Inkwell - Understanding and Sympathizing With the Challenges of the Visually Impaired

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***Abstract*—Many new powerful tools (Sonar canes, ultrasonic sensors, etc.) have recently been invented to aid visually impaired individuals, yet they remain hardly ever used due mainly to their cost and their risk of malfunction; An arguably small risk, but one that could have potentially catastrophic consequences. The great majority of them thus prefer more dependable tools for their reliability and often times simply by habit. Inkwell's objective is to trigger empathy into the world of the vision impaired and stimulate more analogous navigation strategies by virtually placing a user with a healthy vision in the shoes of a blind person. Creating an attractive experience to inspire further investigations into the modification of real world infrastructures. A non-intrusive enjoyable way to raise awareness. Inkwell also doubles as an alternative treatment method for people suffering from phobias such as mazeophobia and scotophobia through virtual exposure therapy**

***Index Terms*—Virtual Reality, Visually Impaired, Exposure Therapy**

I. Introduction

Blind and partially blind individuals largely rely on their hearing and cane to navigate. If this sounds frustrating and inefficient, it is because it is. Most of the technology we wield today would have been classified as magic only a few decades ago yet the advancements made in vision aid seem frozen in time. Braille and voice activated GPS can only get you so far.

The purpose of this study is to help understand and sympathize with the challenges visually impaired (VI) individuals encounter by giving the visually unimpaired (VU) a chance to relate to them. This, in turn will provide better insight on some of the changes that could be made to accommodate for vision related disabilities. Unfortunately, so far these adjustments remain rather limited (e.g. Braille symbols next to doors, foot paths). Evidently, we could do much better. The reason most facilities have not implemented any large scale modifications is poor return on investment. Allocating or deviating funds for 3.8% [1] of the population is not apparently attractive.

This is where applications like Inkwell could make a difference. By allowing VUs to physically and psychologically experience what VIs feel, the number of those actively aware of the struggles will grow which, in turn, will result in a greater engagement. We do not know how to effectively help the lives of VIs because the remaining 96.2% of us remain unaffected. To believe that we have reached the extent of possible solutions would be to greatly underestimate how creative people can be. Inkwell is only there to help kick start that creativity.

The secondary aim of this study is to potentially push forward treatments/solutions for confusion related phobias such as mazeophobia by allowing individuals to regain control in a safe monitored environment.

II. Related studies

A. Blindness

Coming up with solutions to a problem one is not personally confronted with can be difficult. This is especially true when even simulating the problem cannot be properly done. Complete blindness cannot easily be emulated over long periods of time, let alone on a large scale. Efficient solutions to blindness thus remain scarce.

1) Bespoke assistance: A study, carried out by researchers at the University of Surrey, claimed that the needs of *people who lose their sight are many and varied and the support provided for them must be personalized* [2]. The team thus investigated the needs and expectations of VI individuals through thorough interviews with them, their family and care takers as well as accompany them throughout their day using recording devices. This in hope to follow up with useful ways to meet each individual's specific needs.

The study affirms that although more quantitative research have been used in the past, their innovative approach allows them to understand the problems of VI individuals better by being able to virtually follow them for a few hours of their day. They concluded that in order to help VI individuals effectively, they must assist them their personal life as well as their environment. In a society built for the sighted by the sighted, amendments to infrastructures are required. Employment is also an issue as the rate of employment for the visually impaired is still absurdly low(75% in the UK according to the RNIB in 2004). However, their continuous recording approach failed to give more insight than an interview with a daily care taker would. After all, the job of a care taker is to help overcome and report the many difficulties their clients go through. According to their paper, the interviews conducted with the families and friends of the volunteers raised a concerning point: Sighted people are acutely unaware

Fig. 1. Prototype of the EyeCane device

of the challengs VI individuals go through on a daily basis. This is why educating people with healthy vision on the struggles that come with blindness and how to help is one of Inkwell's prime focus.

2) Virtual guidance: In another study from the Carnegie Mellon University, two groups of VI test subjects (14 participants) were presented with two smartphone-based virtual navigation interfaces meant to compare the effectiveness of step by step guidance vs continuous guidance. The first interface: VirtualLeap allowed (According to their paper) the user to jump through a sequence of street intersection labels, turn-by-turn instructions and POIs along the route. The second: VirtualWalk simulated variable speed step-by-step walking with added audio effects [3].

The purpose of the study was to determine the users' ability to build a sequential representation of the environment and understand the relative benefits and disadvantages of the two interfaces (VirtualWalk and VirtualLeap). The team noted that the test subjects reported a slight preference for VirtualLeap to get a quick sense of the route but preferred VirtualWalk for building a more accurate sequential representation of the environment. Their results, however, remain somewhat limited as according to the paper, in both case, *the majority of the participants were able to build an accurate sequential representation of the route structure* as well as the locations of the POIs.

