MAP Literature Review

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Evaluation of Virtual Tactile Dots on Touchscreens in Map Reading: Perception of Distance and Direction

Citation

(Watanabe, Kaga, and Yagi 2017)

Introduction

In order to assist blind people in using a flat touchscreen, "virtual" tactile dots that produce feedback either as speech and vibration or both when touched was proposed. This was then tested with a map application to investigate their effectiveness in map reading application.

Two experiments involving eight blind participants where the participants would perceive the distance and direction between two virtual tactile dots was conducted.

The paper cites the issue that while several navigation maps exist for blind people that can be used with a screen reader, their functions are limited to providing local, point information such as the address of the present location, searching for shops around the present or designated location, and navigating at intersections.

The paper then says that these apps do not provide enough geographical information, including the whole route. It then recommends that for blind people to obtain this area information, two-dimensional tactile maps are necessary.

It's stated that for map apps to display dynamic map information, tactile maps made with thermoform, capsule paper and embossed paper are insufficient and refreshable tactile displays are necessary. The paper cites that development of refreshable tactile display technology, and the issue that refreshable tactile displays are too big and heavy to carry, and too expensive to purchase personally.

As a result based from cited sources, few people use tactile display products. Mainstream touchscreen devices which are smaller, easier to carry and more reasonably priced than specially developed equipment for people with disabilities can have their speech output and vibrating functions be utilized as a substitute of tactile information.

The paper cites that researchers have proposed the use of vibrotactile and speech feedback for blind people using a flat touchscreen. The function of vibrotactile feedback is to vibrate when the predesignated areas are touched on the screen and what is on that place is voiced simultaneously, and this is what this paper refers to as "virtual tactile dots".

The paper cites topics in the introductory such as tactile perception of distance, direction, and length in the field of education for the blind, man-machine interfacing, and tactile perception for robots and in virtual reality.

Against this background, the paper explores if vibrotactile and audio feedback can give the accurate perception of distance and direction that is required in map reading. Their accuracy and time performance was compared with those for real tactile dots made on capsule paper. On the basis of these experimental results, the paper discusses the effectiveness of the vibrating and reading map app in assisting blind users.

Study

- Experiment 1: Distance Perception
- Experiment 2: Direction Perception

Conclusion

The results of the study showed that while the participants perception of the direction and distance between two virtual tactile dots was, by quote, "-accurate enough". The problem encountered was that the search time for these virtual tactile dots was significantly longer than the search for real dots.

The study concludes that the search time issue makes the reading and vibrating tactile map not practical. The reason for this is stated that even though 7 out of 8 participants consistently used smartphones everyday, the issue arises that unlike the app layout of their phones which can be easily remembered, the virtual tactile dots have not been told or memorized by participants.

The study declares that if it takes more than 10 or 20 seconds, the speech and vibrating map can not be said to be useful.

And so the paper attempts to suggest a method of shortening the search time, but the barriers to reducing the search time are that the device can convey the "presence" of vibration but not its "location". More vibrating motors could help facilitate this search. The flat touchscreen is also devoid of tactile information by itself, and the paper states that without tactile dots the search time can not be shortened enough to be practical.

It is stated that an innovative, small, refreshable tactile display device that realize such dots must be developed.

Lessons Learned

- Modern smartphones do not contain enough vibrating motors, correctly placed, to effectively facilitate location finding of virtual tactile dots.
- Refreshable tractile displays are useful for understanding dynamic map information; but are commonly unobtainable due to size, weight, and price.

- While navigation by vibrotactile feedback is possible and can be accurate, the time to do so can be too long. As such, the overarching concern is practicability.

Questions

1.) What ways can we overcome the limitations of the limited amount of motors in smartphones? 2.) How can we reduce the amount of time required for information retrieval by the visually impaired? 3.) Reducing the search time would make the vibrotactile map feasible, how can Fittz's law apply?

Evolution of the Information-Retrieval System for Blind and Visually-Impaired People

Citation

(Dobrišek et al. 2003)

Introduction

Slovenian paper published July 2003

In the mid-nineties the paper's research group decided to develop an information retrieval system suitable for Slovene-speaking blind and visually-impaired people. A voice-driven text-to-speech dialogue system was developed for reading Slovenian texts obtained from the Electronic Information System of the Association of Slovenian Blind and Visually Impaired Persons Societies. The evolution of the system is presented.

Conclusion

The development of the paper's voice driven text to speech dialogue system is expected to evolve towards a specialized web browser with a mouse driven text to speech screen reader and voice driven dialogue management and that improvements in the sense of more accurate and robust speech recognition and a user friendly system to control high quality speech synthesis.

Lessons Learned

This paper is not inherently relevant to any methods of decreasing the amount of time it takes for blind or visually impaired people to retrieve information, and is more so about being able to facilitate the act of being able to retrieve information in the first place than performance increase.

Examination of the Level of Inclusion of Blind Subjects in the Development of Touchscreen Accessibility Technologies

Citation

(Thompson 2018)

Introduction

2018 paper, fairly recent. This is one of the papers that cited Aaron's paper,(Evaluating Fitts' law on vibrating touch-screen to improve visual data accessibility for blind users).

This is mostly a surface level dissertation that explores the efforts of designing accesibility technology for the blind, and the consequences of not including blind participation, or even blind research, in the development of said technologies. It also includes interesting discussion of a lack of standards across applications and hardware and the results of such disparity.

