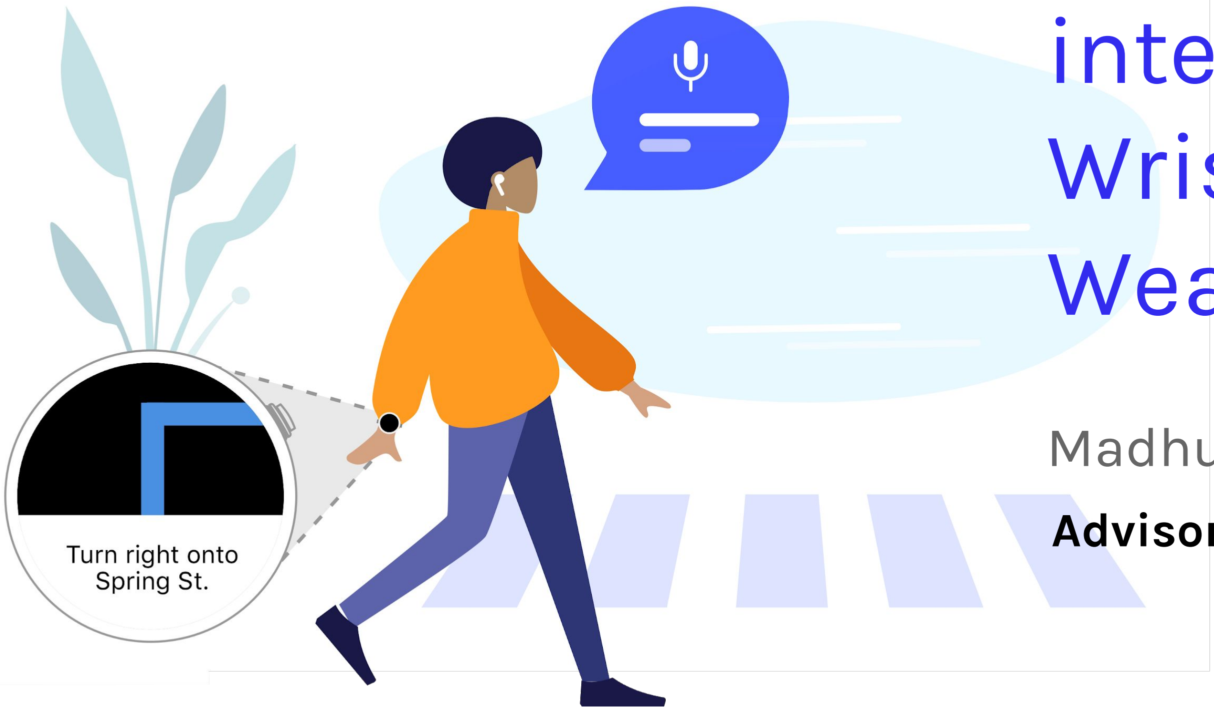
Serpentine: Alternate interactions for Wrist Wearables



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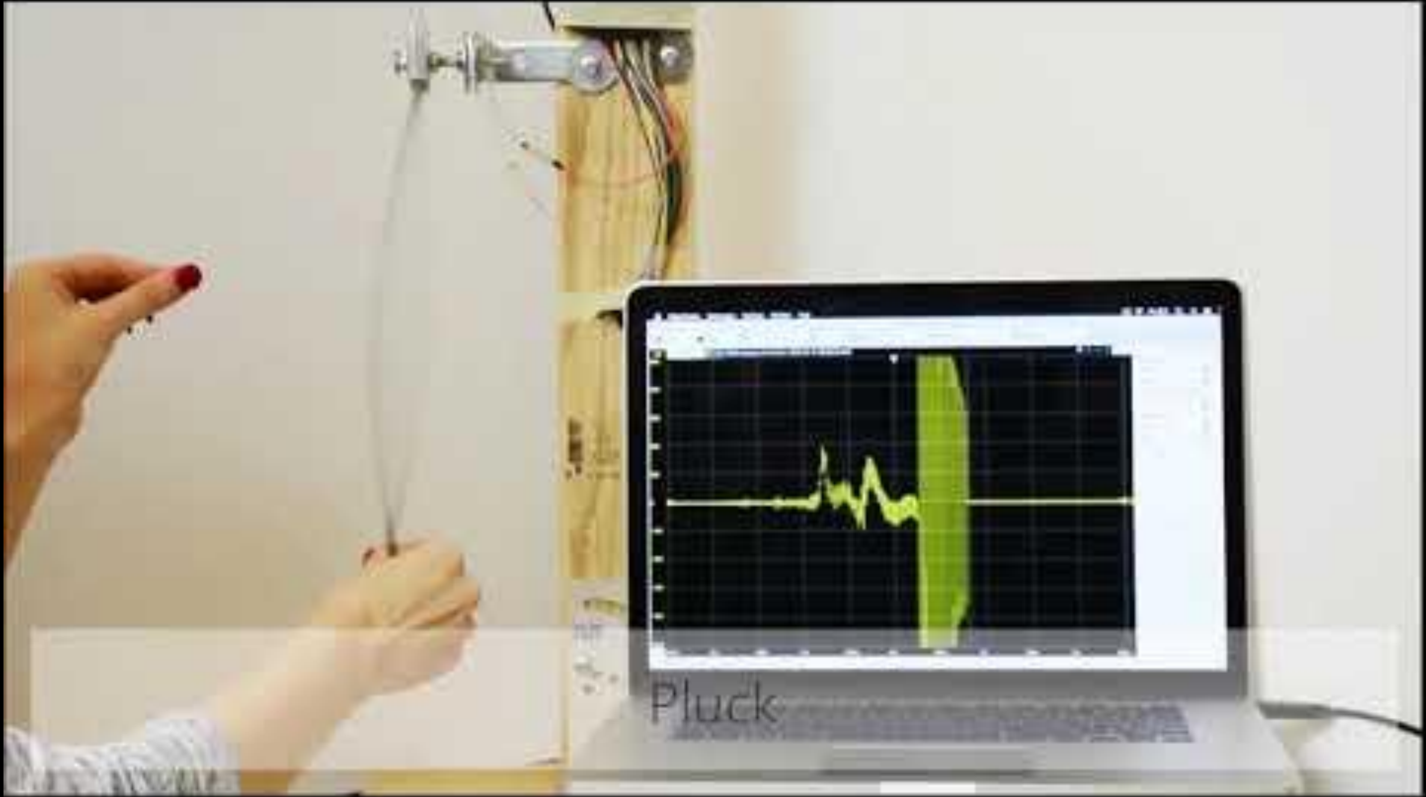
Serpentine

