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AN EFFECTIVE INSOLES SHOES FOR BLIND PEOPLE FOR MOBILITY ASSISTANCE

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Abstract— Our eyes play a significant role in our daily life. Given that it allows us to perceive the world around us, eyesight is arguably the most precious gift we may possess. Some individuals, meanwhile, have difficulties with vision that make it difficult for them to envision such objects. Such people will have trouble moving about freely in public areas. Detecting elevation changes is a crucial component of mobile accessibility. These include obstacles like steps, curbs, and potholes that alter the level of the ground or a floor which is widespread in indoor as well as outdoor environments. In order to traverse these shifts safely and successfully,

Impairment	blind or visually impaired people must be able to recognize them and gauge their distance from one another and their extent. This requires the ability to perceive depth, which can be difficult for people with visual problems. The objective of this research is to develop a smart footwear that offers assistance in ascending and descending staircases by utilizing an IMU sensor to detect the user's movements. Prior to the development of a controller, the system undergoes mathematical and physical modelling. The process of mathematical modelling is carried out with consideration of the mobility patterns of individuals with visual impairments. The smart footwear was designed using Solidwork software to create a 3D virtual model. Furthermore, the shoe is designed to incorporate ultrasonic sensors that detect obstacles or barriers, and subsequently notify users through vibrations. As a consequence, the intelligent footwear is capable of unlocking the heels in response to the detection of low or high elevation, and emitting vibrations in the event of an obstacle being detected in its path. The expectation is that the utilization of this device will enhance the self-assurance of individuals with visual impairment to ambulate autonomously.

I. Introduction

A. Overview

Globally, 285 million people are believed to be visually impaired: 39 million are blind and 246 have limited vision. Approximately 90% of the world's visually handicapped live in low income environments, with 82% of those living with blindness aged 50 and older [1]. It is more difficult for those who have lost their vision to function independently. Despite living a normal life, people who are blind or visually impaired still have their comforts and styles. They significantly rely on other senses for everyday tasks, including hearing and touch.

Due to tough infrastructure and societal standards, visually impaired people undoubtedly have challenges daily [2]. Moving and transporting visually impaired people from one location to another used to be the most common problem in the past. Some previously utilized a guide dog to assist them navigate their surroundings and prevent accidents. At the same time, some used to request assistance from others [3]. Visually impaired people rely on assistive technologies like white canes [4], guide dogs [5], or technological equipment for effective and safe mobility. Although white canes and guide dogs are the most popular assistive technologies, they only partially address safe and independent mobility [6].

The Insole shoe gives blind person immediate sensory feedback about their surroundings, enabling them to move about independently. Helping those who struggle with their vision is one of our goals with the Insole shoes research. We developed a compact, wearable, hands-free device that enables the user to walk confidently.

In addition to Insole shoes, there are several walking aids for those with vision problems, such the WeWALK [7], UltraCane [8], and BawaCane [9]. Although a few of our products have a similar design, their functionality differs from ours. To develop better and more efficient goods, we have carefully analysed the ones that are already available. Every product has flaws, yet there is always room for improvement.

Wearable technology collects information about the user or their surroundings, analyses it (locally or worldwide), and then instantly communicates that information to them via acoustic or haptic signals [10]. To achieve the primary goal of helping blind or partially sighted people use the stairs more effectively and boosting the confidence of those who are blind to ensure that they can live independently every day, several patents are taken into account when designing the product [11].

The Smart Shoe system is intended to function as an addition to any shoe style, be compatible with any shoe design, and serve as a guide for visually impaired people to locate their feet when using various steps. The system's primary working concept is that it can switch between two different modes as you step up a stair or down one. The shoe should be able to recognize changes in surface elevation and alert the user if there are any obstructions.

B. Patent Literature

When making our product, we already looked at and researched several patents that might give us ideas for how to deal with our problem statements and reach our goals in a better way. The majority of those patents, however, have identical repeated characteristics on already existing items, and not many of them have the same goals as our that most patents originate from China and are written in Chinese. Therefore, we have already translated, summarised every significant feature, and shortlisted the best patents that assist us in building our product. We have further improved their features and combined them where we felt it was required.

