1. **DESIGN REQUIREMENTS/CONSTRAINTS**

GAS is an inexpensive, easy-to-use system that involves a belt and two ankle bracelets. GAS is designed to record certain aspects of the user’s gait when walking and present results in a mobile app that can be viewed by physical therapists. Pre-existing methods for gait analysis either are expensive or do not record data; therefore, it is difficult for physical therapists to monitor their patients and determine whether they are improving. GAS accomplishes this task by measuring the distance between the user’s feet, the time taken for each step, the time and direction of arm swaying, and the position of the arms relative to the feet.

**1.1. Technical Design Constraints**

Table 1.1. Technical Design Constraints

|  |  |
| --- | --- |
| **Name** | **Description** |
| Battery Life | GAS has a battery life that lasts a minimum of one hour. |
| Waist Size/Ankle Size | GAS supports, at the minimum, the average waistlines and ankle sizes of both men and women. |
| Results Navigation | GAS should be compatible with Android mobile operating systems for navigating results. |
| Data Collection | GAS must record and store data for analysis. |
| Memory Storage | The memory storage should be at least 0.5MB. |

**1.1.1 Battery**

The battery lasts at least an hour since the intended walking sessions completed with the device last thirty minutes to an hour [1].

**1.1.2 Waist Size/Ankle Size**

GAS is designed to accommodate varying sizes of both men and women. According to the CDC, the average waistline for women is 38.7 inches, while for men it is 40.3 inches [2]. In order to streamline the design process, the belt will be designed to fit the average waistlines at a minimum. According to Military Standard 1472D, the average ankle circumference for women is 8.30 inches, while for men it is 8.75 inches. The standard deviation for the ankle circumferences of men and women are 0.70 inches and 0.55 inches, respectively [3]. In order to accommodate for 68.7% of the population, each ankle bracelet is adjustable and is 7.75 inches to 9.45 inches long.

**1.1.3 Results Navigation**

GAS allows users to access their current and past results through an external app launched on any Android smartphone. As of 2019, Android smartphones had 1.6 billion users worldwide, making it an ideal and accessible candidate for this device [4].

* + 1. **Data Collection**

GAS must record four different parameters for each step, which are the distance between the user’s feet, the time taken for each step, the time and direction of arm swaying, and the position of the arms relative to the feet.

**1.1.5 Memory Storage**

GAS records the user’s gait data into a memory chip attached to the belt. Users wear the device anywhere from thirty minutes to an hour. The amount data recorded by GAS is similar to that of a running app such as MapMyRun. MapMyRun records its user’s routes, heart rates, location, cadence, and much more while only using around 0.5MB per day [5], [6]. Staying on the safe side, GAS will have at least 0.5MB of storage so that it can record all the necessary data from the user.

**1.2 Practical Design Constraints**

Table 1.2. Practical Design Constraints

|  |  |  |
| --- | --- | --- |
| **Type** | **Name** | **Description** |
| Manufacturing | Parts | GAS includes the following parts: a belt, two ankle bracelets, and two wires connecting each ankle bracelet to the belt. |
| Economic | Price | The intended cost for this device is $150. |
| Cultural | Clothing | GAS can be worn over any normal clothing. |
| Manufacturing/  Cultural | Button | GAS only needs minimal user interaction. |
| Health & Safety | Safety | The device must meet IEEE P360 standards. |

**1.21. Manufacturing: Parts**

GAS only consists of three parts and two wires. Since the belt and ankle bracelets are simple in design, the device is convenient to produce.

**1.2.2 Economic: Price**

The price of GAS is at least $150 due to the cost of an Arduino Uno R3 board being $23 [7].

**1.2.3 Cultural: Clothing**

GAS can be worn over normal clothing, meaning the user does not have to either buy new clothes compatible with GAS or wear specific outfits when using GAS. This makes GAS easily integrable into the user’s life at no additional fee.

**1.2.4 Manufacturing/Cultural: Button**

Users simply turn the device on and off using a button. Since this product is marketed towards outpatient therapy, and a lot of patients in this sector are middle-aged adults struggling with gait-related problems [8], this product caters to older patients potentially not having any pre-existing knowledge regarding technology by being easy to use.

**1.2.5 Health & Safety: Safety**

IEEE P360 highlights “suitableness of wear” when discussing wearable consumer electronic devices [9]. GAS is a ‘one size fits most’ device that does not cause any harm in order to be suited to most users.

**1.3 Engineering Standards**

Table 1.3. Appropriate Engineering Standards

|  |  |  |
| --- | --- | --- |
| **Specific Standard** | **Standard document** | **Specification / application** |
| USB 2.0 | Universal Serial Bus Revision 2.0 specification | USB 2.0 allows connection to the physical therapist’s computer/laptop. |
| IEEE 82079 Part 1 | IEEE 82079 | An instruction manual is provided so that the product is safely used. |
| IEC 60228 - AWG | IEC 60228 | The wires used in the construction of GAS must be an appropriate size according to AWG. |

**1.3.1 USB 2.0**

GAS communicates with the device via a USB 2.0 connection in order to sync stored data to an external application used for analyzing results [10].

**1.3.2 IEEE 82079 Part I**

GAS provides users with an instruction manual so that potential misuse will not result in the harm of the user, as per guidelines outlined by IEEE 92079 Part 1 [11].

**1.3.3 IEC 60228-AWG**

GAS uses wires that are of an appropriate size determined by the AWG so that the wires will not be a point of fault [12].

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