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A feasibility study to a touch-grab aid for blind people

Introduction I present a feasibility study about an aid for blind people. This product, a glove equipped with vibration motors (see fig. 1), enables people to 'feel' the distance of objects through technological mediation. The glove senses objects in the environment by a distance sensor and communicates the distance to the user through tactile feedback on the hand. Blind people will be assisted in touching or grabbing objects in the environment with more ease because of the possibility to localize objects without physical contact.


Fig. 1

The feasibility study has been conducted in order to test the usability of this touch-grab aid for blind people, which is patented by Mr. Peter Peters (see appendix 4). My task within this feasibility study is to answer specific research questions to validate the functioning of the aid. The central questions are:

- is it possible to recognize objects and the distance to these objects in the environment
- and is the tactile feedback understood by the user?

In order to test this in isolation, some adaptations and changes have been made to the initial proposal. This re-designed prototype is only valid to draw conclusions regarding this specific part of the general concept (explained in appendix 4).

I have decided to answer the research questions by a research-through-design approach. The advantage of this approach is doing research while at the same time working on test models and learning hands-on. I decided to facilitate my exploration with the help of Phidgets.

From an interview and on the spot observations I learned that blind people tend to use one of their hands to perceive where objects are in the environment. Particularly the sense of touch of blind people is developed to a much larger extent that of an average person. This perception is mostly extended by tools, such as canes and other products already on the market (e.g. Ultracane, Bat "K" Sonar cane). I want to continue this principle of using one hand.

Materials and methods To validate the functioning of the aid, two things are important: first to substantiate whether it is possible to detect objects in the environment, second to get the feeling of the distance of the object through tactile feedback. To examine this principle I have built a primary test model with Phidgets and Max/Msp, which is a glove equipped with vibrating motors as output and an IR distance sensor (type GP2D12, range between 10 cm – 100cm.) to detect objects in the environment closer than 1 meter. This measurement is similar to the canes used by blind people, where they have a reach of approximately 1 meter. The prototype has a dynamic construction to make changes and adaptations more easily.

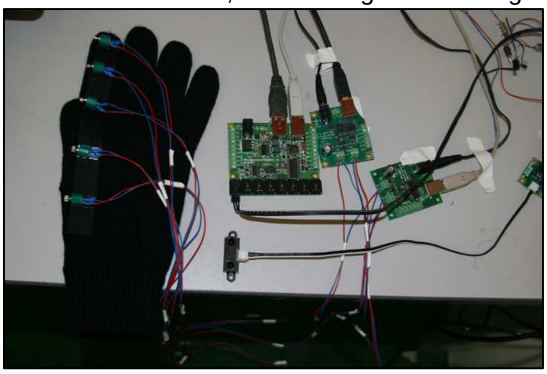
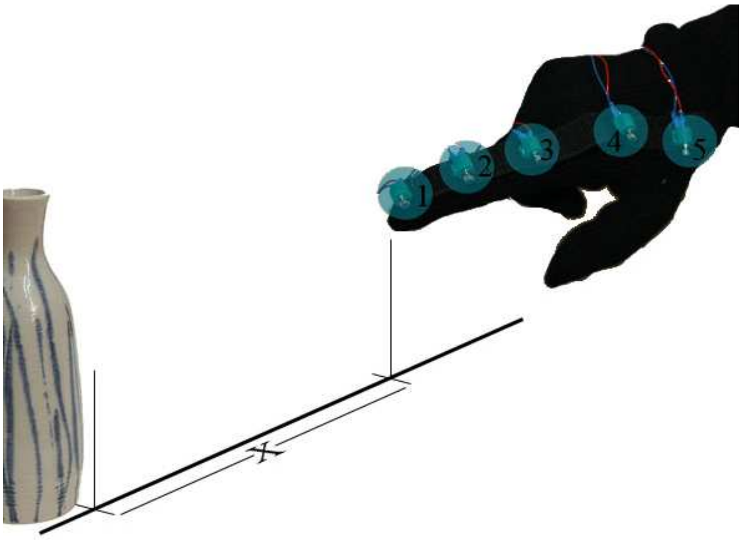


Fig. 2

For testing purposes, the motors are configured in different ways that should communicate the distance to the object. I made a distinction between different feedback patterns and tested which one was perceived the best. Below the patterns are explained.