- there are two core reasons as to why this paper states this dissertation exists. The first is to identify a key gap within the body of research that deals with improving touchscreen accessibility for the blind.
- The second reason is to collect a body of data on both blindness and touchscreen accessibility for blindness in order to make it easier to avoid these types of shortcomings in the future.

Study

There is no study beyond a collection of research and suggestions for future research/applications.

Conclusion

Initially, this paper was to be an exploration of the current research and existing accessibility tools available to the blind in order to allow them to utilize touchscreen devices, particularly with regards to mobile internet. However, it was discovered in the course of the initial survey of literature that some of the research, especially pieces concerning the development of new hardware, frequently lacked references to research on blindness, and in some cases blind participants. So the subject changed and instead became an exploration of the impact of these decisions on the validity of the research results

Lessons Learned

- The inclusion of Blind/visually impaired participants is very important to ensuring that what is being developed is useful to the group it's being devloped for.
- The development of software/hardware should have referenced research to support its development.

Questions

Feasibility of Using Haptic Directions through Maps with a Tablet and Smart Watch for People who are Blind and Visually Impaired

Citation

(Grussenmeyer, Garcia, and Jiang 2016)

Introduction

Published September 2016.

This paper includes a study that includes two prototypes intended to test users' ability to trace graphical lines and directions through Maps on a touch screen using Haptic feedback from an Android smartwatch and tablet.

The research contributes a prototype with two devices that are easily available, a smartwatch and tablet to determine distance between vibrating lines. A comparative user study with this prototype at

Study

Conclusion

The first prototype showed that blind and visually impaired users had a lower threshold than sighted users for determining the distance between two lines on a touchscreen. The plaper suggested that the blind and visually impaired users had an enhanced ability to form representations lot spacial distance from tactile vibrational cues.

The paper's second prototype explores this by showing that it is feasible for blind and visually impaired users to follow directions through graphical maps haggard on vibrational cues.

The paper states that it believes the results from the prototypes show that they have the potential to be effective in real-world applications.

Lessons Learned

Questions

The Sound and Feel of Titrations: A Smartphone Aid for Color-Blind and Visually Impaired Students

(Bandyopadhyay and Rathod 2017)

Introduction

This paper discusses an Android based application that has been developed to provide colorblind and visually impaired students a multi-sensory perception of color change observed in a titration.

(Titration is a technique where a solution of known concentration is used to determine the concentration of an unknown solution; color change often occurs.)

The application that was developed records and converts color information into beep sounds and vibration pulses which are generated by the smartphone.

The application uses a combination of hue, saturation, and value for detecting a color change specific to an indicator, e.g., shades of pink; and informs the user before and upon attending the endpoint.

This approach can enable color blind and visually impaired students to actively perform a fairly routine laboratory activity of titration.

Study

- There does not seem to be any user testing included in the document, it appears that the app was released on the Play store and visually impaired users were able to try it anonymously. There is no formal user study included.
- A summarized process scheme involved in the detection of color change includes the following steps:

1. The user chooses to point the camera near the area on the conical flask where the titrant is added dropwise to the titrand solution. The area viewed through a crosshair is stored by the camera function of the application when the device is pointed at the area of concern in the “record” mode.
2. The data stored in the stored pixel is converted to RGB (red, green, blue) values.
3. RGB data is then converted to the corresponding hex code value and HSV. The hex code is used to return the name of the detected color by cross-referencing with the color-name database. (24)
4. For a particular indicator, e.g. phenolphthalein, a hue coordinate (from HSV color space) range is specified. This range encompasses all the colors

that can appear while performing titration using any of the commonly used indicators as given as an option in the app. Additionally, a saturation value (from HSV color space) threshold ensures that the app detects and responds to the color change above a certain background noise.

5. When the application signals a color change, the hue and saturation values of the detected color satisfy the conditions mentioned above. For notification of the change, the device generates beeps and vibration pulses. This auditory and tactile feedback assists a student to comprehend that a color change has occurred.

Conclusion

The titration app "Titration ColorCam" is available on the Google Play store for Android enter devices. The paper cites without evidence that between users that are not visually impaired and users that are basically impaired, using the app to complete titrations has similar user error.

The paper cites that the application allows visually impaired to autonomously complete titrations with minimal assistance from fellow students, and concludes on a hopeful note that the application could be further developed into a mobile friendly app that allows students to effectively complete titration experiments despite being visually impaired.

Lessons Learned

- mobile phones offer a low cost means of software accessibility for the visually impaired
- Vibration and audio feedback can be useful for relaying information to the visually impaired.

Questions

If we were to pursue navigation or information, would a mobile app be effective for economic accessibility?

This mobile application doesn't allow an individual to know what colors are hy sound or vibration alone, only to indicate when changes are taking place. What studies do have this? Is it feasible?

Visual Impairments and Mobile Touchscreen Interaction: State-Of-The-Art, Causes of Visual Impairment, and Design Guidelines

Citation

(Vatavu 2017)

Background

This was an in depth look into what potential problems and solutions can arise from mobile touch screen interactions when used by people with visual impairments. Along with the latter statement this paper also had a very in depth looks into causes of visual impairment. This portion of the paper does not pertain to us.

Study

The portion of the paper we are making use of includes the summary of the design guidlines put forth by other (referenced) papers. No testing or surveys were done in this portion of the paper, it is simply a summation of previous guidelines.

