Samsung Solve for Tomorrow

NUS HIGH SCHOOL of Math & Science

Illuminating Pathways – A Leap Beyond for the Blind

Problem Overview

200 million individuals across our planet grapple with visual impairment -- a figure expected to rise to 550 million by 2050. The everyday routines of these people are rife with difficulty, as they find themselves struggling to adapt to their everchanging surroundings. Even despite the great leaps in accessible technology in modern times, the support tools available to them remain rudimentary, providing only basic information on the presence of nearby objects without any specifics about distance or height.

Proposed Solutions

Solution Overview

Our proposed solutions aim to revolutionize this scenario by harnessing advanced technologies to provide the visually impaired with the ability to gain a more detailed understanding of their surroundings through auditory and tactile cues. To be specific, we propose two different approaches, one software and one hardware:

1. **Software Solution**: This involves the use of LiDAR technology and camera-based object detection systems integrated into smartphones and tablets. These technologies work together to create an "obstacle map" that provides users with a tactile representation of their environment.
2. **Hardware Solution**: This involves the development of a unique case for an LiDAR equipped device with a tactile interface. This interface translates the visual data captured by the device into tactile feedback, allowing users to "read" their surroundings through touch.

The goal of these solutions is not merely to create another aid but to completely transform the reality for visually impaired individuals, enhancing their ability to navigate their world independently and safely through providing more detailed information about their surroundings, thereby improving their quality of life overall.

The Software Solution

Introduction

The software solution is designed to leverage the advanced sensor technologies and GPS already available in many modern smartphones and tablets to create a more detailed and interactive representation of the user's environment; one which can be understood by touch alone, all while keeping the setup and equipment needed to be no more than just installing an app on their phone. Additionally, a map can be integrated to provide multisensory instructions, including auditory and haptic, for a more transparent and seamless navigation experience for the visually impaired.

Use of LiDAR and Object Detection

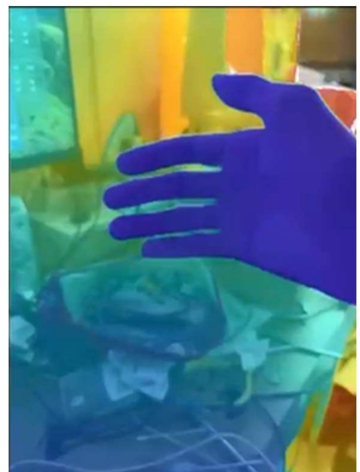
The software solution utilises the power of LiDAR technology and object detection through Artificial Intelligence.

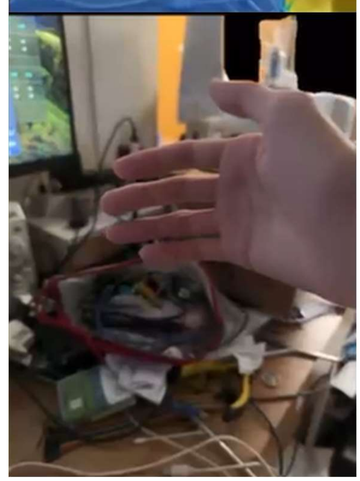
LiDAR is a remote sensing method that uses light in the form of a pulsed laser to measure distances. This technology, which has already been integrated into modern smartphones and tablets, allows for the creation of a detailed spatial map of the user's surroundings.

In addition to LiDAR, the software solution also utilizes object detection capabilities. Object detection is a computer vision technique that uses AI models to identify and locate objects within images or video. This feature enables the software to identify and locate objects within the environment, further enhancing the detail and accuracy of the spatial map.

By harnessing both technologies, we can accurately provide visually impaired individuals with a much richer understanding of their surroundings than traditional aids.

Creation of Obstacle Map





The software processes the data captured by the LiDAR and object detection systems to create an "obstacle map". This map provides a simplified representation of the user's environment, highlighting potential obstacles and their distances from the user.

A sample of such a visual map (original image can be seen below) could be seen in the image to the right, where a very early prototype has been built. The color mapping represents the distance away from the camera, where it could be seen that the orange/yellow sections are further away while the blue sections are closer to the camera. Hence, an "obstacle map" is created, as the sensors accurately determined the distance away from the obstacle.