3) Virtual cane: EyeCane is a virtual cane device built by an Israeli startup with the purpose of extending the user's sensory reach.

The cane itself resembles a flashlight and contains a wide array of sensors to detect surrounding obstacles and intelligently inform the user of their general location and size. The EyeCane device allows the user to scan the room and receive proportional amounts of haptic feedback, according to the distance between the cane and any detected obstacle. In the study following the device's prototype phase [4], the team conducted experiments where test subjects were asked to complete a set of "levels" (Small rooms to exit from) as fast as possible in order to determine the efficiency of the device. Each test subject had to go through random levels using either

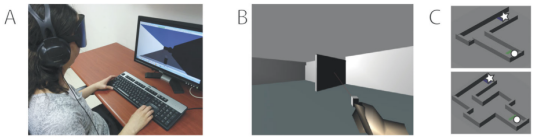

Fig. 2. A test subject going through a level using a virtual EyeCane

a virtual white cane, a virtual EyeCane or neither with real life scenarios later organized.

The results of this experiment were conclusive: Not only did the EyeCane dominate the other two methods, but some test subjects reported feelings of freedom close to those felt from visual navigation. Unlike the two previous studies, who mainly raise awareness about the problems, the team behind EyeCane delivered a viable product that managed to affect the lives of several VI individuals directly despite the device's current unavailability.

B. Phobias

By definition, a phobia is *the irrational fear of something*[1]. As people suffering from phobias are not directly put in danger by their fear, they cannot be properly deemed to have a medical condition. The relative health risks being low, attempts at finding ways to treat them are limited and often poorly executed.

1) Exposure therapy: Since the 1950s, a new method to treat certain types of irrational fear has risen called *exposure therapy*. The therapy relies upon three simple steps:

- Identification
- Relaxation
- Exposure

Identification consists of asking the patient to rank their fears in order of magnitude; thus establishing a *fear hierarchy* [6]. This step enables the therapist to create a structured "battle plan" to address the phobia progressively[2].

Relaxation consists of teaching the patient muscle relaxation techniques to be later used when confronted by a scary situation. The patient is instructed to focus on how they feel when they tense or relax specific muscles.

Exposure is the third and final step in which the patient can use their newly acquired relaxation techniques whilst face to face with items of the their fear hierarchy.

This therapy has proven to be incredibly effective, with a recovery rate of 60% to 90% after only 8 to 16 sessions [7] (a typical session being one hour, repeated weekly). However, as one may expect, exposure is a step most patients feel deeply uncomfortable going through, especially when confronted with real items of their hierarchy. As a matter of fact, in a study comparing acceptance and refusal rates of virtual reality exposure vs. in vivo exposure [10], the refusal rate when reaching step three was as high as 27%. The rate for virtual exposures however, was only 3%. This is a game changer.

[1] According to the Oxford dictionary

[2] Systematic desensitization

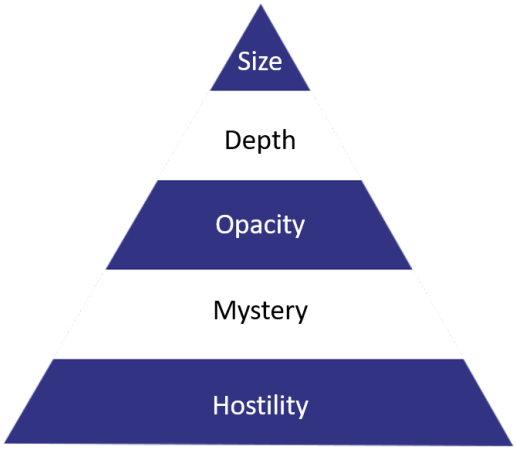

Fig. 3. Fear hierarchy from a patient suffering from thalassophobia (Fear of the ocean)

Fig. 4. A sensory deprivation tank

2) Sensory deprivation: Sensory deprivation has now long been recognized as an effective method to treat physiological disorders like anxiety, depression, insomnia, stress as well as more physical conditions like chronic pain and addiction. Although *floating centers* have only become globally attractive in the past decade or so, they have been around since the 1950s. As an added benefit, sensory deprivation tanks have also been used by people in the look out for ways to boost their creativity and concentration.