The numbers in the green circles represents each vibrating motor. The distance X (cm) is the distance from the top of the finger to the object.

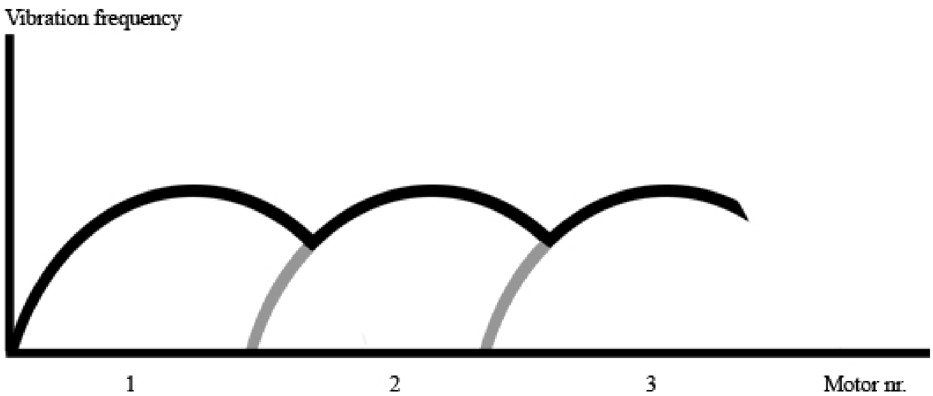
Pattern 1	Wrist to finger					
	Distance X (mm)	1000	700	500	300	200
Motor nr.						
1						■
2					■	■
3				■	■	■
4			■	■	■	■
5		■	■	■	■	■

Pattern 2	Finger to wrist					
	Distance X (mm)	1000	700	500	300	200
Motor nr.						
1		■	■	■	■	■
2			■	■	■	■
3				■	■	■
4					■	■
5						■

Pattern 3	Alternately					
	Distance X (mm)	1000	700	50	300	200
Motor nr.						
1						
2						
3						
4						
5						

Pattern 4	Increasing distance					
	Distance X (mm)	1000	700	500	300	200
Motor nr.						
1						
2						
3						
4						
5						

Pattern 5 (gradually ramping up the vibration frequency):
The motors accelerate gradually to a maximum speed and switch more fluently from one to another; for a more subtle tactile feedback.



User tests
There are many combinations possible with the patterns described above. A preliminary user study (see appendix 1) has shown that the most pleasant and understandable pattern is achieved with a combination of *patterns 1* + *3* + *5*.

Comparing two very similar prototypes (see appendix 2), an arm-device vs. the glove, has shown that both prototypes have different advantages. The glove is more useful for precision focused actions, like grabbing objects and the arm-device is more useful to explore the space and large distances. A combination of both prototypes could lead to a more suitable device. Some adaptations should be made to the vibration intensity and subtlety of transition between motors, which is experienced as annoying now. This aspect should be taken in consideration during concept improvement.

References

Scientific papers

Charles Lenay. The constitution of spatiality in relation to the lived body: a study based on prosthetic perception; France

Internet resources

http://www.optelec.nl/?id=1197

http://www.sensis.nl/index.php

http://www.bartimeus.nl/

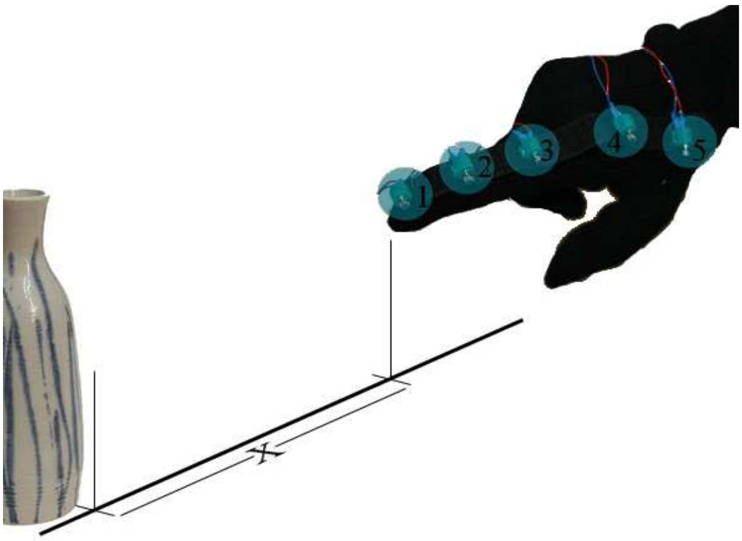
www.google.nl (for general search)