Results

The guideline summation is as stated:

- Allow configurable visual settings. (studies show people with vis impairment will spend alot of time configuring settings)
- Design for commercially-available wearable devices.
- Design mobile device interactions to reduce encumbrance when using other accessibility devices
- Detect and deal appropriately with unintended touch (possibly a toggle for touch)
- Design usable touch gestures for people with visual impairments (favor landmarks of the device)
- Deliver appropriate feedback for all visual abilities.
- Deliver appropriate feedback during and after gesture articulation

Questions

1. What does appropriate feedback look like in our case?

Lessons Learned

Facilitating Route Learning Using Interactive Audio-Tactile Maps for Blind and Visually Impaired People

Citation

(Abd Hamid and Edwards 2013)

Introduction

This paper covers the information needed to develop a route for the visually impaired. This paper also aims to answer which are the most important landmarks and sounds to include in the route design.

Study

The authors of the paper conducted a survey of 15 different mobility and orientation instructors. From the paper:

> An online survey study The aim of the online survey study was to build on the information obtained from the mobility instructor by surveying others in the profession. The questionnaire concentrated on detailed information of the type of auditory features and landmarks they feel important in guiding people with visual disabilities in route learning.

Conclusion

From their results stated in the paper:

- All instructors serveyed claimed the use of landmarks and audio queues was optimal for developing a route.
- All instructors besides 1 developed their own maps.
- All instructors claimed that the use of landmarks that are immovable and permanent such as buildings and intersections where optimal.
- Ambient sounds such as running water, sounds from ground textures, and vehicle sounds are all important.
- Sound from ground textures ranked #1 most important sound for route development.
- Intersections and buildings ranked as the most important landmarks for route development.

Lessons Learned

-Ambient sound should not be overlooked. -Intersections are very important as well as traffic. -Landmarks should be immovable and permanent.

Questions

Investigating Accessibility on Web-based Maps:

Citation

(Medina, Cagnin, and Paiva 2015)

Introduction

This paper presents results of an accessibility evaluation carried out with web-based map applications. Three points of view were considered: experts on accessibility, evaluation tools, and final users (partially or totally blind users)

Study

A number of problems was identified and none of the evaluated applications entirely meet the analyzed criteria.

Below are the goals and questions for the following results

> Goal1: Analyze web-based mapping systems, in terms of accessibility, from the point of view of experts in web accessibility. Question1: Which Success Criteria from WCAG 2.0 - Level A - are implemented by the web systems evaluated? Question2: What level of compliance in WCAG 2.0 each web system can be classified? Metric1: Sum of Success Criteria that are not implemented by the systems, whereas the option given by experts in the questionnaire is "It does not meet". This metric serves the > Question1 and shall be applied in each one of the analyzed systems.

The experts analyzed the five selected websites, searching for some infringement of the Success Criteria. Item by item, the experts had to answer if the Success Criteria was fulfilled on that specific website.

Guidelines Graded By Expert COMS: https://www.w3.org/TR/WCAG20/

Conclusion

I will only be focusing on how google rated among the criteria.

Expert COMS Eval:

Expert COMS evaluation of google:

> 7 successes for google, 12 not met. These 12 not met include: 1.1.1 - Text Alternatives: Provide text alternatives for any non-text content so that it can be changed into other forms people need, such as large print, braille, speech, symbols or simpler language. 1.2.1 - Time-based Media: Provide alternatives for time-based media. 1.2.2 - 1.3.1 - Adaptable: Create content that can be presented in different

> ways (for example simpler layout) without losing information or structure. 1.3.2 - 1.3.3 - 1.4.1 - Distinguishable: Make it easier for users to see and hear content including separating foreground from background. 2.1.1 - Keyboard Accessible: Make all functionality available from a keyboard. 2.1.2 - 2.4.1 - Navigable: Provide ways to help users navigate, find content, and determine where they are. 2.4.2 - 2.4.3 - 2.4.4 - 3.1.1 - Readable: Make text content readable and understandable. 3.2.2 - Predictable: Make Web pages appear and operate in predictable ways. 3.3.1 - Input Assistance: Help users avoid and correct mistakes. 3.3.2 - 4.1.1 - Compatible: Maximize compatibility with current and future user agents, including assistive technologies.

Tool Based Eval:

The tool-based evaluation aimed to identify success criteria that were not properly implemented by the analyzed websites.

> Google ranked lowest in all 5 tools. 11 unmet by google based off of tool checking, the other 4 websites had a better score (6,4,7,8).

End User Eval:

Functionalities graded the highest avg between 8 users:

> All 100% grade Activity 1: lookup for an address, using the search field; Activity 5: find the function buttons to "get directions" and "my places"; Activity 6: use function "get directions" with start and end addresses; Activity 7: use function "avoiding tolls" on a chosen path in a given address; Activity 8: change the path to "walking";

Functionalities graded the lowest on average:

> Activity 9: use the zoom feature on the map. 0% Activity 4: access photos of a given address, and read their descriptions; 0% Activity 3: switch between "Map" and "Satellite" views, using the website tools; 50% Activity 2: find out the name of a neighborhood with a supplied address;87.%

In Activities 4 and 9, not a single visually impaired user completed the tasks, indicating possible severe accessibility problems.

Lessons Learned

1. Google Maps has many accessibility needs to be met.
2. Expert COMS opinions do correlate to how the end user performs.
3. Tool based eval is not the best way but provides a decent evaluation for more broad criteria.