The deep relaxation state, sensory deprivation units put their users in, have more recently sparked the attention of more spiritually oriented individuals. Claiming the state it puts their body in encourages *spiritual awakeness* [8].
Sensory deprivation consists in preventing the body from receiving the following sensory information:

- Smell (Olfactory)
- Taste (Gustatory)

Fig. 5. In-game wall marks

- Space (Proprioception)
- Hearing (Audition)
- Touch (Digital)
- Sight (Vision)

This sensory disconnection, provided by the sensory deprivation tanks, help inducing a deep state of relaxation capable of helping patients suffering from all kind of anxiety: Including phobia related ones.

III. Methodology

In the following sections, we will discuss the ways in which Inkwell attempts to simulate the effects of blindness and sensory deprivation.

1) Navigation: Inkwell's goal is to recreate an environment where the player is faced with the same challenges as someone deprived from vision would face.

The first element emulated is darkness:
Instead of simply preventing the player from seeing entirely (e.g. by turning off the screens), we took the very conscious decision to have the whole world rendered black and allow some elements of the game be or become illuminated (Footsteps, objects touched, exit and the objects to be picked up). This is to allow sighted people to project a mental map[3] of their surroundings onto a virtual world, much like a blind person would when entering an unfamiliar space. Granting the player the ability to leave traces on the walls they touch allows them to reclaim the perception of distance and scale. All solely through touch.

The second element is audition:
By bringing back the importance of sound into the game, the player is forced to rely on an otherwise vastly disregarded

[3]A person's point-of-view perception of their area of interaction

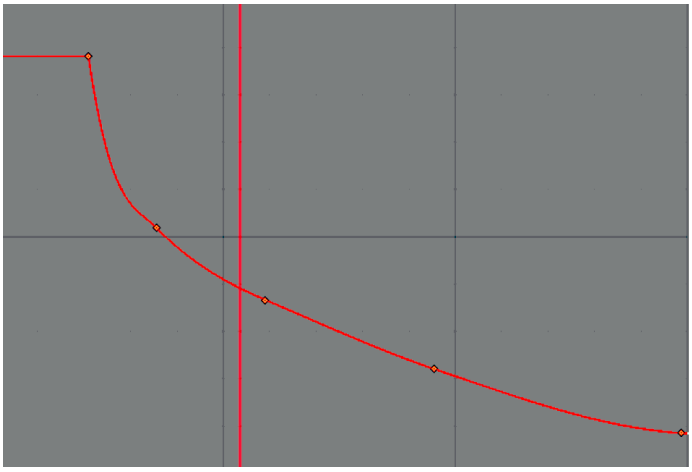

Fig. 6. Audio curve: $\frac{Volume}{Distance(\Delta Player->Exit)}$

sense in casual navigation. We did this by having the door leading to the exit of the maze emit a sound. The sound is loud enough to be heard from everywhere in the labyrinth but it's volume varies in relation to the distance between it and the player. This grants the player a general location to aim for and a way to tell whether or not they are making progress.

The third element is memory and orientation:
Our ability to see allows us to remain safe even if we happen to forget the exact location of items around us (Stairs, glass, walls, steps, etc.) because if we need to use them or remember where they are, we simply have to rescan the room and recalibrate our memory. However blind people do not have this incredible gift and must work on their sense of orientation and recollection to keep track of where they are as well as the direction they are facing. This element is in part emulated by the sense of touch illustrated above but also by the addition of foot steps. The foot steps or here to give a temporary memento of the player's whereabouts. Allowing them to briefly retrace their steps without relying on their sense of touch.

The forth and final element is purpose:
By giving the player a goal (Reaching the exit) and simple objectives to complete (Collecting all three keys), we attempt to simulate simple everyday tasks such as finding the toilets or the help desk (represented in Inkwell by the maze's exit) after going through a set of instructions (e.g. *Second door on your right after the stairs*: represented in Inkwell by the keys).

2) Therapy: In this section we will discuss the ways in which Inkwell attempts to provide a safe supervisable environment for therapists to treat patients through exposure therapy.

The benefits of virtual exposure vs real life exposure are evident. The patient can, at anytime, "Hop out" of the experience and do so as many times as they wish. This, on its own,

Fig. 7. In-game footsteps

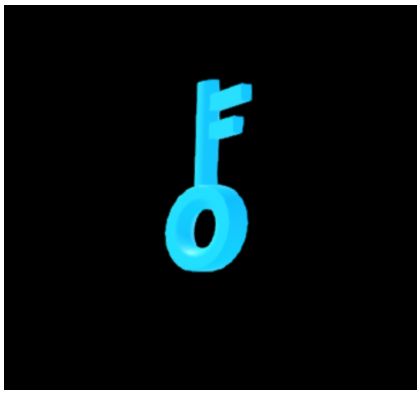

Fig. 8. In-game key

has three major consequences:

- The patient can tackle their biggest fears multiple times with very little effort
- Knowing that the experience is not entirely real can help can help the user relax more easily
- Each session can be accurately measured, leading to more quantifiable improvements for them and their potential therapist

Mazeophobia in particular is the irrational fear of being lost. Inkwell provides the player with a virtual maze designed to trigger such a fear. Mazeophobia is often accompanied by other related ones like claustrophobia (Fear of confined spaces), scotophobia (Fear of the dark). Inkwell attempts to resolve all of those in a short enjoyable experience.

