Ontario Tech University

A Wearable Device Supporting Multiple Touch- and Gesture-Based Languages for the Deaf-Blind

Nicholas Caporusso, Luigi Biasi, Giovanni Cinquepalmi
Gianpaolo Francesco Trotta, Antonio Brunetti,
and Vitoantonio Bevilacqua

Presented by: Noopa Jagadeesh
16-03-2020

Introduction

- Deaf-blindness is a condition where an individual has little or no useful sight and little or no useful hearing resulting in limited communication, access to information, and mobility.

- In order to interact with other people, most of them need the constant presence of a caregiver who plays the role of an interpreter with an external world organized for hearing and sighted people.

- Deaf-blind individuals primarily use touch to communicate with others and to interact with the world.

- Advanced tactile signing techniques and tactile alphabets, such as, the deaf-blind manual, Lorm, or Malossi, are the preferred communication system in the communities of people who are deaf-blind.

- At this time the hand becomes a typewriter for writing and reading messages using a specific tactile code.

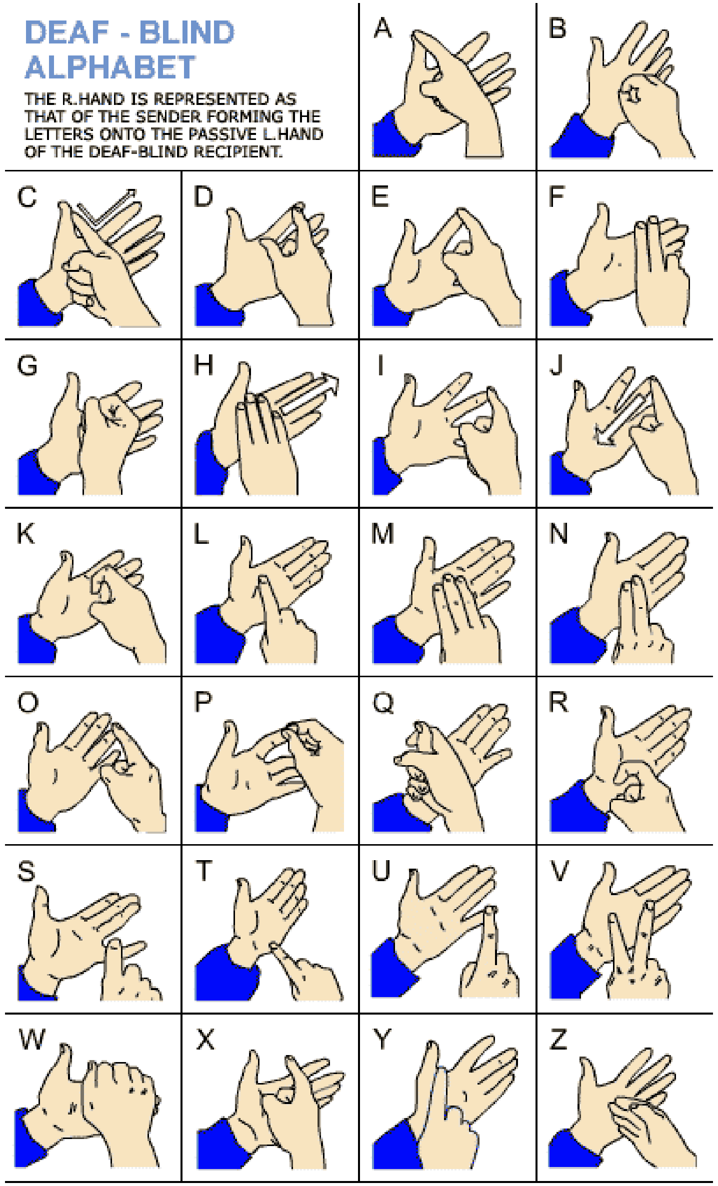


Figure1: Deafblind Manual Alphabet
Source Credit: https://www.deafblindinformation.org.au/

The Deafblind Manual Alphabet

- The Deafblind Manual is the best way to communicate with someone who is Deafblind.
  - For A, Touch the tip of your friend's thumb.
  - For E, Touch the tip of the index finger.
  - For I, Is the middle finger.
  - For O, Is the ring finger.
  - For U, Is the little finger.
  - For B, Bunch the tips of your fingers and place them on your friends palm.