Questions

CapMaps - Capacitive Sensing 3D Printed Audio-Tactile Maps:

Citation

(Timo Götzelmann 2016)

Introduction

This paper presents us with ways to link audio with tactile maps in order to reduce the tactile complexity of the map. the major challenge of audio-tactile maps is linking the audio to the map in a presentable way. The way this is achieved in this paper is by using conductive filement inside the 3D printed tactile map. This conductive filement will transmit the touch from the map and produce audio output from a mobile device. To demonstrate the effectiveness of this approach they performed a study.

Study

In order to actually produce the audio-tactile maps a duel headed 3D printer was used, one head printed in standard PLA while the other head printed a special conductive filement called Trijexx Conductive. On one side of the map there is a conductive flat portion. A touch of the user on the one side of the 3D printed capacitive code is forked into multiple locations on the display's surface, inducing the detection of multiple concurrent touches. Software analyzes concurrent touches and classifies them into normal touches and specific codes. Thus, the 3D printed tactile map is able to transmit information to the surface by a single touch. This also provides I nice landmark for users to determine the orientation of the map.

Next they performed a feasibility study that essentially tested whether or not the flat conductive material on the side worked well enough to transmit the scale of the map, GPS coordinates, distances, and orientation of the map to the real world. During the tests the users where able to obtain all of this information about the map features via double tap(name of feature), triple tap (type of feature), and a long tap(names of surrounding features).

Conclusion

In conclusion this paper focused mostly on attaching audio descriptions to tactile 3D printed maps and discovered how interactive content should be structured to support navigation and orientation.

Lessons Learned

1. 3D printed audio-tactile maps are feasible but have limited capabilities.

2. 3D printing a map that combines PLA and conductive material is time consuming yet effective for areas that aren't subject to change.

Questions

Is there a way to automate designing the 3D maps with CAD (designing the maps seemed like the most time consuming part)?

Accessible smartphones for blind users: A case study for a wayfinding system:

Citation

(Rodriguez-Sanchez et al. 2014)

Introduction

This paper starts of by introducing the problems with current smartphone accessibility and provides solid background on each issue: screen readers, each app having different layout, current accessible maps not being scale-able, storing audio locally vs web based that would require a connection, and provides and interesting statistic that 82% of blind people are aged 50 or over (Zajicek & Brewster, 2004) therefore smartphones are harder to make accessible since most people that age aren't attuned to using them in the first place. They also state that the age of going blind is a factor that should be considered.

Study

Before setting up the end-user testing they begin by developing an accessible navigation app that has a menu(current location, help, destination address, and information) based off of the smartphones landmarks(each corner). This app provides multi-model feedback, audio and tactile. To begin thier end-user testing they have 18 participants (9 partially blind, 9 fully blind) navigate from a building to a subway across 430meters while using the app. The feedback about the proper direction is constantly provided and the phone vibrates when the direction is the correct. These participants that are partially blind performed better both using just audio feedback and using multi-model. The fully blind participants actually halved thier travel time switching from audio only to multi-model. The app made use of a waypoint system, these participants would not simply go straight to the destination but instead follow waypoints sequentially. Something of note is that the authors supposed an idea that the users could comment on waypoints so that when another person takes the route they can hear the comment and hopefully be provided with helpfull info. At the end of this study the participants where asked a series of questions:

> Q1) After the training, do you think the wayfinding application software is easy to use for blind users? Q2) Is it easy to choose a specific destination? Q3) Is it useful that the wayfinding application contains physical references on the route? Q4) Is there enough auditory feedback? Q5) When the auditory and tactile feedbacks are activated, is the navigation better than when you are using only audio?

Conclusion

> Multi-model is proven time and again that it is the ideal feedback medium (audio-tactile).
>
> From the authors results it is shown that partially blind participants perform better in all test cases.
>
> Questionaire results are shown in Table 1. shown that most features of the app are effective.
>
> All participants preferred the fixed regions.
>
> Constant feedback was preffered.
>
> A waypoint system is effective.

in the reverse path, the average time decreased down to 10 min for blind people and 8 min for limited vision users. Furthermore, when users were using the second mode (audio, touch screen and tactile feedback) in the second trial, the time spent also decreased: 14 min for blind people and 12 min for limited vision users when they are walking from the building to the subway and the reverse path was the half the time for both types of users. This fact is due to the users learning both the path to follow and how to interact with the wayfinding application of the smartphone.

We can conclude that the wayfinding application is well designed and it is usable and accessible for visually impaired people

Lessons Learned

1. Constant feedback is preffered
2. A comment system may be effective?
3. Fixed regions for application design is preffered.
4. Multi-model strikes again.(very effective and preffered)

Questions

1. Is this app still availible today?
2. How scalable is the GUI using device landmarks?
3. Which type of constant feedback is preffered(audio or tactile)?

Usability Evaluation of a Web System for Spatially Oriented Audio Descriptions of Images Addressed to Visually Impaired People:

Citation

(Neto et al. 2014)

Introduction

This paper starts by introducing the fact that 285 Million people are visually impaired and of those 39 Million are blind (worldwide). Next they present the fact that screen reader software is getting more advanced yet still generally lacks the ability to “read” digital images because it often lacks alternate text(html coding thing). This paper will present a software to address this issue as well as user backed testing. The user backed testing with verify the usefullness and the validity of the implemented solution.

