# 2. Design Requirements/Constraints

The golf glove will use an unobtrusive design consisting of stretch and orientation sensors to accurately measure the movement of the hand and display this information to the golfer. The glove will consist of two systems: the garment with integrated peripherals, and a wrist-mounted controller. The controller will gather the information gained from the integrated sensors, and broadcast it to a desktop application that will receive and process this information. This data will then be displayed to the user and allow the user to gain valuable insight into his/her swing. In order to make this product functional, as well as acceptable to the consumer, there are technical and practical design constraints.

## 2.1. Technical Design Constraints

Table 2.1. Technical Design Constraints

|  |  |
| --- | --- |
| **Name** | **Description** |
| Hand Orientation and Position | The glove must accurately determine wrist flexion and extension, wrist deviation, wrist acceleration, hand orientation, and hand acceleration. |
| Wireless Communication | The wrist-mounted controller must communicate wirelessly with a minimum range of 20 feet. |
| Data Display | The system will communicate its measurements to a desktop in real-time where an application will display them through a simple interface in a web browser. |
| Comfortable | The user must not feel obstructed while gripping the club with the glove on. |
| Portability | The wrist-mounted microcontroller must be battery powered and not require recalibration on startup. |

### 2.1.1 Hand Orientation

The golf glove must measure forearm, wrist, and hand orientation to within a 5° margin of error and the hand position within a 5cm margin of error. The position measurement will be used to calculate velocity and acceleration of the hands. These margins of error will allow the glove to fulfill its purpose of tracking the wrist’s biomechanics to such a degree that meaningful feedback can be given to the user.

### 2.1.2 Wireless Communication

The golf glove must be able to reliably maintain a connection with the data display over a maximum distance of 20 feet. This enables the user to use the product without keeping the mobile device on their person. Users must be able to store mobile devices nearby, as in a golf cart or bag, while still connected so that recorded golf swings can be easily viewed after performing one or more hits. In the event of a lost wireless connection, the golf glove must be able to store several golf swings on-board until the connection is reestablished.

### 2.1.3 Data Display

The golf glove will transmit data to a computer where an application will display the measured data. A display is necessary to show the gathered data to the user in addition to providing feedback, an essential component of the system. The application will be web-based to allow similar interaction on a mobile device in the future.

### 2.1.4 Comfortable

The target audience for this product is a golfer that is trying to improve. Therefore, the golf glove will aim to be as unobtrusive to the golfer’s performance as possible. The hand will be covered with intricately placed sensors that will not require a readjustment in grip and will not induce friction to the user. Also, the wrist housing will not prevent proper flexion and extension throughout the swing.

### 2.1.5 Portability

The device must be small enough to fit comfortably on the user’s wrist without hindering or hampering their normal golf technique. A system that negatively affects the user’s swing defeats the device’s purpose given the device must accurately be able to track the user’s swing. The device must also utilize a battery system to avoid any lengthy wires that may hinder user performance. The device must not require any additional calibration steps from the user. By removing the need to calibrate before every use, the user is required to complete less work to get the device up and running, allowing for quick and easy use of the device. The entire system must be able to fit in a pocket of the user’s golf bag either , allowing the user to easily bring the device onto the golf course without any separate carrying case or bag.

## **2.2. Practical Design Constraints**

In addition to the previously mentioned technical constraints, there are also the following practical constraints listed in Table 2.2 to be considered in the design of the robot.

Table 2.2 Practical Design Constraints

|  |  |  |
| --- | --- | --- |
| **Type** | **Name** | **Description** |
| Economic | Cost | The golf glove must cost less than $200. |
| Environmental | Weather-Resistant | The glove must be IP54 water and dust resistant. |
| Health and Safety | Swing Form | The glove encourages proper swing form which helps prevent unnecessary stress and injury. |
| Manufacturability | Modular/Replaceable Parts | The glove unit will need to be modular to accommodate different glove sizes and handedness. |
| Sustainability | Battery Life, Safety, and Rechargeability | The glove must have a battery life of at least 5 hours for an 18-hole round of golf. |

### 2.2.1 Economic

The total cost of the sensor glove and controller must be under $200 in order to make the golf glove competitive to other products on the market. Though some other golf tracking products are in this price range, the additional functionality available with the golf glove through flexion and extension sensors justifies the price. The golf glove must be replaceable separately from the controller in order to further improve affordability for the user.

### 2.2.2 Environmental

Due to sustained use in potentially wet and/or dusty environments, the product design must conform to the Ingress Protection (IP) standard. Specifically, our product needs to pass the IP54 standard described in the *EN 60529* standard document [1]. The product’s main enclosure and sensors will be shielded from dust accumulation and water sprays.

### 2.2.3 Health and Safety

Since the product is designed to be used as a training aid it must not harm the user during normal operation. One of the objectives to the golf glove is to promote good swing technique and indicate to the user about behavior that is hazardous to health, such as gripping too hard in the top half of the hand during swinging. The glove will be made out of materials appropriate to remain comfortable for the product’s sustained use. Also, the golf glove must remain operational

### 2.2.4 Manufacturability

The design much make efficient use of current off-the-shelf systems wherever possible. Creating a “System of Systems” removes potential issues caused by working with new or unfamiliar technologies. Therefore, it will be important to utilize systems that have large amounts of community and/or manufacturer support. The system must be swappable between different glove sizes and shapes, allowing users of different hand sizes to use the system effectively. In the event of a depleted battery, the system must account for user/technician replacement to reduce waste and allow for prolonged system use. Components and housing must be designed to decrease the complexity of manufacturing allowing for an efficient creation on a production line.

### 2.2.5 Sustainability

The design must contain a battery/power-system that is sufficient to power the device for a minimum of 5 hours. This will allow the user to effectively use the device throughout an average 18-hole round of golf. The power-system must contain a protection circuit to prevent over-discharge, overcharge, and short circuit situations. Over-discharge can occur when the user forgets to turn the device off, and will permanently damage the battery. Overcharge can occur in the event of a charger malfunction and can cause rapid discharge of the battery. Lastly, short circuits can occur in events of corrosion, and internal shorts in the circuit. A protection circuit is necessary to protect the user from these potential, scenarios. The glove must be able to charge in under 2.5 hours using either an on-board charging circuit or an external charger. By keeping the charge time below 2.5 hours, the user can theoretically charge between holes or “hot swap” between multiple wrist units. Ideally the charging time should be less than or equal to half of the operating time of the device.

# 

# References

[1] Secure Systems and Technologies. (2018). *Ingress Protection*. [online] Available at: http://sst.ws/downloads/Ingress-Protection-iss-4.pdf [Accessed 19 Sep. 2018].