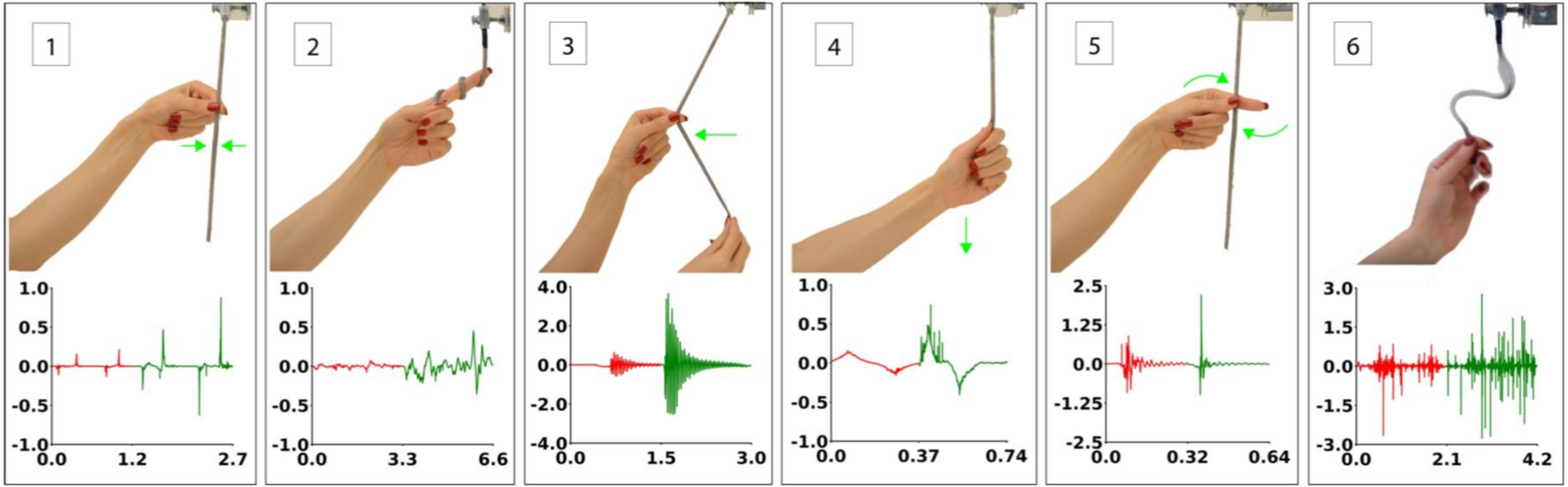
Serpentine is a highly stretchable self-powered sensing material that can recognize human input based on deformations of its shape.

- Can **sense** human gestures
- **Flexible** and can be embedded into various objects
- Cylindrical shaped cord allows several **intuitive** and playful interactions.
- Easy to **manufacture** with readily available materials