Appendix 1
Qualitative user study

Introduction
To evaluate on the various feedback patterns I have set-up a preliminary session. The main purpose for this session was to evaluate different tactile feedback possibilities and to verify which one was perceived best by users.

I have invited 3 people aging between 20 – 25 years. All of the participants did not have any problems with seeing. The first participant is from the faculty of Industrial Design, the second from Computer Sciences and the third from outside the university.

Implementation
The test had a very simple set-up, where the wall was used as the object to be approached. The closer you come to the object (wall) the more motors are working in a different order.
For this session I have designed 5 possible patterns, which could be combined with each other. Below I will give an explanation of each pattern.



Pattern 1(from wrist to finger):

Pattern 1	Wrist to finger					
	Distance X (mm)	1000	700	500	300	200
Motor nr.						
1						
2						
3						
4						
5						

Pattern 2 (from finger to wrist):

Pattern 2	Finger to wrist					
	Distance X (mm)	1000	700	500	300	200
Motor nr.						
1						
2						
3						
4						
5						

Pattern 3 (alternately):

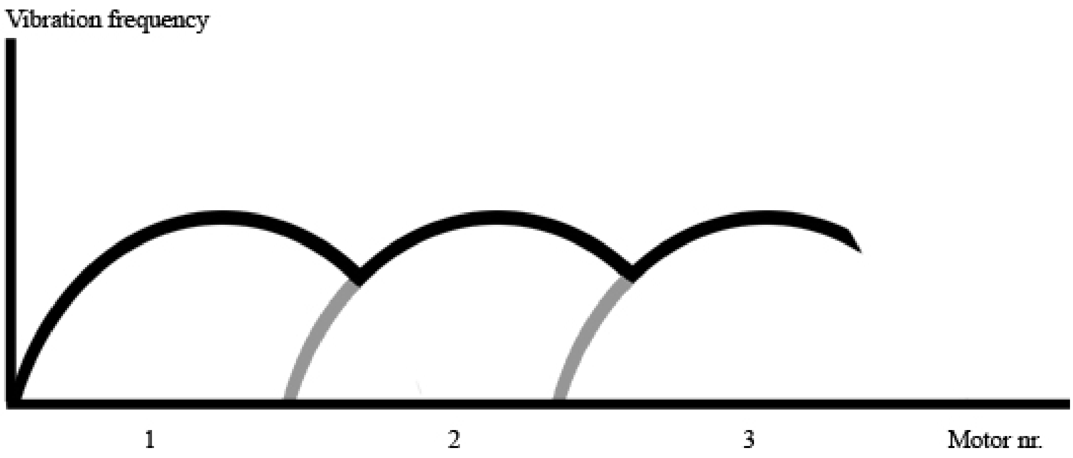
Pattern 3	Alternately					
	Distance X (mm)	1000	700	50	300	200
Motor nr.						
1						
2						
3						
4						
5						

Pattern 4 (increasing the distance between motors):

Pattern 4	Increasing distance					
	Distance X (mm)	1000	700	500	300	200
Motor nr.						
1						
2						
3						
4						
5						

Pattern 5 (gradually ramping up the vibration frequency):

The motors accelerate gradually to a maximum speed and switch more fluently from one to another; for a more subtle tactile feedback.