Table 1: Patent Comparison

Patent Number	Title	Inventor	Description
CN202069017U	Guiding shoe system	Li Xiuwei	With its blind wave guided shoe system, this utility device aims to make navigation naturally safe. To draw attention and prompt essential action, it may emit a

			sound that others may hear nearby.
CN103169599A	Shoe used for blind people based on sensors	Xu Juan	The footwear is equipped with an ultrasonic sensor which is to be used by blind people to map out their walking path since it detects effectively and accurately. The sensor also has an alert system that will activate when they get close to an obstacle.
CN204133804U	Shoes special for the blind	Pan Dinglong	The shoes made just for the blind can help the blind feel more connected to the ground. The main goal of this feature is to avoid the problem that blind people walk out from a blind path in the walk.

C. Customer Survey

Knowing and satisfying the customer base is one of critical factor for the product success in business. It makes a good business sense then to survey the customers to learn about expectations, perceptions, satisfaction, and areas for improvement. Thus, in this project, we conducted a survey with targeted group of people which is with Disability Services Unit (DSU) of IIUM, Sekolah Kebangsaan Pendidikan Khas Jalan Batu, and some random public people.

The methods that were used to conduct this survey are by using Google form method which is online-based survey. Below is the analysis of some selected question.

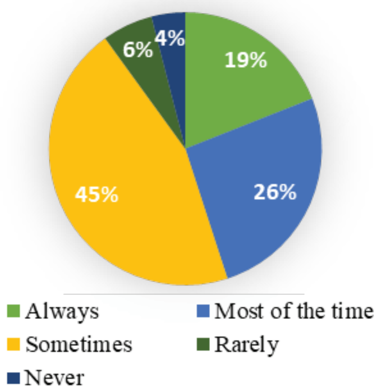


Figure 1: Pie chart frequency of climb up and down the stairs

From the above data, generally most of the people with vision impairment from time to time using the stairs or at least a split-level. Hence, we have to design a product that have high strength and high durability and choose the material with low tendency on fatigue failure.

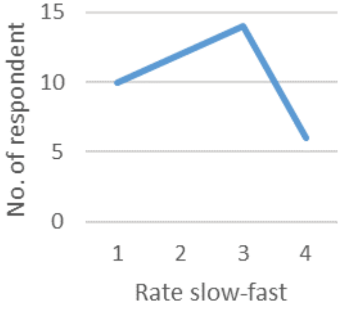


Figure 2: Time taken to take a step forward using the staircase

In the line chart above, the mean from the distribution of all the respondents skewed to the left which mean most of them took longer time to us a staircase or a split-level. They have to admit that the people with vision disability walk slowly and carefully when using the staircase.

From the suggested box in the survey form, we analyse the features needed by the customers with the below criteria. It can be seen that the most prioritise by the is safety, followed by accuracy, low cost, durability, simple design and small in size.

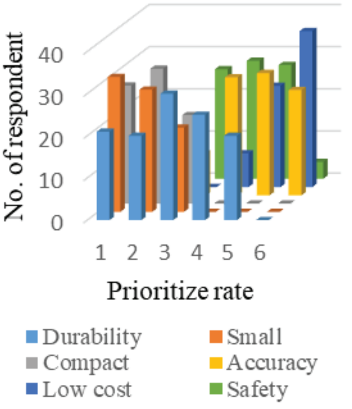


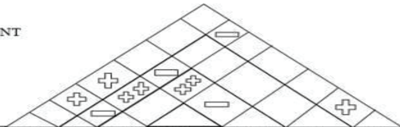
Figure 3: Customer prioritize requirement

D. Quality Function Deployment

House of Quality (HOQ) are organized methodologies for identifying customer needs and translating specifications for design and quality control characteristics into a planning matrix. In other words, by employing QFD, consumer needs and technical how-tos may be mapped out, leading to a more precise knowledge of design linkages.

In the Figure 4, the ranking of the importance of quality that needs to be put first is related to customer needs in the survey. As stated in the Figure 4 safety is the most important in order to prevent any injuries that can occur.

QUALITY OF DEPLOYMENT
(HOUSE OF QUALITY)



CUSTOMER REQUIREMENT	IMPORTANCE (1-5)	Percent %	Weight	Cost	Safety	No of Component	Accuracy	Water resistance	Long-lasting
DIRECTION OF IMPROVEMENT			↘	↘	↗	↘	↗	↗	↗
I want the price to be cheap	4	0.13	0	9	5	0	0	0	5
I want the weight to be light	3	0.1	9	0	0	3	0	0	0
I want the shoes to be durable	3	0.1	0	5	5	3	0	9	9
I want low profile design	3	0.1	0	0	3	5	0	0	0
Easy to use/less complex	4	0.13	0	5	5	9	0	0	0
Safety guaranteed	5	0.16	3	5	9	3	9	0	0
I want the accuracy to be high	5	0.16	0	5	9	3	9	0	0
I want the shoes to have weather proof	3	0.1	0	3	5	3	0	9	5
TOTAL	30		1.38	4.22	5.5	3.52	2.88	1.8	2.05