Pluck

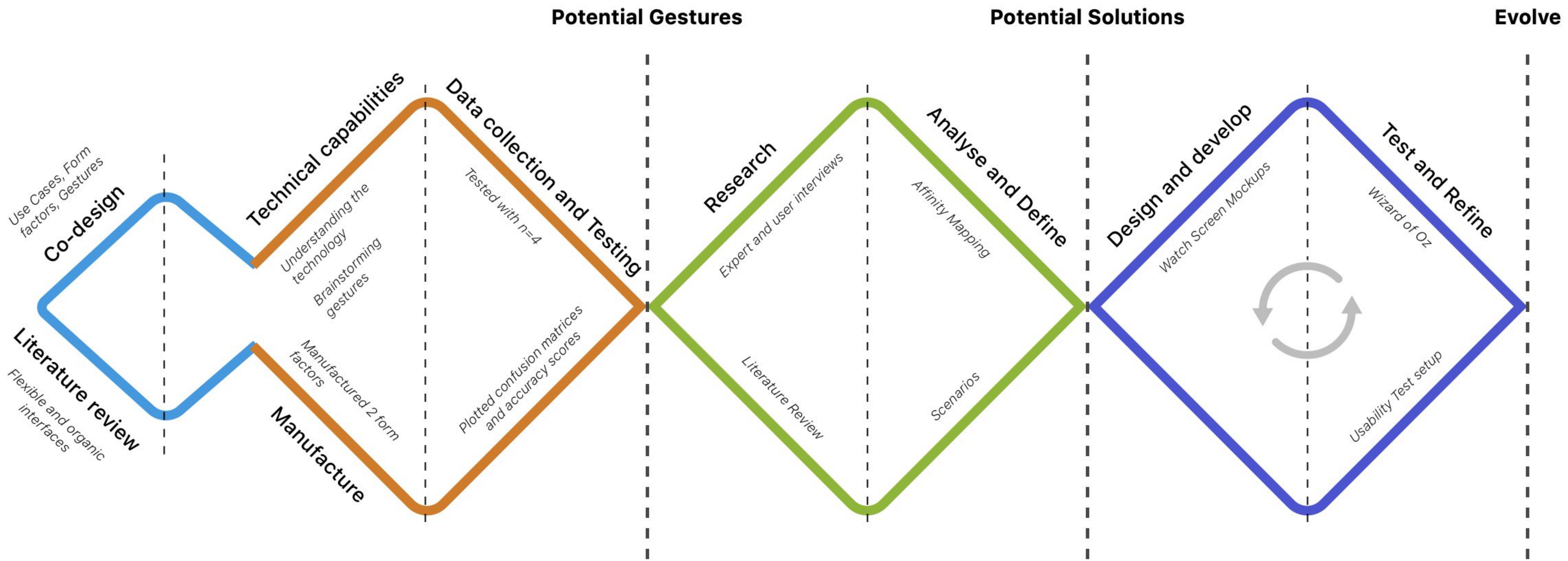
Gestures

The gestures that serpentine has been established to sense and classify.



Double Pinch	Twirl	Pluck	Stretch	Twist	Wiggle

Process


Potential Gestures
Potential Solutions
Evolve
Co-design
Use Cases, Form factors, Gestures
Literature review
Flexible and organic interfaces
Technical capabilities
Understanding the technology
Brainstorming gestures
Manufacture
Manufactured 2 form factors
Data collection and Testing
Tested with n=4
Plotted confusion matrices and accuracy scores
Research
Expert and user interviews
Literature Review
Analyse and Define
Affinity Mapping
Scenarios
Design and develop
Watch Screen Mockups
Test and Refine
Wizard of Oz
Usability Test setup

Literature

- Design of organic interfaces and vision of claytronics.
- Alternate interaction techniques with wearables (tapskin, watchout, whoosh)
- Flexible interfaces (paperphone, Foled, flex stylus, morphees, Bendflip)
- Interactions for rollable displays, Foldable interactions
- Sensing technologies
- Research methods
- Prototyping techniques
- Evaluation procedures

Co-design exercises

Aim

To determine

- intuitive and natural gestures
- contexts and use-cases
- form factors
- social acceptable locations to wear/interact with the technology

Method

Groups of 3-4 participants (typical users) were given sensors of different diameters and lengths.

Probes: Cards with different domains/themes printed on them.

Insights from lit review and co-design

- **Wrist** and fingers were the most preferred places for wearing the band.
- Users prefer basic and simple gestures.
- Ability to **customize** the actuation.
- The interactions with the band are most relevant in **eyes-free contexts.**
- Participants wanted to look like an accessory and expressed concerns regarding the look and feel.
- **Wrist** and Spine are best for the body to sense haptic feedbacks
- The themes **safety**, health tracking and gaming had the most number of contexts generated within them.

Wrist worn Contexts

What gestures can serpentine sense when worn on the wrist?

1) Ideated 12 unique gestures

2) Experiment 1

Description

- 4 users Performed gestures (n=10/20) in a random order which were classified.
- Plotted Accuracy scores and confusion matrices.

Results

6 out of 12 gestures were eliminated because of low voltage values, low accuracy scores and low intuitiveness to users.

Pluck
Stretch
Tap
Double tap
Pinch
Double pinch
Slide
Twist
Bend
Roll
Roll and leave
Knot

3) Manufactured 2 form factors

Manufactures in-house 2 types of sensors similar in shape and size, but with different sensing zones.

One single sensing zone

4 sensing zones

Advantage:

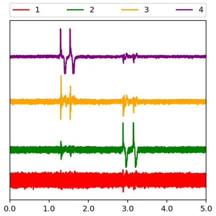
- Greater range of gestures
- Several combinations of locations and patterns
- Number of fingers used can also be sensed.

4) Experiment 2

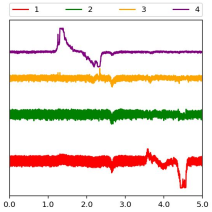
Description

- Performed the same set of ideated gestures on the band
- Plotted V/t graphs to determine the shape of the signal shape
- 6 gestures produced significant differences in signal shapes

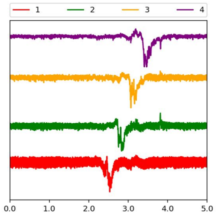
DOUBLE TAP



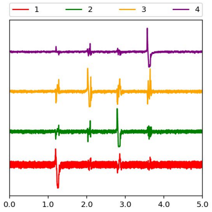
PINCH



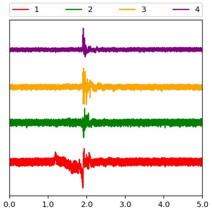
SLIDE



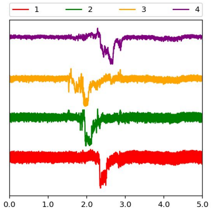
SINGLE TAPS



PLUCK



SLIDE WITH 2 FINGERS



Alternate input methods

For partially visually impaired users

For normal vision users in eyes-free contexts

Goal

To design alternate + multimodal interactions with smartwatches by using serpentine as the strap of a smartwatch.