There are two main problems that are being addressed, firstly, alternative text is rarely properly placed/written. Secondly, the alternate text that is provided is insufficient.

It is difficult to write an image description that can cover various types of information that a visually impaired user could ever possibly need to understand.

The text description is insufficient to make users understand clearly the spatial arrangement of elements in the image.

The authors propose a solution to the spatial arrangement problem via tactile feedback. A basic solution is to create a tactile screen/display with pins or sensitive polymer membranes capable of forming complex outlines and shapes.

Expensive devices can remedy these issue’s to a degree but cost in the thousands. Instead the authors propose that a simple and cheap but no less effective solution is through multi-modal web based applications.

Study

They developed a software prototype of a web technology called AudioImagem through which a sighted person is able to delimit areas within an image and associate audio descriptions to them. There are two forms of use in the app and these are: static mode and navigation mode. Static mode doesn’t depend on cursor position(can place cursor anywhere and won’t affect outcome). Their are two ways to get audio descriptions in static mode: short response and long response. Simply put they are short and long descriptions of the image. These descriptions rely on programmers/users to type out both descriptions for the images.

The next mode navigation mode is where a user can guide the cursor around the image and obtian descriptions based off of position on the image. Again, these descriptions rely on a real human to type them out.

In navigation mode if the cursor leaves the image the app will have an audio queue for which side the cursor left out of.

The authors added a end-user test to determine the usefullness. 5 participants where monitored through cameras, keylisteners, screen recorder, and microphone, and tasked with a list of 12 tasks.

For Example: Task 2:

> Short description: “Photo of an autumn landscape”. (C key) Long description: “This is a photo of a bleak autumn day landscape. There is a street crossing the photo on the left and a leafy tree with orange leaves on the right side”. (L key) Task: “Observe the photo and describe as you understand it” (T key)

Task List:

> tasks 1 and 2 displayed landscape photos
>
> task 3 a drawing of the world globe
>
> task 4 a geographical map of Brazil
>
> task 5 an ecosystem flowchart
>
> task 6 a trigonometric table
>
> task 7 an algorithm flowchart
>
> task 8 a drawing of the kinds of cow meat
>
> task 9 a phase graph diagram of chemical substance
>
> task 10 a plan drawing of chessboard with all pieces
>
> task 11 a diagram of Daniel chemical cell
>
> task 12 a figure of the periodic chemical table

Each task was designed to take 5-10 minutes.

Conclusion

In conclusion: On average the 5 users spent 2 hours and 20 minutes to complete all tasks. This meant it took 11.5 minutes on average per task.

Users	Kind of disability	Screen reader experience	Tasks concluded	Tasks part. concluded	Tasks not concluded	Time test (hour)	Tablet (Pen or Finger)
P1	Low Vision	Yes	11	0	1	1:59	Finger
P2	Blind	Yes	5	1	4	1:58	F and P
P3	Blind	Yes	4	4	2	2:43	F and P
P4	Low Vision	Yes	9	0	2	2:21	Pen
P5	Low Vision	No	5	0	7	2:49	Pen

Lessons Learned

1. Screen reader experience matters when developing something like this.
2.

Questions

1. Can the use of AI speed up or improve this design?

Evaluating Fitts' law on vibrating touch-screen to improve visual data accessibility for blind users:

Citation

(Lahib, Tekli, and Issa 2018)

Introduction

The goal of this paper is to evaluate whether or not Fitts' Law can be applied to a vibrating touch screen in the context of blind users. In this case the blind users where either fully blind, blindfolded, or sighted.

To evaluate Fitts' Law the authors produced thier own app that would be used to record the data and calculate Fitts' Law along with relevant data points. This app was made to study the ability of blind users to tap specific shapes on a touch-screen while varying different parameters: mainly(target distance/size, and angle of attack).

This paper's highlights:

> Reviews the literature on Fitts' Law and visual data accessibility solutions for blind users.
>
> Studies the ability of blind users to point to shapes(circles) on a vibrating touch-screen (VTS).
>
> Varies different pointing task parameters: target distance, target size, and angle of attack.
>
> Fitts' Law can be applied for blind users using a VTS when varying target distance and target size.
>
> Fitts' Law is not verified for blind users using a VTS when varying the angle of attack.

Aside from everything stated above, this experiment was conducted NON-multi-modally.

Study

As the expirement protocol three pointing task experiments where performed in which 1 parameter changed per experiments.

1. Distance variation from target
2. Size variation of target
3. Angle of approach variation

Every experiment first contained a "Mapping/Learning" phase where the user would point(**not touch/tap**) to both points with the help of a test overseer.

Firstly each user would be told, the experiments to be conducted, the nature of each experiment, the tasks to be completed, as well as how to handle the vibrating touch-screen, environment (e.g., how targets are presented on the vibrating screen, control buttons, etc.). In addition, test subject profile data (e.g., name, age, gender, type of blindness: since birth or after birth, etc.) is recorded at this stage. After this stage the users would enter the actual testing phase where they were tasked with touching given points on the screen.

Experiment 1: The goal of this experiment is to prove the following hypothesis: A pointing task performed by a blind user on a vibrating touch-screen is affected by the distance between the source and the target points following Fitts' Law.

The distance being varied was ranged between 120, 200, and 240 pixels on a 1280x800 screen with a density of 149 pixels per inch and a 10.1 inch screen size.