9= VERY STRONG RELATIONSHIP
5= STRONG RELATIONSHIP
3= WEAK RELATIONSHIP
0=NONE
(++) = VERY POSITIVE RELATIONSHIP
(+) = POSITIVE RELATIONSHIP
(-) = NEGATIVE RELATIONSHIP

RANKING:
1) SAFETY
2) COST
3) NO OF COMPONENT
4) ACCURACY
5) LONG-LASTING
6) WATER RESISTANCE
7) WEIGHT

Figure 4: Quality Function Deployment of Insole Shoe

II. Methodology

A. Insoles Shoes Mathematical Modelling

Many blind people need navigational assistance when navigating unfamiliar surroundings. We introduce the Insole shoes initiative, which enables people with mobility issues who are blind to avoid impediments. Our system identifies obstacles like curbs, stairs in the ground, and even static obstacles by utilizing existing robotics technology, and it also conveys obstacle information using haptic feedback.

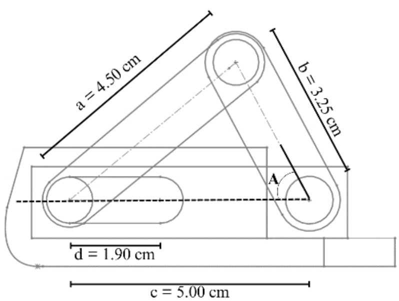


Figure 5: Before the user recognises the stairs

Figure 5 depicts the heel's initial position, where our locking mechanism is located at the bottom of the shoes. This position involves hooking an extension spring and placing it horizontally until it reaches its ideal length, c, and then using it to join parts a and b. Part A will remain fixed until the servo unlocks and releases the heel, while Part B is rigid. ABS filament, which may be utilized for 3D printing, is the only material used for this part. the length of c.

Here is the design specification based on Figure 5 at initial position: According to cosine rules, we found the angle of A:

$$\cos(A) = \frac{3.25^2+5^2-4.5^2}{2(3.25)(5)} \quad (1)$$

$$A = 61.89° \quad (2)$$

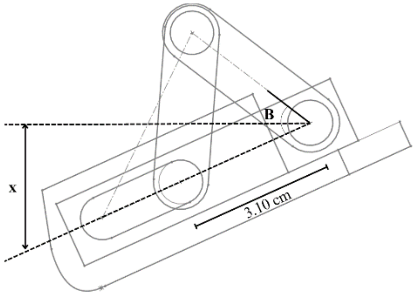


Figure 6: After the user recognises the stairs

When the heel is freed, the position is illustrated in Figure 6. Part A of the servo will unlock when the sensor detects the stairs. The extension spring will extend from 5 to 3.1 cm again before returning to its original length. The calculation shows that the angle is now shifting, allowing the "x"-shaped heel to slip out by a distance of 2 cm.

$$B = 85.41° \quad (3)$$

$$B - A = 23.53° \quad (4)$$

$$x = \sin(23.53°) = 2\ cm \quad (5)$$

To calculate the maximum pressure applied, we also needed to specify the user's maximum mass, which we set at 100 kg.

$$F = (100)10 = 1000\ N \quad (6)$$

The average surface area of covered by human's foot is between:

$$117.5\ cm^2 - 225.5\ cm^2$$

Hence, we take the minimum surface area to calculated for pressure. Aluminum alloy T6-6061 has a high strength-to-weight ratio and can sustain high pressure, so it was placed between the heel and the shoe's sole.

$$P = 85.1\ kPA \quad (7)$$

For the locking system, we can design the extension spring and calculate the maximum force that the heel part can pull to ensure it will not exceed the elastic limit thus breaking the mechanism part. The material used for the spring is Music

Wire ASTM A228, and the diameter ranges from 0.0127 – 0.3175 cm. It has the highest shear modulus value and is most widely used for small springs in tight spaces.

$$k = \frac{(79\times10^{3})(0.0014)^{4}}{8(0.012)^{3}6} \quad (8)$$

$$F = k(x) \quad (9)$$

where:
F = Force applied to the spring
k = The spring constant
x =The extension of the spring

$$F = 9.52\,(50-31)$$
$$= 180.88\,N \quad (10)$$
$$F = 9.52\,(50-32) \quad (11)$$
$$F = 171.36 < 180.88N \quad (12)$$

According to the design specification, the value of the F is the highest force that portion of the heel (from Figure 2) can apply to the spring. We only need 1 mm to the spring's length to prevent it from stretching above its elastic limit. Based on the specifications of the servo motor, we utilize a 9G micro servo motor that rotates at a speed of 0.10 seconds per 60 degrees. Therefore, we could set the rate to 0.15 seconds per 90 degrees or 0.025 RPM. This speed will be utilized when locking and unlocking the heels.