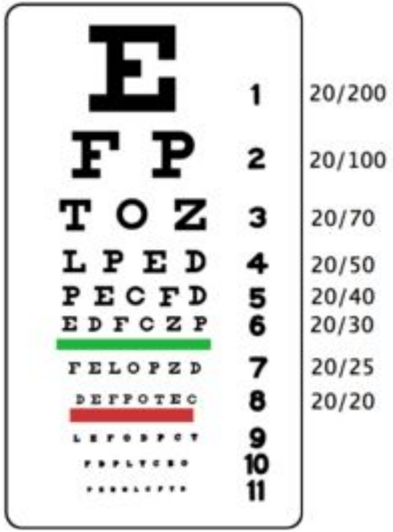
My User Group

Users with Moderate Vision Impairment

Snellen visual acuity = 20/70 to 20/160

Users with Severe Visual Impairment

Snellen visual acuity = 20/200 to 20/400



Snellen Visual Acuity from the standard eye testing chart

Research

- Literature review | Assistive wearables for visually impaired users

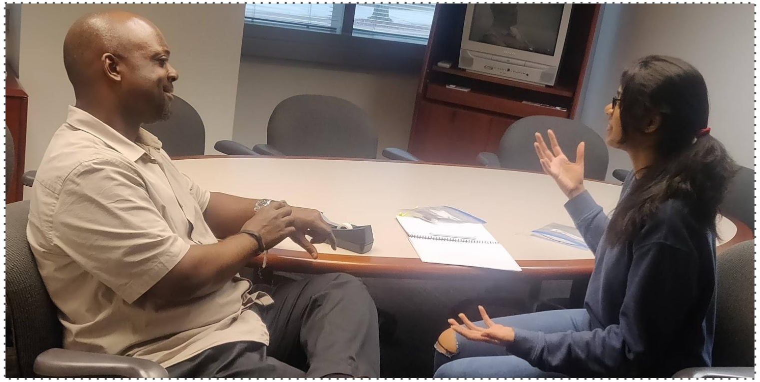
  Major Finding: Alternate/Multimodal interactions for generic devices such as smart watches/Fitbits have not been addressed.

- 2 expert interviews

  Director of CVI, Dr. Rasheeda Wilkins and Ph.D student from the Sonification Lab

- 2 user interviews

  Partially visually impaired staff and a client at CVI



What is the partially visually impaired user like?

- **Weak** Vision
- **Weak night vision** or no vision at nights
- Can perceive presence of **light**, color and direction of light
- Some require **high contrast in colors** to identify an object
- Rely on voice based outputs and inputs
    - Always have their **earphones** on.
- Don’t want to be **recognized** as visually impaired.

*The participants at CVI might not be average of all partially visually impaired users.


TECH USAGE
NON-TECH
Canes
ASSISTIVE TECH
Blind solitaire, Bar Audible, C and AI, K and Fb Reader, Scan, Victor trek, Victor screen reader
Victor Reader Trek
Use screenreaders and magnifiers mainly
JAWS, Zoomtext, Opentext, Braille Write
Fusion - Screenreader JAWS (Tells what you are pressing)
Be my eyes - for knowing attires of people, names of products in grocery stores and their expiry dates
BlindSquare for navigation
DEVICES
Laptop, Iphone, android tablet, braille reader
Tablets and Iphones
iPhone, mp3-player, GPS, Smart fitness tracker (steps, activity, water and meals)
DEVICES: Bluetooth earphones
Prefer iPhone - since it has good accessibility features
APPS
Screenreaders, Color Invert, Magnifier
Rotor : Depends on what she is working on
E-commerce apps, email, gmail, Navigation: Waze, Google Maps,
Gmail, Text, JW Library, JW.ORG, Audibooks, BARD (Audiobooks), Maps, Voiceover, Large Letters (Magnification)
FEATURES
Keyboard shortcuts instead of mouse
Brightness features Zoom In features
GPS
PAINPOINTS WITH APPS
Screenreaders come with their on issues. It says "BUTTON" but does not read out the text on the button.
INFORMATION ACCESS
The watch needs to act as a backup source if I forget my phone.
SAFETY AND SECURITY
OUTDOOR SAFETY
Uses fake names for the number 911 - Wishes to dial 911 in stealth mode
Doesn't go out at nights due to safety concerns
Dosen't use the cane all the time. They act as identifiers and the blind person can be targeted.
Have somebody with her to go out at nights
Safety hinders mobility
Refuses to make herself a target
Dont want to draw attention and be noticeable that I am blind
Tries to be always aware of surroundings
Act like she is looking around
Don't want to pull out your phone in treatening situations to call 911.
Send distress signal
This can help in child safety.
SECURITY
Lock doors with this gesture.
Unlock phones in public situations
Don't like to open bags to pull out phones in public transport
This will help me send distress signal in stealth
Like to keep hands free while in public spaces - safety and security purposes
MOBILITY
Safety hinders mobility
FITNESS
Use Fitbits for tracking mobility
Blind people are encouraged to be active.
Exercises only indoors
Only run in daylight
The band can help me cut/answer calls while exertion
NAVIGATION
Navigate using common landmarks or ask people
While describing locations, it is important to be very specific and provide all details.
I wish the navigation apps are more interactive
She wants to get the cross street and the main street
Difficult to read street signs
Want the watch to help me navigate
Voice Input for address
USE CASES
Playack screenreaders
5 important things to do: Call, SMS, SOS, Find keys, TV Remotes, Turn Alexa(On/Off)
Helpful in situations where voice I/O is not possible: MEETING, DOCTORS', THEATRE
Can be used as oth input and output device
Lights on/off
No numpad in ATMs - Use a pattern of interactions on serpentine as the pin.
Different gestures mean different signals.
Use it while in Treks(low signal areas) for communication, because it uses less power.
Use it as Morse code generator
Mouse or Keyboard
Open doors using the stretch interaction
Code, own pattern to open a safe
Invisible Switches - blend into the room. Not one specific button.
Protects privacy in ATMs
PRODUCT-IVITY
Check time and weather (1-2 times a day)
Will want the watch to give alarms and reminders. That is more useful that just text messaging.
Can be used for finding things
Unlock your phone
EYES-FREE
Visually Impaired
Cut calls when phone starts ringing.
Helps during presentations
Feedback for sports people.
HEALTH AND FITNESS
Healthcare purposes - Track body parametres
In the shoe/ankle guard to pretect ankle injury
Stress Buster - If data is used for something else, then I can use it.
Displays a happy face that lights up whenever I press the stress ball multiple times.
GAMING and FUN
Music instruments
String controller | Change form and change gesture. Combinations of gestures and form factors.
Having something physical in the hand that can be deformed gives more feedback. More fun.
Game controller | Archery game
Know how much pressure I am putting
FORM FACTOR
Made something which is used universally and can be comfortably used by the blind audience.
Want something flat - which is comfortable to wear.
Will prefer having it as a band rather having it as a strap of a wrist watch.
Haptic Feedback - Wrists and Spine best for detecting vibrations
Jewellery can be masked too.
Will want a different form factor - a more flat band.
Wrist Band or Ring
Wrist Band or Ring looks more accessory and can be well masked.
Want to use phone as a computational device
Does not look so good now, maybe if it looks good, then I will use it.
Want to use it as accessory
Unique: Always on the hand.
PAINPOINTS WITH TECH
Using fitbit is also a challenge
Need a speaker on the smartwatch, most outputs on the smartwatch are visual
The reminders buzz the fitbit but due to low screenspace she cannot tell what those reminders are.
INTERACT-IONS
Want a more pronounced way to dial an SOS call so as to prevent false triggers.
Visual outputs are not blind friendly
Lighting outdoors requires me to adjust the lighting on the screen several times a day
Watch has a very small screen space
Learnability of gestures might be an issue but with practice they get pretty fast.
VOICE I/O
Hearing in public spaces is an issue- due to ambient noise
Comfortable using Voice i/o in public spaces - avoids voice I/O for something private
Voice input is also troublesome esp. while inputting punctuations
I dont want to talk.
This actually removes talking and can help people in that category.
WANTS/ DESIRES
Want to be more independent.
The watch will be more useful if it can also help him visualize
Want it to pair with existing devices.
Fit into the ecosystem of existing devices
CUSTOMIZA-TION
I want to customize what the gesture will actuate.
The needs vary from person to person. Hence, a way to customize these features will be good.
Want basic and simple gestures
The needs vary from person to person. Hence, a way to customize these features will be good.
LIFESTYLE
Digital divide and dependence leads to less participation work/education.
ORGANIZING
Organized in storing stuff.
Misplacing stuff makes a huge difference.
Prefers compartmentalized bags
While describing location of a particular item, it is important to be specific
OTHER
Filing forms on paper is tough
At nights, I need a flashlight
Blind users: Good spatial memory
Like that the interaction is fixed and the location is not.

