Head Movement Recording System

TEAM #7
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Client: Dr. John D. Enderle
Statement of Need

The client has requested a device that can detect and display the real time head movements of a test subject. The client is interested in performing diagnostic tests on subjects who have experienced a severe impact to their head in order to determine whether or not the subject has suffered mild brain trauma. The client has requested that the motion recording system be mounted to the subject’s head during the testing, and that there be a monitor to display the plot of the position of the test subject’s head in real time. The device is required to be a portable, lightweight, and able to withstand various outdoor climates and conditions.

Introduction and Overview

The head movement system will be a component of a future device that will detect whether or not a subject has suffered mild brain trauma, and in which part of the brain the trauma occurred. The trauma test will run a series of audio and visual stimuli using virtual reality. The diagnosis from the test will be based on how well the subject can move his/her eyes towards the stimuli. The purpose of this head movement system will be to record, in real time, the position of a test subject’s head. Since the eyes move in accordance to head motion, the data acquired from the head movement system will ultimately be used to accurately determine the position of the subject’s eyes in real time.

The head movement system will consist of two separate components connected wirelessly. One of the components will be mounted to the subject’s head, and the other component will be fixed a distance away from the subject. The part mounted to the subject’s head will contain at least two infrared light sources. The fixed device will contain a camera with an infrared filter that will be able to identify the position (relative to its fixed position) of the light sources on the subject’s head. From there, data acquisition software will be used to acquire the position of the subject’s head in three dimensional space. The data will be displayed in a position plot on a computer monitor.

Realistic Constraints

Health and Safety: Since the design of this project requires the patient to place some sort of headgear onto them, while they are possibly suffering from head trauma, it will be important for the design to ensure that the patient’s health and safety is not compromised any further when using the device. To ensure this the design will be as lightweight as possible since the patient may be experiencing headaches from the injury. Furthermore, the test run will be mindful of the fact that fast, intense head movements may cause discomfort to the patient. Also, the tests will likely require the patient to be seated for the duration of the exam. This will allow the tests to be more accurate as well as be safer for the patient as they may be light headed or dizzy after the injury. Since the patients that will be utilizing this device will have suffered possible traumatic brain injury it is our greatest concern to ensure their health and safety.
**Manufacturability:** The manufacturing constraints to this project will come from the time constraints it will take to manufacture one product. The device will be small and require intricate wiring which will limit mass production and possibly cause a delay in manufacturing. Furthermore, the device will need to be adjustable since the patients will have different sized heads which will cause a limitation on how the device is manufactured. Also, a system to keep the tracker on the patient’s head will need to be tight without causing any further discomfort.

**Ethical:** In the production and design of this product very ethical procedures will be followed. No testing will be done on anyone or anything that is not pre-approved and all ideas and research will be done honestly.

**Environmental:** The device will need to be weatherproof to an extent which may cause environmental constraints in the design of the project. There will be no negative effects to the environment due to the project since the machine will likely be run on batteries and will not be mass produced; therefore, limiting environmental concerns during production.

**Sustainability:** Corrosion could become a problem with certain parts of the project if it is used outside in high humidity or in the rain. The corroded parts will have to be disposed of in accordance with town, state, and federal law. Furthermore, the test may need to be updated in the future as more research is done on the eye movement system.

**Social/Political:** Although this technology would be beneficial to the health of athletes, it may not be welcomed by them. Athletes rarely think about their own safety before they think about going back to their respective sport. If this device prolongs their absence from the sport, although it would be in their best interest, athletes would dread the use of it after suspected traumatic brain injury. This social constraint must be taken into consideration and it may be beneficial to offer education on the long term effects of such a traumatic brain injury before introducing the product.

**Other Information**

The client, Dr. Enderle, has spent the last thirty years focusing his research on fast eye movements and the associated neuron activity. His research has provided him with substantial findings to proceed to the design phase. His ultimate goal is to build a portable device that will run visual and auditory stimuli tests to detect whether or not a subject has suffered a concussion. This device would be extremely practical in any real world situation where physical contact can occur (i.e. a football game or other sporting event, the military, etc.). Close to two million Americans suffer a traumatic brain injury every year, however, many people are not treated properly for concussions. If a concussion is ignored then there is a severe risk of a future, more serious injury.
Questions

What is the budget?

How many reference points will we need to accurately record the head position?

Will the device need to be adjustable for people with different head sizes?

Will the device be able to withstand varying outdoor environments?

Will we be able to integrate the head movement device with the virtual reality device?

Will we have to restrict head movement for the benefit of the test results?

Will the lighting of the test environment affect the efficiency of the device?

Technical Specifications

Physical:
  Type of Material: Nylon, Polycarbonate, Infrared Light Source, Camera with Infrared Filter

Mechanical:
  Weight: <10 pound (lbs)

Electrical:
  Infrared Sensor Maximum Input Voltage: 3 Volts DC (VDC)
  Infrared Sensor Maximum Input Current: TBD
  Infrared Light Source Maximum Input Voltage: 1.6 Volts DC (VDC)
  Infrared Light Source Maximum Input Current: 200 mA
  Battery Life: 50 hours
  Infrared Sensor Sampling Rate: 100 Hz
  Infrared Sensor Range: 5 meters

Environmental:
  Storage Temperature: Room Temperature
  Operating Temperature: 40-95°F
  Operating Environment: Indoors, Low Humidity, Low Dust, Non-Infrared Emitting Lighting

Software:
  User Interfaces: Monitor
  Infrared Sensor Technology
  Hardware Interfaces: Monitor
<table>
<thead>
<tr>
<th><strong>Data Acquisition Equipment (NI)</strong></th>
<th><strong>Infrared Sensor Technology</strong></th>
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<tbody>
<tr>
<td>Communication Protocols:</td>
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<td><strong>Computer Requirements:</strong></td>
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**Safety:**

Unrestricted movement of the head could result in self inflicted injuries. This free range of movement can lead to injury such as slipped disks in the neck. To prevent this, patients may be subjected to restrictions in head movement. Since patients are suspected to have suffered at least mild traumatic brain injury, they will be confined to a seated position for the test. This is to prevent any falling and resulting injury due to dizziness and other symptoms common to head injuries.

**Maintenance:**

The device may need up keep in order to prevent disruption with the infrared sensor and infrared light source. This may include, but is not limited to, cleaning the infrared sensor and the infrared source between use, and wiping condensation off if used in high humidity or rain to prevent corrosion or internal parts.