B. Operational Sequence on the System

Before any wiring is done, the circuit diagram, a crucial component of an assembly involving two or more parts, should be taken into account. Figure 7 shows circuit diagram for the Insole Shoe. The Insole shoes are attached with IMU sensor, which can detect the user's body's specific force, angular rate, and orientation. If the user starts climbing either up or down the stairs, the heels will unlock respectively, allowing the user to ascend or descend the stairs more easily. The IR sensor had been integrated in the Insole shoes to detect any obstacles in front of the user and alert them via vibration.

Figure 8 depicts the general layout of the Insole shoes with the leg support, an IR sensor for seeing obstacles in front of the user, and a vibrator to alert them. Figure 9 depicts where the heel will extend as the user ascends or descends the steps.

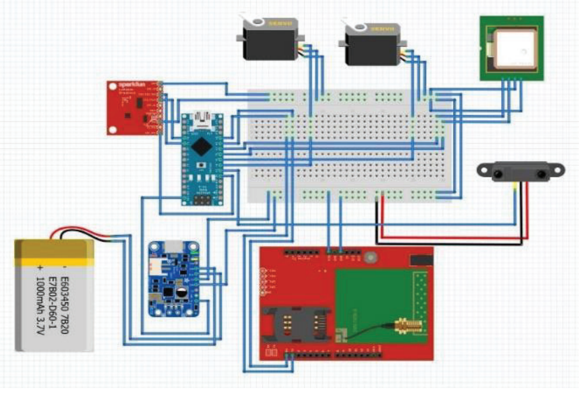


Figure 7: Circuit Diagram for Insole shoes

Figure 8: Smart Shoes Design

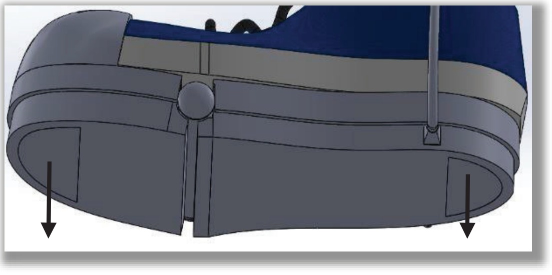


Figure 9: Part of the Extension Spring

III. Result and Discussion

The majority of the parts and components of our product are readily available on the market. Therefore, no significant changes are required. For instance, our work used an Arduino, servo motor, power boost, and Initial Measurement Unit (IMU) module. The only alteration is to put the parts and components inside the shoes, guaranteeing safety while reducing connection complexity and making manufacturing more accessible.

When it comes to our product, we place an extreme emphasis on the importance of its safety features. We will not consider our product successful if it does not adhere to all applicable safety standards. When we design something, we try to make it as safe as practicable without compromising any of the utility of the design. It is dependable and efficient as a result. Furthermore, the locking mechanism is flexible. Therefore, if the user has not yet become accustomed to our product in any way, the locking system will prevent the user from tripping due to the flexible build we have created. People's primary worry with this product is that the soles are not slip-resistant.Thus, the manufacturer has addressed this issue. To ensure that the wearer's feet maintain a secure grip on the ground while they are walking, the bottoms of the shoes will be covered with rubber or different material typically included in everyday footwear.

Vibrator to indicate the user, an alternative to an alert or buzzer designed to signal the user when approaching barriers. We want them to walk with extreme caution. Therefore, we won't let anything occupy their sense of hearing in a crowd or any other situation. Because they are blind, it would be counterproductive for us to interfere with their hearing ability for the product to function correctly. In addition, the IMU module will recognize any movements that are not typical and will communicate this information to an emergency contact.

IV. Conclusion

In conclusion, the goals of these Insole shoes, which were to assist blind individuals with walking on stairs and providing assistance in unfamiliar environments, have been met. The assistance of this technology could boost the self-confidence of visually impaired people. In the future, anyone with a physical disability that makes climbing stairs difficult may benefit from utilizing this device.

V. Acknowledgement

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