Participant 1

Pattern 1

- clear feedback, feels like you are approaching something
- strong vibrations

Pattern 2

- shocking vibrations, annoying
- not logical

Pattern 3

- feels like a ball rolling on the hand
- signals are perceived better than all motors working together
- able to make a distinction between vibrations

Pattern 4

- less feedback of what is going on

Pattern 5

- subtler

Participant 2

Pattern 1

- intuitive
- last signal on the finger is warning
- coupling between touching an object and feeling the signal on the top of the finger is informative

Pattern 2

- It is the same as the first pattern, but the other way around
- A bit more shocking

Pattern 3

- less annoying than all motors working together
- pleasant
- feel the flow much better

Pattern 4

- better distinction between vibrations, but less feedback
- sudden vibrations, no flow

Pattern 5

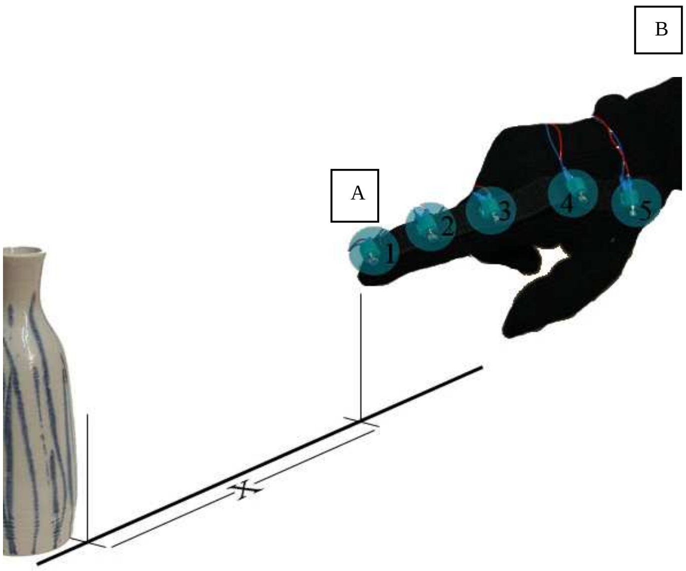
- less annoying
- more comfortable

Appendix 2
Qualitative user study

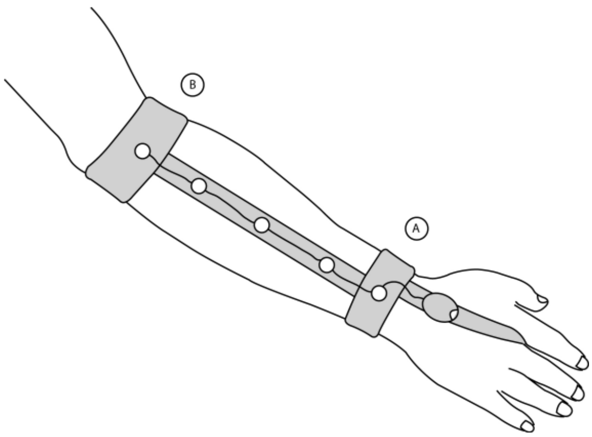
Introduction
The purpose of this user test was to verify the appropriateness of 2 different mappings communicating the distance to an object and to compare two very similar concepts; the glove vs. the arm-device.

To conduct a qualitative user testing we invited 5 people. All of the participants did not have any problems with seeing. The participants were all from the faculty of Industrial Design aged 20 – 25 years and were all male.
Initially we have chosen for a qualitative user test to evaluate the concept on the two promising mappings (patterns), which were perceived as the most pleasing and understandable feedback patterns in an early user study.
These are: actuators working in turn from wrist to finger (elbow to wrist in case of the arm-device) or the other way around. The motors were vibrating at a maximum speed, so no gradually ramping up. We kept it this way in order to keep the conditions equal for both prototypes, although this property was experienced as pleasing feedback from the early user tests.

From now on I will mention the following mapping patterns as follow:
- finger to wrist (or wrist to elbow): A – B
- wrist to finger (or elbow to wrist): B – A



The glove



The arm-device

Implementation
The set-up of the user test was very basic, executed in a room where the participants were asked to close their eyes and approach a white area at a distance of 1 meter.






Below I will sum up the reactions of each participant for each concept.