The size of the target is fixed and the angle is fixed at 180 degrees(horizontal).

Experiment 2: The goal of this experiment is to prove the following hypothesis: A pointing task performed by a blind user on a vibrating touch-screen is affected by the size of the source and the target points following Fitts' Law.

The target size being varied ranged between 40, 60, 80, and 90 pixels using the same screen configuration as above.

Because the targets are circles the size refers to the diameter of the circle.

The distance is fixed and the angle is fixed to 180 degrees(horizontal).

Experiment 3: The goal of this experiment is to prove the following hypothesis: A pointing task performed by a blind user on a vibrating touch-screen is not affected by the angle between the source and the target points, following Fitts' Law.

The angle being varied ranged between 0, 30, 60, 90, 120, and 150 degrees.

The distance is fixed to 120 pixels and the target size is fixed to 40 pixels.

Users/Testers: Twenty-nine testers, aged between 21 and 30 years old, participated in the experimental evaluation:

i) six Blind Since Birth (i.e., BSB)(1 female and 5 male)
ii) seven Blind After Birth (i.e., BAB)(5 females and 2 males)
iii) sixteen Sighted (8 females and 8 males).

The authors asked half of the sighted testers (4 females and 4 males) to conduct the experiments Blindfolded (i.e. BF), whereas the other half conducted the experiments sighted (so that we could compare and contrast results)

All in all, each tester performed: 4 (runs of Experiment 1) x 3 (distance variations) x 25 (pointing trials) + 3 (runs of Experiment 2) x 4 (size variations) x 25 (pointing trials) = 600 pointing trials.

Conclusion

- Results of Experiments 1 and 2 show that MT (movement time) and Err (tapping error percentage) for all groups of users tend to concur with Fitts' Law, where both average MT and Err increase with increasing target distance (1) and decreasing target size (2). In other words, both hypotheses of Experiments 1 and 2 have been verified.
- Results of Experiments 1 and 2 also show that BAB testers produce the highest MT and Err levels, followed by BF testers and then BSB testers.
- Results of Experiment 3 show that MT only marginally varies with varying angles of the target, which concurs with Fitt's Law: given that angle variation is not a parameter in Fitt's mathematical model.
- Yet, results of Experiment 3 show that average Err levels are seriously affected by changes in the angle of the target, where Err is highest with steep angles (e.g., 120° and 60°), and lowest with close to flat (e.g., 0°) angles. Err is highest with BAB testers, followed by BF and then BSB. Given the latter, we can state that Experiment 3's hypothesis is not verified: A pointing task performed by a blind user on a vibrating touch-screen seems to be affected by the angle between the source and target points.

Lessons Learned

1. Fitts' Law can be applied to touchscreens with blind users when the distance and target size are being considered but not when angle is being considered.
2. a single medium of feedback is still affective in this context. (varying distance and size).
3.

Questions

1. I wonder if the reason for the varying angles producing more error is because of the practice the had from the previous 2 experiments.
2. Will the use of multi-modal feedback be able to be evaluated by Fitts' Law and if so, will it improve the MT and decrease error rate?
3. Will using a plethera of vibration motors in the device improve performance?

The Reliability of Fitts's Law as a Movement Model for People with and without Limited Fine Motor Function:

Citation

(Sharif et al. 2020)

Introduction

The goal of this paper is determine how affective Fitts' Law is on subjects with limited fine motor skills. It does not cover anything about visually impaired peoples or blind people. However, this paper may still be relevant to our research.

This paper will explore specifically the test and re-test reliability of Fitts' Law in terms of throughput and model fit.

Study

Apparatus:

> Microsoft Surface Book 2 laptop measuring 13.1" by 9" set as 3000 x 2000 resolution running the Windows 10 operating system, using 8 GB RAM.

Test Procedure:

> "Each participant took part in two sessions, which were at least four and at most 48 hours apart. In each session,participants performed 10 target acquisitions for 5 target widths (W : 8, 16, 32, 64, 128 px) $\times$ 3 target distances (A: 256, 384, 512 px), for a total of 15 A$\times$W conditions and $10\times15 = 150$ target acquisitions. Each acquisition was a single attempt to click a 1-D vertical"ribbon target" (Figure 1). The target sizes and distances were decided based on typical icon sizes and the distances between the elements present in conventional user interfaces such as Web pages. To account for learning efects, the order of the conditions was randomized across sessions and participants, as is standard practice in Fitts's law studies. Participants were instructed to perform the tasks as quickly as possible while conforming to an error rate between 4-8%, equating to a total of 6-12 target misses per session. Participants were given the choice to practice the tasks before the start of the session. However, none of the participants chose that option and found the instructions sufcient. Additionally, participants were encouraged to take breaks in between the A$\times$W conditions but not during the trials."

Participants were tested over 15 Distance$\times$Width conditions in each of the two sessions, resulting in a total of $10\times15\times2 = 300$ trials per participant. With 50 participants, a total of $50 \times 300 = 15,000$ trials were produced and analyzed in this study.

Conclusion

Results suggest that Fitts's law provides low test-retest reliability. Importantly, the test-retest reliability of Fitts's throughput metric was 4.7% lower for people with limited fine motor function.