The Lorm manual Alphabet

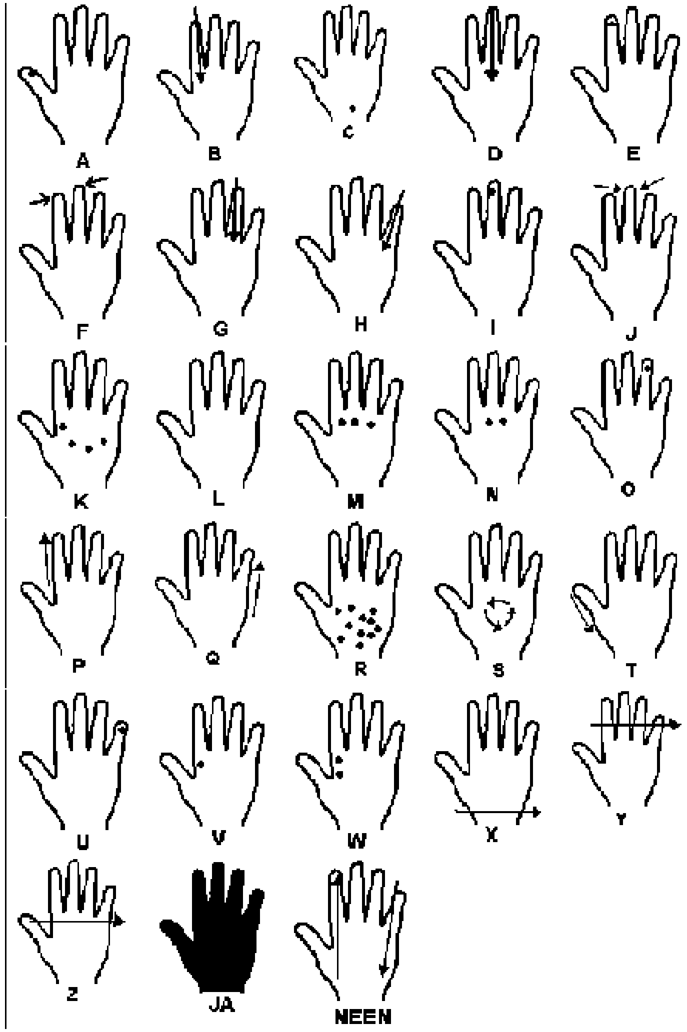


Figure 2: The lorm manual alphabet
Source credit : http://www.deafblind.com/lorm.html

- The deafblind person shows the palm of his right hand (or the other side of the left hand) to the speaker, who uses mostly the tips of his fingers to point into the deafblind persons hand.
  - For A, touch the tip of his thumb.
  - For B, strike downwards along his index finger from the tip till just above his palm (so don't touch the palm).
  - For C, touch the middle point of the lowest part of the palm of his hand.

