide more accurate motions and readings. Predetermined thresholds on angular velocities and accelerations may also be incorporated in order to mitigate the effects of hand jitter in order to ensure smoother usage of the glove.

Article [4] identifies an important factor about wearable glove interfaces, personalization. Most studies focus on sign language or other gesture related systems. However, these approaches focus on an individual's results. Once the product reaches further development stages it will run into problems when facing different individuals. Readings that indicate one movement and one gesture could be interpreted completely differently on a different hand. The article's authors plan to remedy this problem by utilizing a mixture-of-experts model. [4]

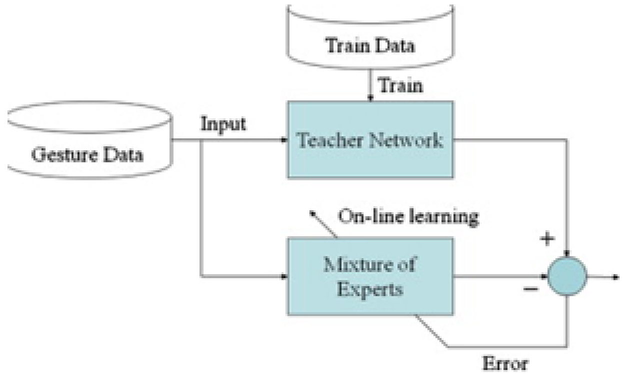


Fig 5. Example Mixture-of-Experts Learning Model [4]

This model will collect the results of a multitude of individuals and combine their results through a gating network. This will allow the wearable glove software to "learn" through continuous error modification. A sample of test data obtained in the study indicated 95.38% accuracy with the first user. The following user dropped the accuracy to 89.97%. [4] However, as the error function processed the new user the accuracy gradually increased.

Section 3:

<u>Realistic Constraints for Glove-based interaction:</u>

-Limit of costs in materials and equipment to efficiently manufacture and mass produce
-High structural integrity
-Easily replaced sub-components for maximized use
-Durable and non-volatile structure to minimize environmental impact when discarded
-Product should aim at high quality and sustainable uses
-Manufacture process should be clean
-Packaging and storage process should be protective and minimal at same time
-Design should not be overly complicated for streamlined manufacture and assembly
-Repair and replace procedures should not be overly complicated
-Reliable circuitry to avoid health hazard due to potential electrical shock
-Circuitry should have cost and quality constraints
-Product contains no potentially harmful factors to human body
-Product should fit a wide range of users
-Design should allow calibration for individual users

Professional and Ethical Responsibilities:

Safety standards:

Safety standards describe a set of responsibilities that address basic health and safety concerns associated with this product:

-Electronic circuit should be reliable and safe with no potential harm to human and other machines

-Materials used should not be potentially dangerous to human body

-The device should be as protective and waterproof, shock-proof, and tamper-proof as possible

-Glove should not be too physically constricting

-Glove should potentially emergency shutoff system if deemed necessary

Agile standards: Agile standards describe a set of responsibilities that outline the agile strategy and grand scheme underlying how to give this product good competitive edge and high longevity

-Components of this device should be interchangeable

-Maximize the upgradability and customizability while maintain a sufficient quality standard.

-This product's program interface should be secure and versatile

-Sensing capability should be effective with a wide range of hand sizes

-Have a easy to calibrate process

Efficiency standards:

Efficiency standards describe a set of responsibilities that help maintaining ethical, professional, environmental, and functional standards involved in this product and its associated businesses

-Gloves should have high structural integrity and stability

-Minimize electricity and power usage

-Maximize accuracy and precision of glove's movements

-Glove should fit a variety of hand size and shape

-Glove should register consistent user preference over time.

Profitability standards:

Profitability standards describe a set of responsibilities that detail how to achieve maximum profit without going out of bound from previously mentioned standards.