Participant 1

Glove:

- Too strong vibration of motors
- Varying the intensity of motors preferable (stronger vibration when coming closer)
- Strong vibrations on the nail is annoying (very sensitive area)
- Mapping from B – A is not logical

Arm-device:

- Much relaxing to have it on the arm
- Mapping on the finger is clearer (communicates much better)
- B – A is “scaring” → less feeling for distance

Comparison/advice:

- Mapping A – B is much clearer
- Hand is more sensitive, so clearer feedback
- Reducing intensity of motors (annoying)

Participant 2

Glove:

- No feeling of directionality
- Distance between motors are too small, so hard to distinguish each vibration
- Fingertip is very sensitive
- Mapping is less clear, because of the distance of the motors
- B – A mapping is clearer with this prototype
- Different sound of each motor communicates the distance as well

Arm-device:

- No feeling for directionality
- A – B is more intuitive
- Vibrations are too strong, but clear
- The sound is annoying

Comparison/advice:

- Arm-device is more space and environmental focused
- Glove is more focused on small items and precision actions

Participant 3

Glove:

- You get the feeling that you approach something
- B – A is more intuitive in comparison to A – B and feels like you are or have approached an object (the last motor on the finger)

Arm-device:

- A – B → the first motor is jerky; like there is happening something, while it is the first vibration of the series
- B – A → first vibration is alarming (jerky)
- Mapping A – B is clearer

Comparison/advice:

- tactile feedback on the hand is more logic, because you approach something with your hand

Participant 4

Glove:

- I don't like it! Feels strange
- B – A is much clearer in comparison with A – B
- Feels like rolling a ball on the hand

Arm-device

- Vibrations are too strong
- Don't dare to approach the wall; no clear feedback
- More logic to feel the vibrations on the fingertip
- B – A is much clearer tactile feedback (more intuitive); feels like approaching something

Comparison/advice:

Appendix 4
Onderbouwing van de ingediende aanvraag
prototype tast- grijphulp voor blinde mensen

Doel van het apparaat
Met het apparaat kan een blinde of slechtziende in zijn woon- leef- en werkomgeving objecten vinden, inschatten hoe ver het object verwijderd is van zijn hand en zo het object pakken. Daarnaast kan men het gebruiken om objecten te vermijden en wanden en deuren te signaleren.

Gesprekken met instellingen:
In gesprekken met de instellingen Sensis (Grave), Bartimeus (Utrecht) en Viataal (St.Michielsgestel) zijn wij tot de volgende doelgroepen gekomen. Hierbij denkt Sensis vooral aan de doelgroep ouderen en Bartimeus en Viataal aan alle doelgroepen.

Doelgroepen
- Oudere blinde en slechtziende mensen om de mobiliteit m.n. binnenshuis te vergroten.
- Jongeren om in bekende en onbekende situaties en ruimten de zelfstandigheid en mobiliteit te vergroten.
- Deelnemers aan het arbeidsproces om binnen de werksituatie de zelfstandigheid en mobiliteit te vergroten.
- Doof-blinde mensen.