Technology they use

Devices

Laptops, Tablets, Mobile Phones

Fitbits, Earphones

Assistive Softwares

Screen readers softwares

Magnification softwares

Blind Friendly Maps

AI apps that tell the visualize/recognise objects before them.

Frustrations with wrist wearables

- Low screen space
- Limited space for interaction
- Smaller font sizes and smaller graphics

Insights and Solutions

Navigation, Information Access and Safety

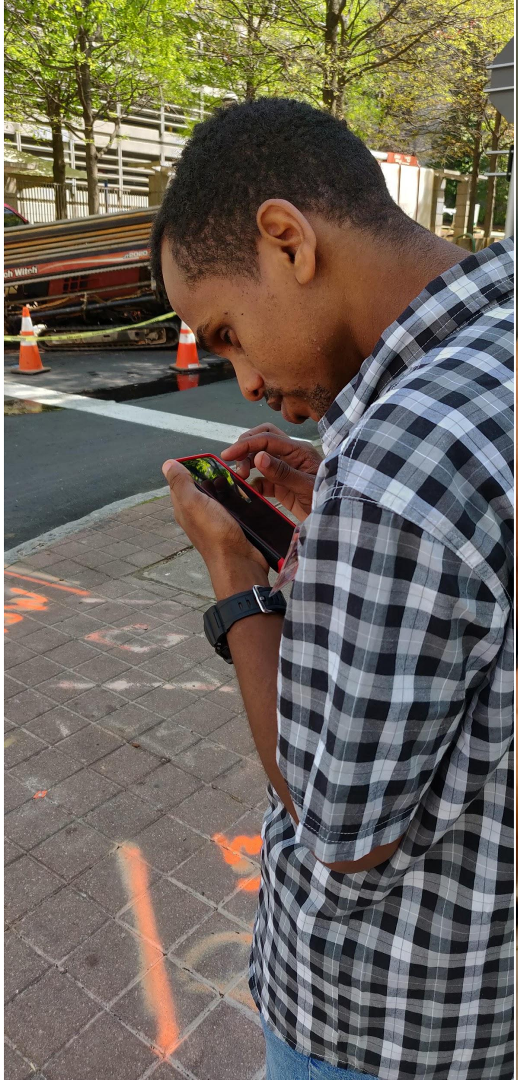
Navigation

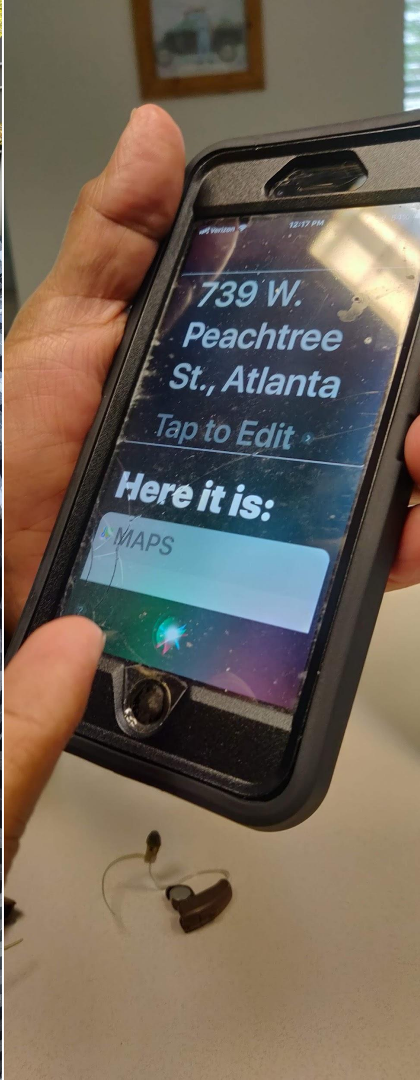
1 Knowing the current location

2 Repetition of the navigation instruction.

3 Adjusting Brightness and inverting colors