Malossi Alphabet

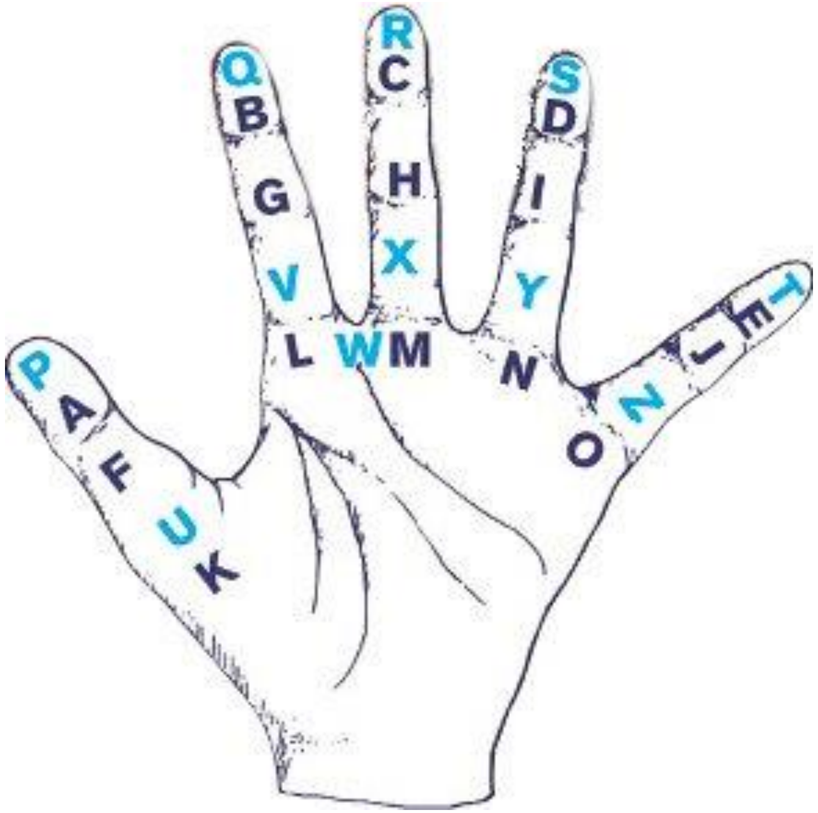


Figure 3: Malossi Alphabet
Source credit: A Wearable Malossi Alphabet Interface for Deafblind People

- The first 15 symbols (from “A” to “O”) have to be pressed.
- The other letters (15, from “P” to “Z”, excluding “W”) have to be pinched.
- This method is often used by those who had learned to read and write before becoming deafblind

Related Technologies

- Several devices successfully explored the possibility of incorporating touch-based languages into wearable technology in the form of gloves to help people who are deaf-blind interact with the world.

1. Mobile Lorm Glove

2. DB-HAND

Mobile Lorm Glove

Figure 4a: Input unit on the palm of the glove **Figure 4b: Output unit and control unit**
Source credit: Mobile Lorm Glove – Introducing a Communication Device for Deaf-Blind People

DB-HAND

Figure 5: An early prototype of DB-HAND
Source credit: A Wearable Malossi Alphabet Interface for Deafblind People

dbGLOVE

- A wearable interface for touch and gesture-based interaction which is specifically designed for providing people suffering from multi-sensory conditions with support for bidirectional communication.

- dbGLOVE is designed to refine the work discussed to incorporate several already existing touch-based languages, so that people who are deaf-blind are not required to learn a new communication system, which is among the most complicated tasks for them.