User Interaction

Users interact with the obstacle map through their device's screen. By tracing their fingers on the screen, users receive continuous haptic feedback. The strength of this feedback varies based on the proximity of objects in the environment, allowing users to "read" their surroundings through touch. For example, if the user would touch the centre of the screen, they would experience strong and rapid pulses of vibrations, which indicates that there is an object that is very close to them in the center of the screen. However, if they trace their fingers outwards, to the orange area, the strength of vibrations will be weaker, and the frequency will be more spaced out. If there is imminent danger of a collision, the phone will vibrate regardless of if there is a finger tracing it to warn the user of the collision.

Furthermore, auditory feedback through natural spoken language could augment the experience with additional matrices such as the distance to an obstacle.

The Hardware Solution

Introduction

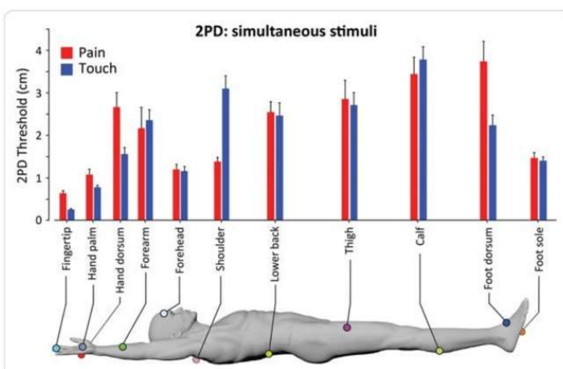
While the software-based solution does provide a great leap in assistive technology for visually impaired individuals, it still has its limitations. One of the main challenges arises from the fact that through the haptic interface, users can only "sense" a single point of interest at a time; thus, to obtain a good map of their surroundings, one would be required to stop to touch the screen and feel around oneself, thereby interrupting the flow of movement and making navigation clunky and less fluid.

Our hardware solution aims to address this limitation via the development of a unique case for mobile devices equipped with a tactile interface: specifically, one that translates the visual data captured by the phone into tactile feedback in real-time across multiple points of interest, allowing users to navigate their surroundings by feeling this feedback throughout their hand. As such, during movement users can receive a continuous stream of updates on their entire environment at once, making navigation smoother and more intuitive without the need for pauses.

Tactile Interface

A major concern with most tactile interfaces is that it is difficult to distinguish between two points close together. Hence, our team reviewed some literature to find that the tip of a finger has one of the highest touch sensitivities. From the figure below, we can observe that a fingertip has the lowest simultaneous stimuli distance of around 0.25cm which means that the fingertip can distinguish between two points on a fingertip when the separation is 0.25cm minimum. Hence, it is feasible to implement a tactile interface on the hand.

The tactile interface is a key component of the hardware solution. It consists of a series of small

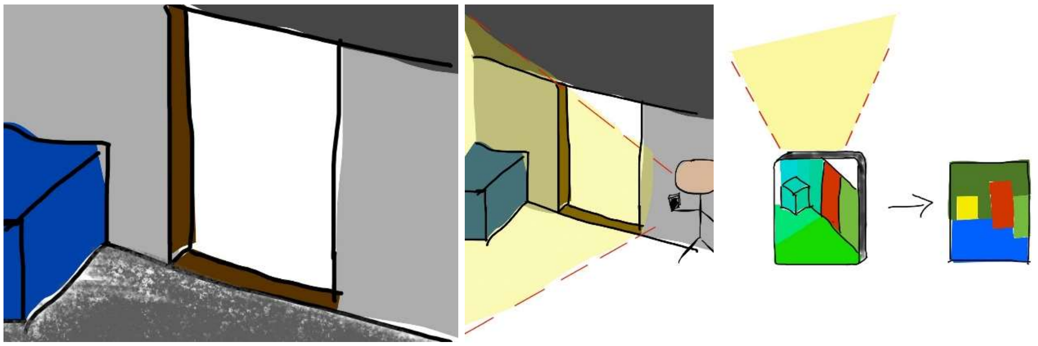


metal pins that can be pushed into every joint of every finger. These pins are controlled by a rotating cylinder equipped with a series of wedges. As the cylinder rotates and moves left or right, the wedges push the pins up to varying heights, providing tactile feedback to the user.

Translation of Visual Data

The tactile interface translates the visual data captured by the device into tactile feedback by varying the height of the pins based on the proximity of objects in the environment. For example, if an object is very close, the corresponding pin will push hard against the user's finger. If an object is further away, the pin will push less hard. If there are no objects in a particular direction, the corresponding pin will not push at all.