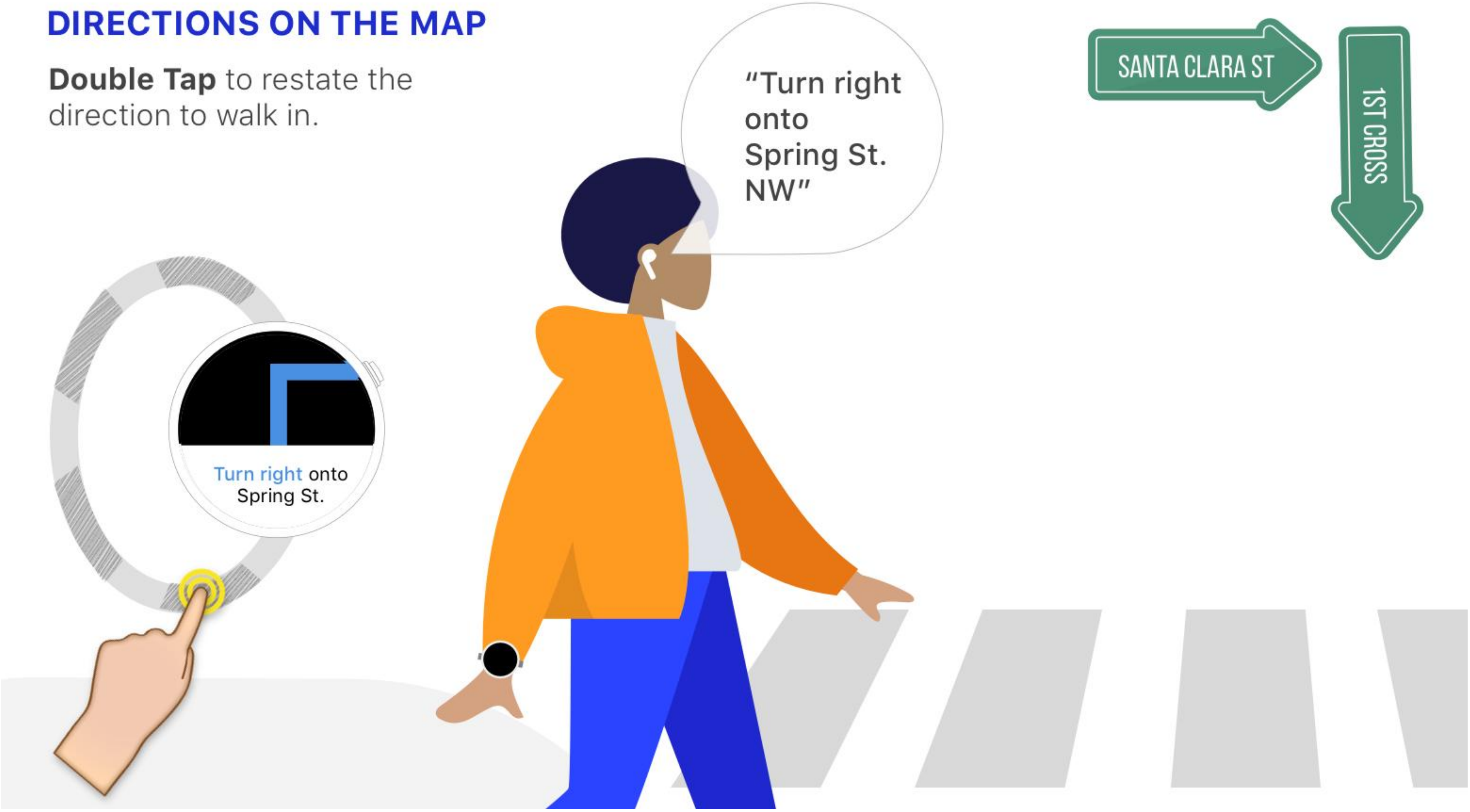
4 Ambient Noise in public spaces hinders voice Input





DIRECTIONS ON THE MAP

Double Tap to restate the direction to walk in.



CURRENT POSITION ON THE MAP

Pinch to get the current position on the map

Safety

"I want to be more independent"

"I want to be able to dial 911 quickly and in stealth "

1 Directly Hinders Mobility

2 Low confidence and dependent on others

3 Refrain at home during nights

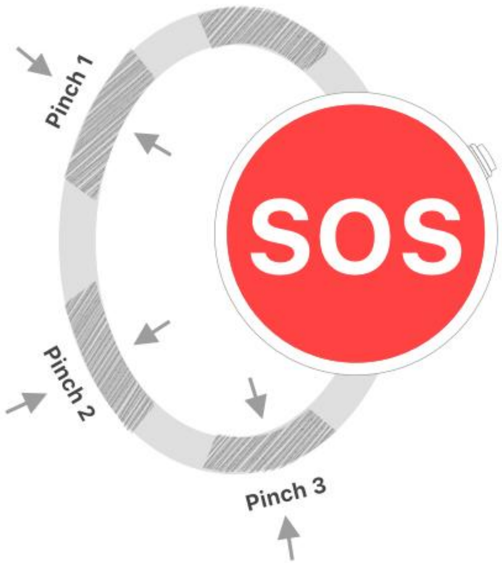
4 Afraid of being a target in public spaces

5 Want to dial SOS in stealth.

6 Stick to indoor fitness activities

SAFETY

Pinch in a pattern you set to dial 911.