System Design and Architecture

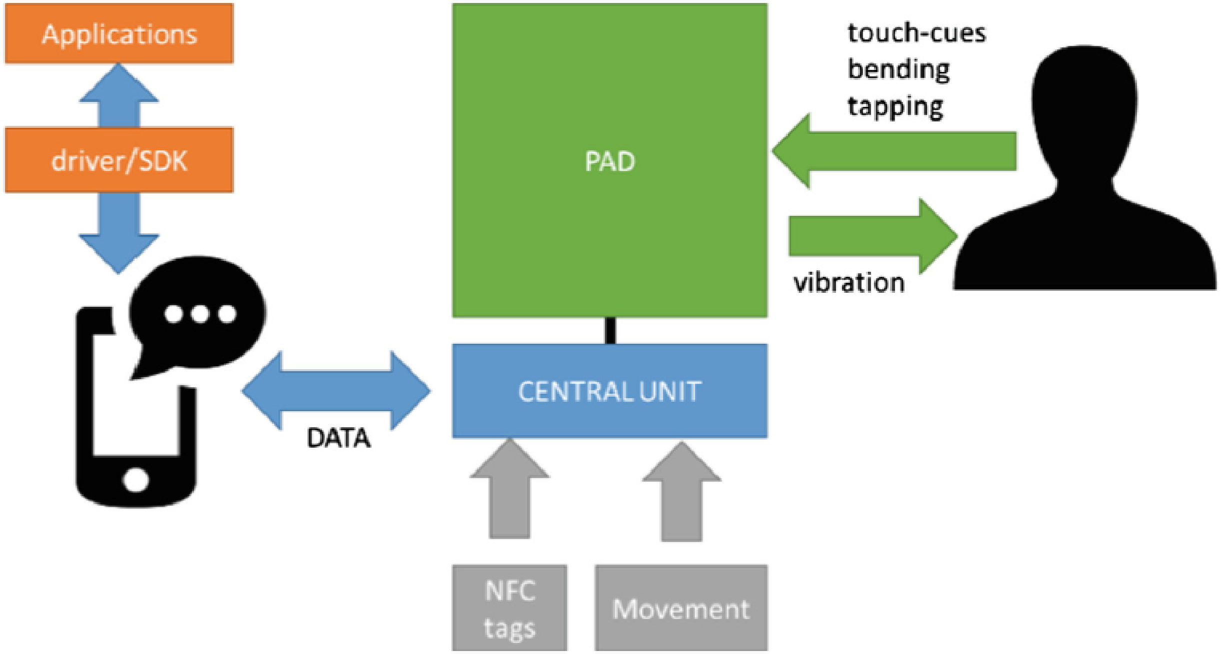


Figure 6: Block-diagram of the architecture of the device

- The hardware component of the system consists in a device that can be worn on the left or right hand.
- dbGLOVE utilizes a single surface consisting of a hand-shaped pad in which electronic components are incorporated in a polyurethane cast to ensure resistance to moisture.
- The surface of the pad includes 18 one-wire capacitive sensors.
- 15 sensors are conveniently placed over the phalanxes, to accommodate for the layout defined by the Malossi alphabet; 3 additional sensors are located on the top of the palm, to provide users with additional functions (e.g., menu, next, previous).
- A tactile texture modeled over the surface of the pad displays the corresponding representation of the letter in Braille, in order to facilitate users who are Braille-savvy and to increase Braille-literacy of people who know touch-based alphabets, only.

- It also includes 5 commercial flex sensors which support recognition of sign languages.
- The back of the pad, which is in contact with the surface of the palm, includes 16 vibrotactile actuators in the form of precision button-style motors.
- 15 motors are located over the phalanxes, in locations which correspond to capacitive sensors.
- One actuator is located over the palm to provide the user with feedback about menu functions.
- The pad is connected by means of an I2C bus to the central unit.
- The device connects via Bluetooth to smartphones.

Figure 7: Front and rear views of the pad of the device.

Experimental Study

- Evaluated the efficacy of dbGLOVE as a bi-directional communication tool.
- Divided the study in two experimental tasks focusing on the output and on the input features of the device.
- A total of 88 individuals were recruited for the experimental studies.
- Utilized two different groups of users for task 1 and 2, because the objective was to evaluate the input and output features separately.
- Participants had normal vision and hearing, and no prior knowledge of any tactile languages.
- The experiment was realized in noisy environments to reproduce the condition of real-life scenarios, though they were allowed to comfortably seat in front of a desk with the equipment.
- Subjects were provided with short briefing about deaf-blindness, and they were instructed about the tasks before starting the experiment.
- They had 5 minutes to get familiar with the device and explore it, before the beginning of the task.

Task 1

- In task 1, participants were delivered tactile stimulations at different intensities over the palm of the hand, and they were asked to identify the area in which the stimulation occurred.
- Trials involved 3 sets of stimulations each consisting of 5 pressure cues at different intensities, and on different sensitive areas.
- Both intensity and location were chosen randomly, ensuring that each trial included different intensities and areas, in order to deliver at least one stimulus for each sensitive area.
- Vibrations were delivered at intensities ranging from 1 to 251, representing no stimulus and maximum intensity, respectively: with 6 different intensity levels (i.e., 1, 51, 101, 151, and 251) to standardize the protocol.
- In each trial, motors were activated according to a specific pattern: intensity was increased by 50 in each stimulation, in the first trial; it was completely random in the second trial; in the third trial, intensity was descending.
- This was to identify the minimum and maximum sensitivity thresholds, and to evaluate individuals' touch sensitivity.
- 70 volunteers participated to the study.
- Individuals ranged from 16 to 65 in age.
- A total of 1071 responses were recorded.