Fig. 9. A person playing Inkwell

Treatments for mazeophobia are diverse as the fear of being lost can sometimes be confused with the fear of the unknown. In most cases cognitive behavioral therapy [9] will be used as a first attempt but it's effectiveness can be rather limited, as monitoring it can be very difficult. Most methods consist of having the patient gradually travel further and further from their home (or wherever they feel comfortable) as they slowly build up their confidence. Inkwell is helpful in that it offers a controlled environment for patients to gain self-assurance and overcome their phobia, all from the comfort of their home or their therapist's office. It also allows the therapist to monitor the patient's reactions and possibly help come up with more effective treatment methods.

As an added component, Inkwell's theta wave inducing soundtrack combined with the lack of vision and general sense of space, mimics the benefits one would receive from spending some time in a sensory deprivation tank. This is to help the player/patient relax and feel safe despite the apparent challenge the experience presents.

IV. Discussion

In this paper we have discussed many different ways to approach making the lives of the visually impaired better with three distinct study cases. Each of them had their own successes and failures but one failure in particular was shared across them all: None managed to spread their efforts and achievement in any significant scale. Eventually condemning them.

The first case study failed to get more insight from their individualized assistance method than a simple interview with a few care takers could. The study also suggested that although other "more quantitative methods" exit, their sample size were too small, yet the study it self only managed to examine a handful of cases.

The second case study, on the different ways to tackle virtual navigation prior to leaving your house, suffered from the same sample size issue with only 14 people tested but also happened to be hardly practical outside of the testing environment the subjects were set up in.

The third and final case study on the use of high-tech tools, like the ergonomic and advanced EyeCane, faced the challenged of affordability and global availability. It could also be argued that the procedures put in place to assess the device's effectiveness were tailored to reflect it's benefits.

Inkwell attempts to deal with those issues by learning from them:

- More than 11 million Virtual Reality kits capable of running Inkwell have been sold in 2017 only [11]
- Easily spreadable through platforms like Steam or direct online downloads
- A single VR kit in the hands of a therapist could help many different patients in a single day

Following the feedback form discreet workshop sessions, many gameplay elements inside Inkwell have been retrofitted sequent to the game's conception. Some have now become core aspects of the game (e.g. Ghost, colored zones). Ironically however, some of the proposed improvements ended up highlighting the very purpose of the game. Being blind comes with a whole world of frustration that Inkwell alone cannot simulate entirely. These suggested features can henceforth become virtual blueprints for real world modifications.

A good example of this would be to have the soundtrack of the game emit from the exit of the maze. This helps the player locate themselves using their sense of hearing. We could translate this behavior in real life by having key locations (e.g. Help desks, toilets) in buildings emit a distinguishable non-intrusive sound. Another example, which rose from the annoyance of having to follow walls, would be the implementation of the ghost. The ghost is here for multiple reasons but one of them is to have the player look away from the wall they are following and notice that they are able to, at the very least, walk up to the ghost's location obstacle free. Thus allowing the player to detach themselves from their only known point of reference. This feature could be implanted outside of Inkwell by adding small perceptible dimples on the surface of floors to help VIs using walking sticks navigate inside a building without having to rely on touching walls.

In only a few sessions, a whole array of potential practical changes came up from in-game discoveries. This is very promising for the future of Inkwell and its purpose.

V. Conclusion and future work

Inkwell's vision to generate the level of empathy required to come up with practicle solutions for the vision impaired has already proven to be effective in the small scale. The game's uncommon way to tackle this challenge, by integrating it into a fun experience, has the potential to make it attractive on a larger scale. The game's ergonomic controls makes it easily accessible to anyone regardless of age.

Inkwell's second objective: To provide a safe environment for

therapists to help people recover from phobias through a form of enhanced exposure therapy, suggest promising results.

However, Inkwell's ambitious objectives have yet to be formally tested. Giving more people access to the game will not only provide useful feedback but will finally unleash Inkwell's full potential: Generating innovative ideas to improve the lives of visually impaired individuals.

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