Need for a complex interaction to prevent errors

Information Access

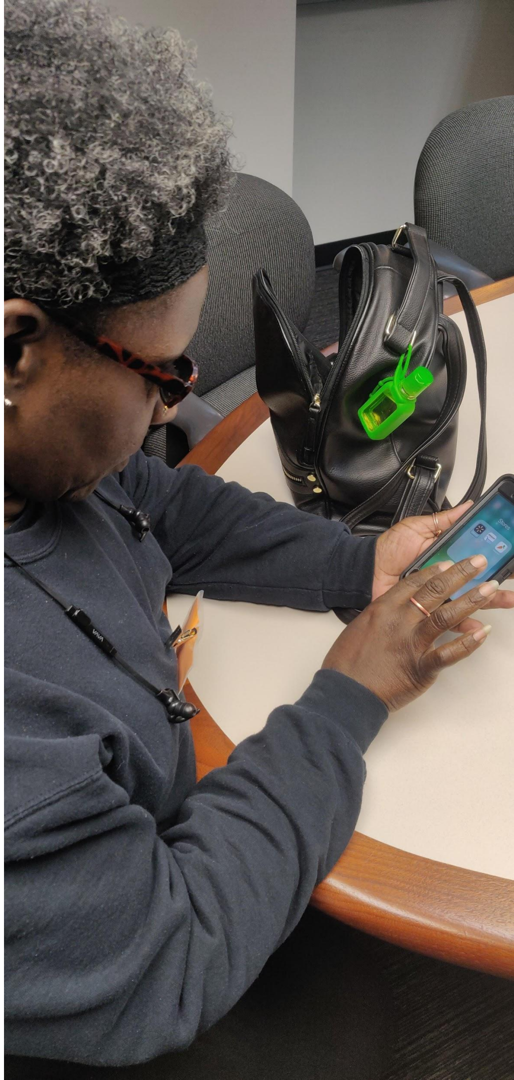
1 Every app is not designed for equitable use

2 Different Apps work best in different color modes.

3 Small Screen Space on watches

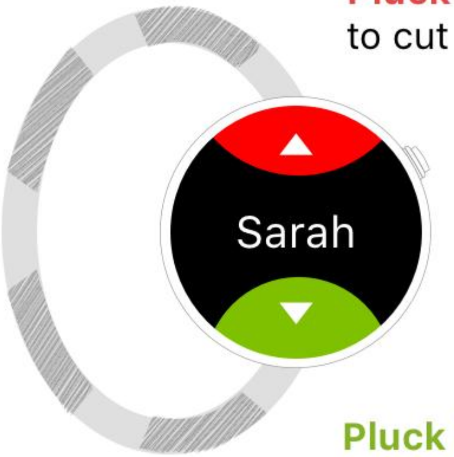
4 Accessibility features in phones/watches are hidden inside the menu trays.

5 Audio feedback and Voice I/O is not suitable for all contexts



COMMUNICATION: CALLS

Plucking cuts the call.



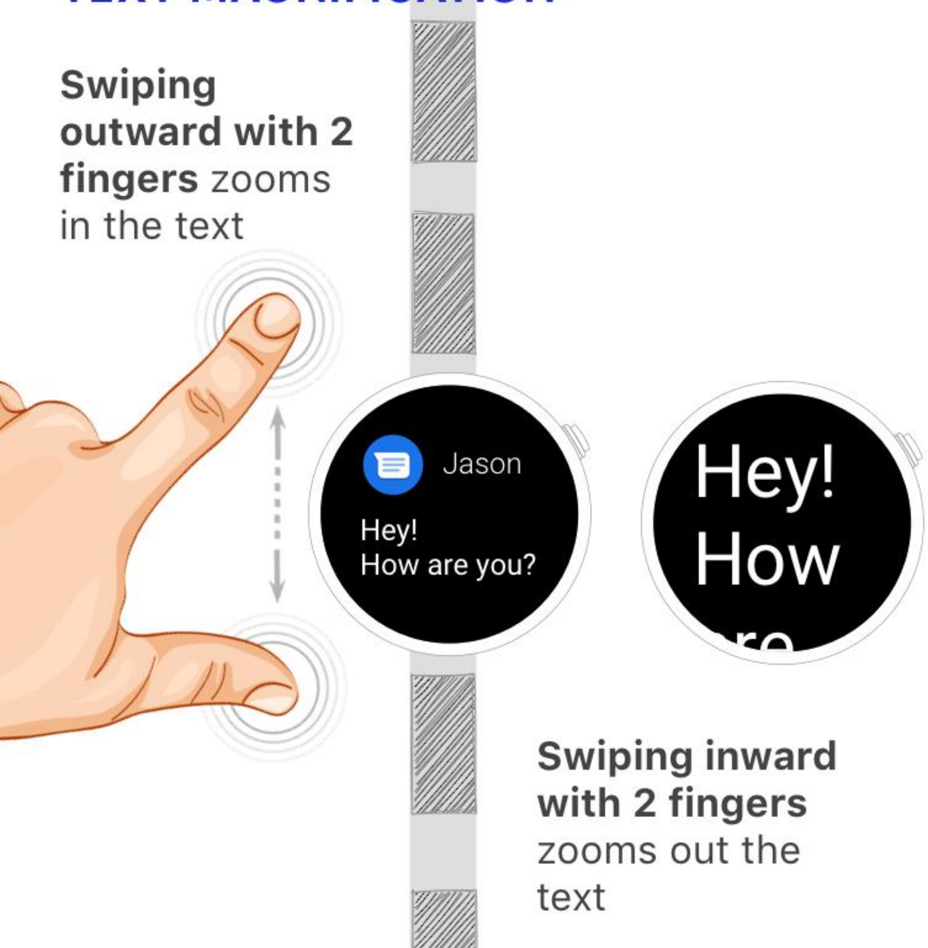
Pluck here to cut the call

Pluck here to pick call

Other scenarios include churches, meetings.