> "Additionally, we found that the model ftness of Fitts's law as measured by Pearson correlation coefcient, r, was .89 (SD=0.08) for people without limited fine motor function, and .81 (SD=0.09) for people with limited fine motor function. Taken together, these results indicate that Fitts's law should be used with caution and, if possible, over multiple sessions, especially when used in assistive technology evaluations"

Lessons Learned

1. Reliablity of re-testing Fitts' Law is sketchy especially when evaluating with impaired users.
2. When testing for accessibility reasons, multiple testing sessions should be utilized.

Questions

1. Will this apply to blind participants?
2. Can we make assumptions relating to blind participants?

Bullseye! When Fitts' Law Doesn't Fit:

Citation

(Friedlander, Schlueter, and Mantei 1998)

Introduction

This paper looks to discover the effectivness of a bullseye menu by evaluating with Fitts' Law and a study.

The papers introduction specifies they are trying to find the selection time and not the search time.

Study

> "The experiment consisted of four one-hour sessions. The sessions were on four consecutive days -we wanted subjects to have one night's sleep in between sessions to alleviate fatigue effects and at the same time to ensure that any learning that had taken place during that day's session would not be forgotten."

For each trial, a bIack compass was displayed at the center of the screen (Figure 4), with the north, south, east and west arms marked "N", "S", "E" and "w" respectively. The centre of the compass contained a letter (either N, S, E, W) and a number (1 to 7) indicating the direction and ring index of the target selection.

Each trial set consisted of 32 trials. It began with 4 practice trials, where the user was instructed to move in one of four directions for 4 signals. These practice trials were not included in the data analysis.

Conclusion

It should be noted that the results from the regression analysis of theFitts' Law case are quite good: in both the auditory and tactile cases the ? value of these analyses are higher than 0.9. Wnhout consideration of the linear model it would be quite understandable to assume that Fitts' Law is the best predictor model for the task at hand. An important implication of our work is that Fitts' Law should not be the only performance model tested for new user interface tasks. Even if it fits the task quite well, there may be a better choice.

Lessons Learned

1. Fitts' Law should be double checked with possibly another algorithm or even replaced with a better fitting model.
2. the Law should be followed carefully when exploring new UI.

Questions

1.

Using an Audio Interface to Assist Users Who Are Visually Impaired with Steering Tasks:

Citation

(Cohen et al. 2006)

Introduction

The goal of this paper is to explore and design tools that assist users with visual impairments to understand relational data through graphs(mathematical term, edges and vertices).

Using audio feedback only (single modal), the users will be able to traverse a graph and obtain spoken word data from the graph as well as varying audio pitches to determine how far along an edge they are and if they have navigated off of the edge.

Figure 3 in the paper provides an example graph of European cities in relation to each other. For users to traverse the graph they use a stylus and navigate based off the audio feedback listed above. When they reach a vertice there will be a robotic voice much like Apples Siri that will tell them the information attached to that node. The users will also recieve audio feedback in varying frequencies related to how close they are to the next vertice. This audio will cut out when the user leaves the edge.

The latter statements are what led to many participants using a "tacking" technique in which the users would slide the stylus back and forth along the line to get a better idea of the slope of the line.

Study

The beginning tests where broken into four stages in which the graphs would get increasingly complex. For example:

> First test - Single vertex/edge Last test - Complex graph showing European cites

They note that the participants generally enjoyed using the system and where all able to learn the interface.

Next from these first tests they concluded that the largest problem was context. Each participant had trouble when asked to find a specific vertice because they would have to randomly search the entire graph in order to find it (there was no relational data). However, the same was not the case for geographic graphs assuming the user had some experience of the area. For example in the European cities graph if a user found London then they would know where to generally look to find Kiev. So in closing, if the user had some time to study the graph/geographic area they would be able to locate specific vertices in a relatively short amount of time.

Conclusion

> "To our surprise, we also found that edge angle and edge direction were not statistically significant factors in performance between subjects."

In conclusion they found no preferance in differing angles or positions. The next idea they conclude is that this software/tool may be better suited for graphs with geographic data rather than graphs with purely abstract data.

Lessons Learned

1. Relational graphs involving geographic data can be effective.
2. Graphs should contain relational data rather than abstract information.

Questions

1. How much more training if possible would make this technique second nature?
2. How much time would users need to study a graph for this to be an effective solution?
3. If the user doesn't want to use "tacking" is there an ideal edge width or vertice size?

Timbremap: Enabling the Visually-Impaired to Use Maps on Touch-Enabled Devices

Citation

(Su et al. 2010)

Introduction

> Mapping applications on mobile devices have gained widespread popularity as a means for enhancing user mobility and ability to explore new locations and venues. Visually impaired users currently rely on computer text-to-speech or human-spoken descriptions of maps and indoor spaces. Unfortunately, speech-based descriptions are limited in their ability to succinctly convey complex layouts or spacial positioning.

Study

> This paper presents Timbremap, a sonification interface enabling visually impaired users to explore complex indoor layouts using off-the-shelf touch-screen mobile devices. This is achieved using audio feedback to guide the user's finger on the device's touch interface to convey geometry. Our user-study evaluation shows Timbremap is effective in conveying non-trivial geometry and enabling visually impaired users to explore indoor layouts.

Conclusion

> This paper contributes an implementation and user study with visually impaired participants using two sonification hinting modes, both of which were effective in conveying shape geometry to participants. In addition, we qualitatively show that a participant is able to use the presented sonification interface for an indoor floor-plan exploration application, and is able to piece together a map larger than can be displayed in one screenful.