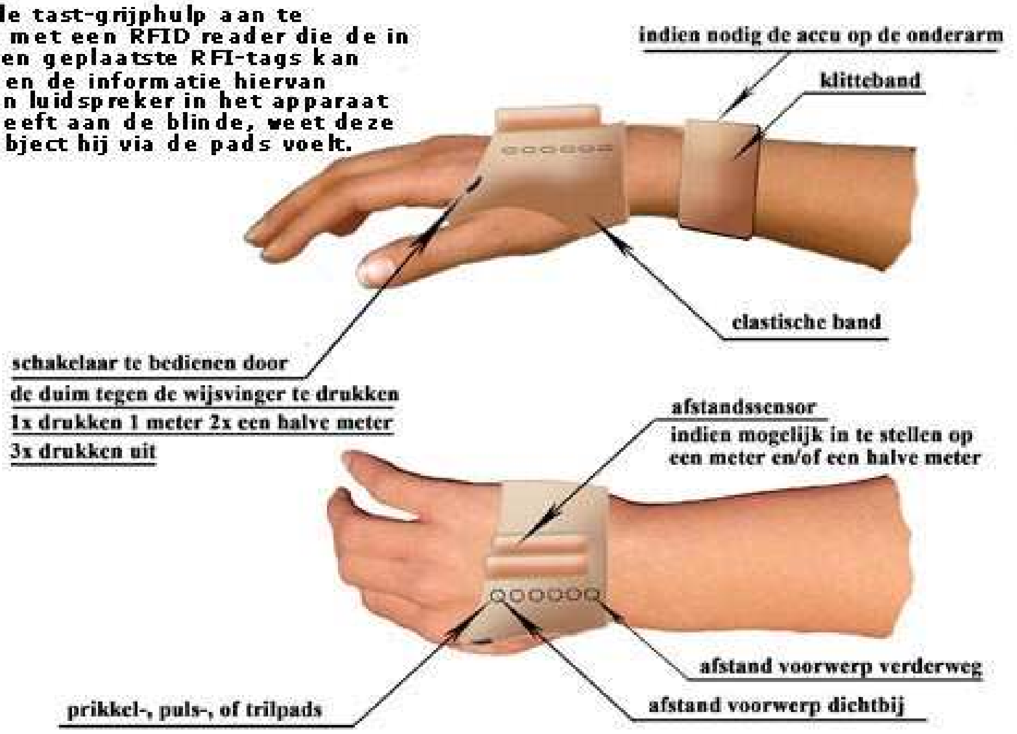
Toelichting
De tast- grijphulp voor blinde en slechtziende mensen is een hulpmiddel bij de dagelijkse activiteiten in de woon- leef- en werkomgeving. Door het gebruik van de tast- en grijphulp is de zelfstandigheid en de mobiliteit te vergroten.
In plaats van alles met de vingers af te tasten kan men met het apparaat in een grotere straal objecten ‘voelen’ en deze zo gericht pakken. Bij de mobiliteit binnenshuis of in de werksituatie biedt het apparaat de mogelijkheid om objecten te mijden en de omgeving (wanden, deuren etc.) eerder bij nadering te ‘voelen’.

Bij alle dagelijkse levensverrichtingen zijn we ons meestal onvoldoende bewust van het gemak waarmee we objecten pakken doordat we kunnen zien waar het object zich bevindt. Ook het lopen in onze eigen woon- en leefomgeving levert geen problemen op. Veranderingen die er onverwachts zijn worden gelijk herkend.
Anders wordt dit als we niet meer kunnen zien of heel slecht zien. Met behulp van andere zintuigen, vooral het gevoel, zal e.e.a. gecompenseerd worden. In de directe woon- leef- en werkomgeving zullen dan vooral op de tast objecten gepakt worden of obstakels vermeden worden. Niet altijd even gemakkelijk, vooral om te bepalen waar iets zich precies bevindt. Vaak moet dan een beroep gedaan worden op anderen die aanwijzingen geven waar het object zich precies bevindt of wat vermeden moet worden. Ook is men vaak geneigd de ander ‘even te helpen’ door het object in handen te geven. De tasthulp kan bijdragen tot het behouden of verbeteren van de zelfstandigheid en mobiliteit in de eigen woon- leef- en werkomgeving.

Met de tast- grijphulp kan men binnen bijvoorbeeld een straal van 1 meter of van een halve meter objecten aftasten en zo inschatten waar iets staat of iets zich bevindt. Doordat de afstand van de straal in te stellen is kan men afhankelijk van de situatie kiezen voor een groter of kleiner bereik. Als men het object ‘gevoeld’ heeft kan men, door met het apparaat dichter naar het object te gaan, inschatten op welke afstand van de hand van de persoon het object zich bevindt. Vervolgens is het mogelijk om het object eventueel te pakken. Men ‘voelt’ het object op de handrug door de pads die op de handrug zijn aangebracht (zie beschrijving tekeningen). Het inschatten van de afstand tussen object en hand ‘voelt’ men doordat men de trillingen op de verschillende plaatsen voelt van de pols naar de vingers naar gelang men het object nadert.

Tast-grijphulp voor blinde mensen

Door de tast-grijphulp aan te vullen met een RFID reader die de in objecten geplaatste RFI-tags kan lezen en de informatie hiervan via een luidspreker in het apparaat door geeft aan de blinde, weet deze welk object hij via de pads voelt.



de pads zijn voelbaar oplopend van de pols naar de vingers naar gelang men het voorwerp nadert

door dat bij harde materialen de detectie sterker is dan bij zachte materialen (absorptie) geven de pads sterke of minder sterke signalen af waardoor de blinde enigszins kan bepalen of het voorwerp hard of zacht is