INFORMATION ACCESS: TEXT MAGNIFICATION

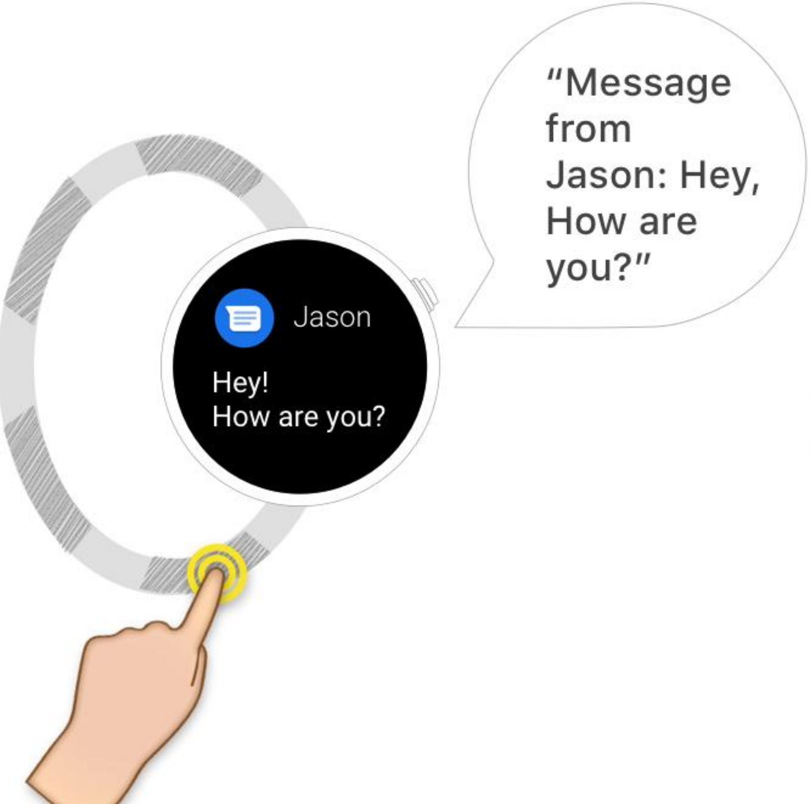
Swiping outward with 2 fingers zooms in the text



Swiping inward with 2 fingers zooms out the text

INFORMATION ACCESS: SCREENREADER

Double Tap to turn on the screenreader



INFORMATION ACCESS: COLOR INVERT

Pinch to smart invert colors back and forth.

INFORMATION ACCESS: SCREENREADER

Double Tap to turn on the screenreader

Usability Testing

Wizard of OZ with 6 partially visually impaired users

Unstructured feedback with normal vision users

Goal

To validate the concepts
To test the learnability of interactions and usability of the designs
To know the perceived value of the product.

Method

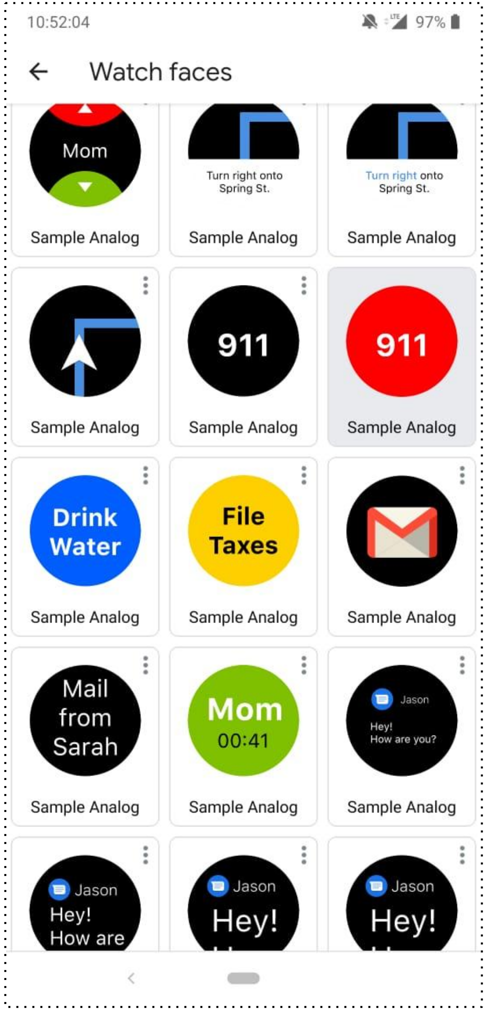
Wizard of Oz

- scenario based questions
- modified SUS questionnaire.

The setup

Participants (average age: 49) were asked to wear the watch and were asked to perform interactions based on scenarios.

Remotely controlled watch screens by building the android watch face extension



Major Findings from Wizard of Oz

- Users felt that the watch added to their **convenience**
- Users wanted to be able to **customize** certain actuations.
- Users liked that the device prevents other people to notice that they are blind.
- **Cost** was a concern
- The testing also surfaced certain interface issues that were addressed.

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SUS Score

High learnability index

Low perceived mental and physical demand

Conclusion

The **multimodal interactions** combined with the **ubiquity** of the smartwatch can make several phone interactions more accessible.

The generic nature of the device adds to increased **social acceptance** of a smartwatch as an assistive device.

Future Work

Customization

Building interaction scenarios for more contexts

Work towards making the design more universal

Thank you

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