Lessons Learned

- Timbremap

Further Questions

- Is this open-source?
- How can we use it?
- How difficult is it to use?

Visually Augmented Audio-Tactile Graphics for Visually Impaired People

Citation

(T. Götzelmann 2018)

Introduction

Tactile graphics play an essential role in knowledge transfer for blind people. The tactile exploration of these graphics is often challenging because of the cognitive load caused by physiological constraints and their complexity. The coupling of physical tactile graphics with electronic devices offers to support the tactile exploration by auditory feedback.

Study

As a proof-of-concept, we carried out a feasibility study including working prototypes of a com- mon type of audio-tactile graphics, i.e., audio-tactile maps. These prototypes used the capacitive codes proposed in the last section and adapted the obtained technical parameters for designing the tactile elements. Multiple approaches exist to generate tactile maps and to automatically as- sign verbal explanations and visual augmentations to graphical elements of the map. These maps, called LucentMaps, were translucent to be visually augmented. For this study, we implemented a mobile application for detection of the tactile graphics, to provide verbal feedback and to visually augment parts of the graphics the user is interacting with.

Conclusion

Based on the developed generic concept on visually augmented audio-tactile graphics, we presented a case study for maps. The maps used for the case study can be semi-automatically generated by existing approaches (e.g., Reference [13]). We designed an interaction concept and adapted our approach to the needs for the audio-tactile exploration of maps. Finally, it was implemented prototypically and tested with a user study with visually impaired people. All the participants were able to couple the tactile graphics with a standard tablet computer within seconds and to interact with the 3D printed tactile maps. They visibly enjoyed the interaction with the visually augmented tactile maps.

Lessons Learned

- 3d printing a map and adding audio feedback is a fantastic way to provide information

Further Questions

- What's the easiest way to add audio feedback to the 3d prints?

Differences between blind people's cognitive maps after proximity and distant exploration of virtual environments

Citation

(Cobo et al. 2017)

Introduction

According to the authors,

> There have been three traditional hypothesis about whether blind people can understand and manipulate spatial concepts.

1. Deficiency
   - Argues that blind people are unable to develop spatial thought
2. Inefficiency
   - Blind people *can* understand spatial thought, but cannot understand to the same level as someone who is not blind
3. Difference
   - Blind people are just as capable of spatial thought

Many studies have been done, and a significant portion seem to support the Difference hypothesis.

Study

The authors developed an Android app using Unity3D. This app allowed participants to "explore" and/or "look" around a room containing furniture, objects, etc, by using the touchscreen and the gyroscope.

The authors wanted to specifically test "distant-exploration" and its effectiveness:

> We propose a distant-exploration approach where blind people can explore the room by controlling the direction of the avatar's line of sight. Feedback regarding obstacles beyond the reach of the cane may be obtained with no need of making the avatar to walk along the virtual space.

Conclusion

The authors found a significant difference in understanding and required exploration time when using the "distant-exploration" approach. The sample size was limited though, and more research is needed to come to a sound conclusion and methodology.

Lessons Learned

Further Questions

1. What were the feedback forms used?

Image Accessibility for Screen Reader Users: A Systematic Review and a Road Map

Citation

(Oh, Joh, and Lee 2021)

Introduction

Oh, Joh, and Lee (2021) reviewed 33 papers (using PRISMA guidelines) with two goals in mind:

1. Understand the current accessibility solutions for screen reader users to "view" images
2. Identify gaps in understanding and suggest a research roadmap

They discovered several things:

- The types of images, visual information, input devices, and feedback modalities that have been studied to assist in image accessibility on touchscreen devices
- Very little research has been done on the automation of image-related information
- Input from target users is *very* important when designing new accessibility solutions

Study

Note: BLV = Blind/Low Vision

The authors had five questions for their review:

> RQ1. What types of images have been studied for image accessibility?
>
> RQ2. What types of image-related information has been supported for BLV people?
>
> RQ3. How has image-related information been collected?
>
> RQ4. How has image-related information been delivered?
>
> RQ5. How have BLV people been involved in the design and evaluation process?

Most of the reviewed papers focused on specific types of images. Here were the main three:

Specific Image Type	Number of Papers
Maps	10
Graphs	6

Specific Image Type	Number of Papers
Geometric Shapes	4

Conclusion

The authors came to several conclusions:

1. Image types other than maps, graphs, and geometric shapes are rarely studied
2. Only about 1/3 of the papers provide multi-modal feedback
3. The lack of an automated way to retrieve image-related information is currently an important barrier in making large-scale solutions
4. Studies should get BLV individuals involved early in the process, as their feedback is very important when making design decisions

Lessons Learned

Further Questions

Accessible Maps for the Blind: Comparing 3D Printed Models with Tactile Graphics

Citation

(Holloway, Marriott, and Butler 2018)

Brief Summary

Several studies were done on the effectiveness of Orientation and Mobility (O&M) training for people with blindness and severe vision impairment using 3D models. These studies seem to suggest that 3D models are preferred and more effective than the tactile equivalents for 2D graphics. 3D models can also be enhanced using interactive audio labels.

Main Study: Comparing Tactile Maps & 3D Prints

- 3D models were preferred

Preferred format by map type, as revealed through use (neighborhood map) or self-reporting (park maps and station plans)

map	tactile graphic	both	3D model
neighborhood	5	2	9
park	3	0	13
station	4	1	11

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