To further illustrate this concept, we can imagine the field of vision to be divided up into grids, where magnitude of each grid will be taken to be the distance closest from the object to the phone sensor. A human has 5 fingers, and we can place 4 “pins” on a singular finger to obtain a resolution matrix of 5x4. Hence, we can divide the field of vision into a grid of 5x4, and the height of the pins will vary depending on the closeness of the objects in the grid, allowing the blind individual to “see” with such a simplistic device.



Comparison with Existing Products

While there are several products on the market that aim to improve accessibility for visually impaired individuals, our proposed solutions address some of the key shortcomings of these existing offerings. In this section, we provide a comparative analysis of our solutions with two popular preexisting products: Apple’s Magnifier and general “Blind” glasses.

Apple Magnifier

Apple’s Magnifier, while a useful tool, requires the user to have an iPhone, which can be a significant investment for those who do not use the Apple ecosystem. In contrast, our software solution is designed to work with any LiDAR-equipped smartphone or tablet, making it more accessible to a wider range of users. Furthermore, Apple Magnifier fails to provide general information on the environment, instead choosing to focus only on people, which may increase the chance of a collision with non-human objects, such as walls or chairs.

“Blind” Glasses

Commercial “Blind” glasses can cost anywhere from $3000 to $4000 per unit - a high cost that can be prohibitive for many users. Our hardware solution, on the other hand, is expected to cost *no more than $50 per unit,* making it a much more affordable alternative. Furthermore, many blind glasses on the market only read out text and do not provide any real time feedback or warnings for imminent collision.

Advantages

1. **Cost-Effective**: Our software solution requires only an application download, reducing the cost to zero. The hardware solution is expected to cost no more than $50 per unit, making it an affordable alternative to expensive medical solutions.
2. **Accessible Infrastructure**: Our solutions are designed to work with any LiDAR-equipped smartphone or tablet, making them more accessible to a wider range of users.

3. **Detailed Environmental Understanding**: By harnessing advanced technologies like LiDAR and object detection, our solutions provide a detailed and interactive representation of the user's environment.
4. **Real-Time Tactile Feedback**: Our hardware solution provides continuous updates about the surroundings, allowing users to move while receiving information, thereby making navigation smoother.

Possible Work

This section proposes some possible future works in which prototypes are not possible due to limitations in current technology.

Looking ahead, the integration of AR and AI holds immense potential for enhancing the user experience and addressing mobility issues. A key player in this space is Samsung, which has been making strides in leveraging these technologies to create innovative solutions.

One of the promising advancements is the Snapdragon AR2 Gen 1 platform. This platform, designed specifically for augmented reality glasses, is built on a multi-chip distributed processing architecture combined with customized IP blocks and delivers 2.5x better AI performance than its predecessor.

As we continue to push the boundaries of what's possible with AR and AI, it's crucial to ensure these technologies are accessible to all. This means not only making devices affordable but also ensuring they are intuitive and easy to use. By doing so, we can truly transform the reality for individuals with visual impairments or mobility issues, significantly enhancing their quality of life.

Conclusion

In conclusion, our proposed solutions intend to be a significant step forward in assistive technology for the visually impaired, one that hopefully sets a precedent for more technology to come.

By harnessing the power of LiDAR technology, object detection, and artificial intelligence in our software solution, we can provide a detailed and interactive representation of the user's environment, which allows users to "read" their surroundings through touch bolstering their navigational abilities in a safe and effective manner. Such a technology only requires the user to download an application which uses preexisting technology already available in phones, allowing the incurred cost for the user to be close to nothing.

Moreover, our hardware solution addresses the limitations of the software solution by providing the user with real-time tactile feedback of their entire surroundings simultaneously, giving users the ability to continue moving while receiving continuous updates about their environment, making the navigation experience smoother and more intuitive. The total cost of the "add on" phone case is expected to be no more than 50 dollars and has great potential to serve as a cheap alternative to expensive medical solutions which many cannot afford.

Together, these solutions have the potential to revolutionise the reality for visually impaired individuals, and by doing so uplift their quality of life to new heights. While there are undoubtably still challenges to overcome in execution and improvements to be made, we believe that this approach is a promising step forward in creating a more accessible and convenient world for those with visual impairments.