-Minimize cost and manufacture complexity

-Have different version available for different target customer group

-Make repair service streamlined and readily available

-Keep this device versatile both in hardware and in software

Section 4:

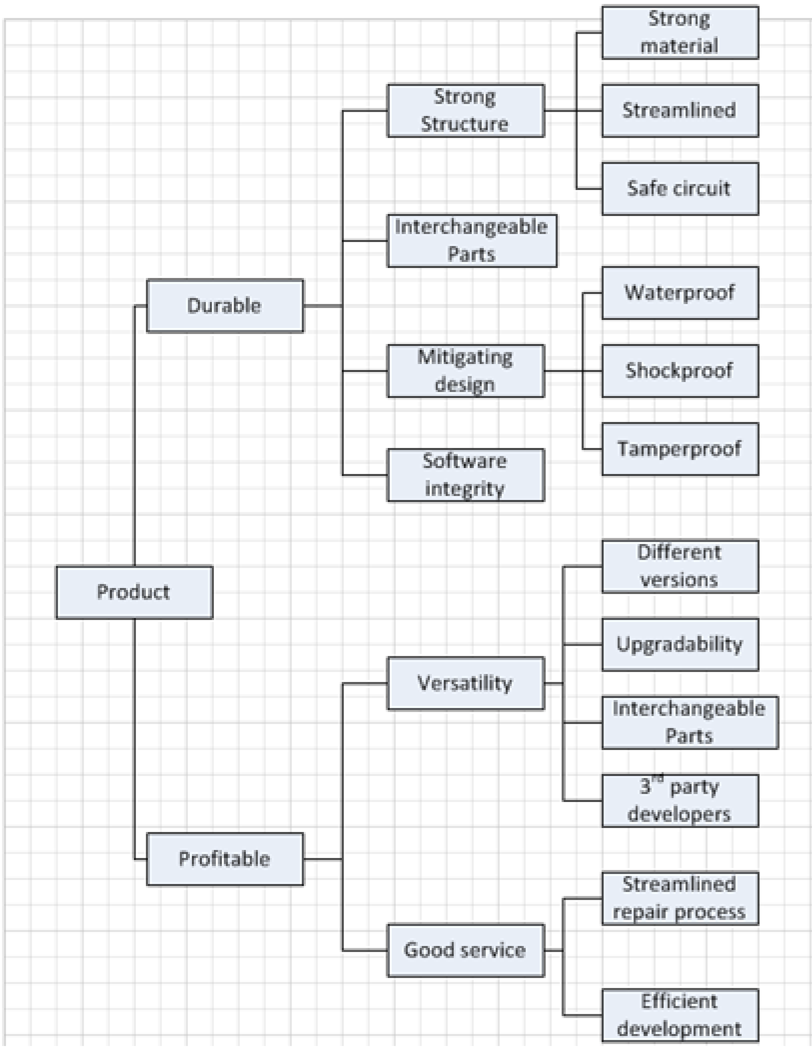
Objective attributes:

Durable -> Directly Important

Durability directly affect the quality of this product and how much will customer want it.

Profitable -> Directly Important

If this product isn’t profitable, it will not be invested and business will not sustain
Strong structure -> Durable
Having a strong and stable mechanical structure is important in making the glove durable
Strong material -> Strong structure
Using strong material is integral in making this device
Streamlined design and manufacture -> Strong structure
A design and creation process too complicated will affect the overall product quality
Safe electronic circuit -> Strong structure
An unsafe electronic structure will seriously compromise the product
Good interchangeable parts -> Durable
Having interchangeable parts can help with partial repairs and replacements while reducing unnecessary costs.
Damage mitigating design ->Durable
Product like this should be designed to face worst case scenarios
Water- or Splash-proof -> Damage mitigating design
Device should be resistant to water damage to certain degree
Shock-proof -> Damage mitigating design
Device should be able to handle certain level of undesired electrical surges
Tamper-proof -> Damage mitigating design
Device should be able to resist unwanted intrusion to a certain degree
Software interface integrity -> Durable
Uncompromising software interface will boost the durability and usage of this product
Versatility -> Profitable
Having a versatile product can satisfy largest customer base
Having different versions -> Versatility
Making different versions and levels of product available can fulfill a better array of different people
Upgradability -> Versatility
Making upgrades retroactively available and easily developed can help boost usage
Good interchangeable parts -> Versatility
Having good interchangeable parts go well in boosting integrity while maintaining versatility
Encourage 3rd party developers -> Versatility
Having 3rd party developers around can further boost popularity of the product
Good service -> Profitable
Good customer service will boost reputation and sales of the product
Streamlined and organized repair process -> Good service
Giving the versatility of this product, a more streamlined service will increase quality of service
Efficient development cycles -> Good service
Given how quickly this product can change. An efficient and agile development cycle is needed



References:
[1] http://ieeexplore.ieee.org/xpls/icp.jsp?arnumber=5326285
[2] http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6064356
[3] http://digitalcommons.mcmaster.ca/cgi/viewcontent.cgi?article=1024&context=ee4bi6
[4] http://www.sciencedirect.com/science/article/pii/S0957417411015302