Task 2

- In task 2, participants were provided with an informative leaflet displaying the Malossi alphabet for 10 min before the beginning of the test.
- Then, they were presented with random letters on the display, and they had to touch the area of the device representing the letter.
- The objective of the test was to evaluate the effectiveness of the device in recognizing input from the user, in terms of sensitivity of the actuators, and thresholds for avoiding spurious signals.
- 18 individuals participated to the study. Their average age was 25 ± 7.
- In each trial, users were presented with 27 letters displayed at random.
- A total of 468 responses were recorded.

Results

- **Task 1** focused on evaluating the effectiveness of the device in representing output.
- Specifically the objective was three-fold: (1) obtaining the range (minimum and maximum) in terms of intensity for vibration to be recognized correctly; (2) studying the efficacy of dbGLOVE as an output device; and (3) identifying critical areas of the hand in terms of recognition of the stimulation.

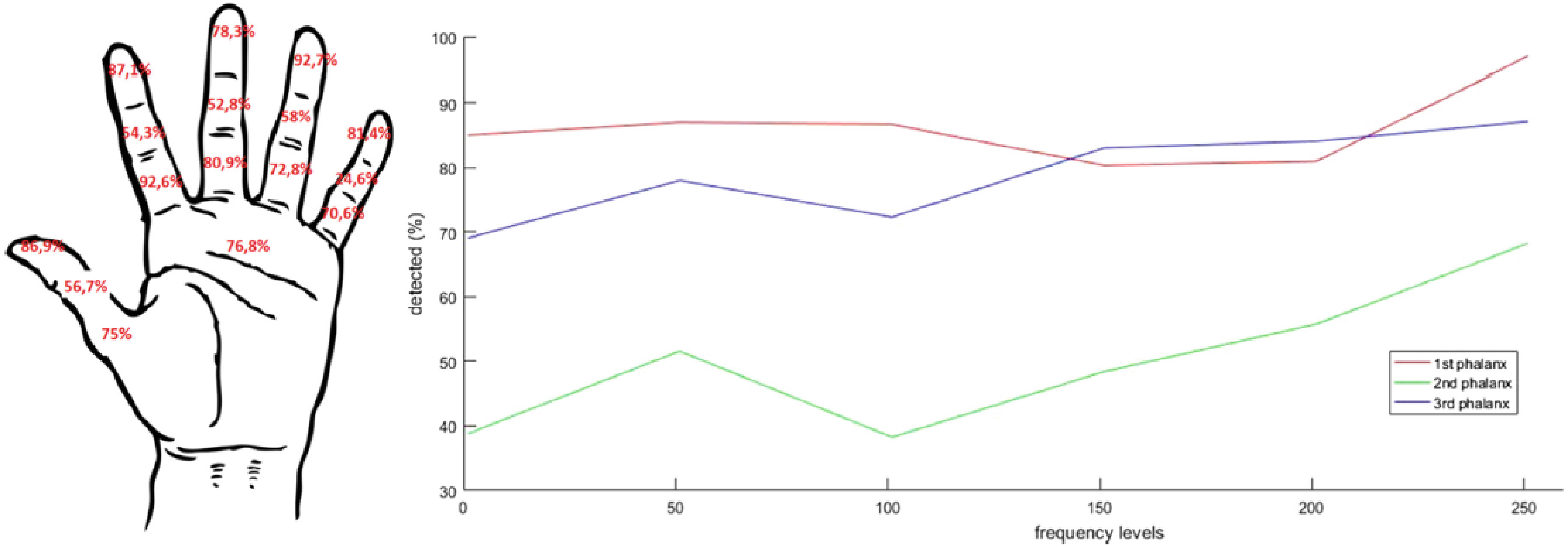
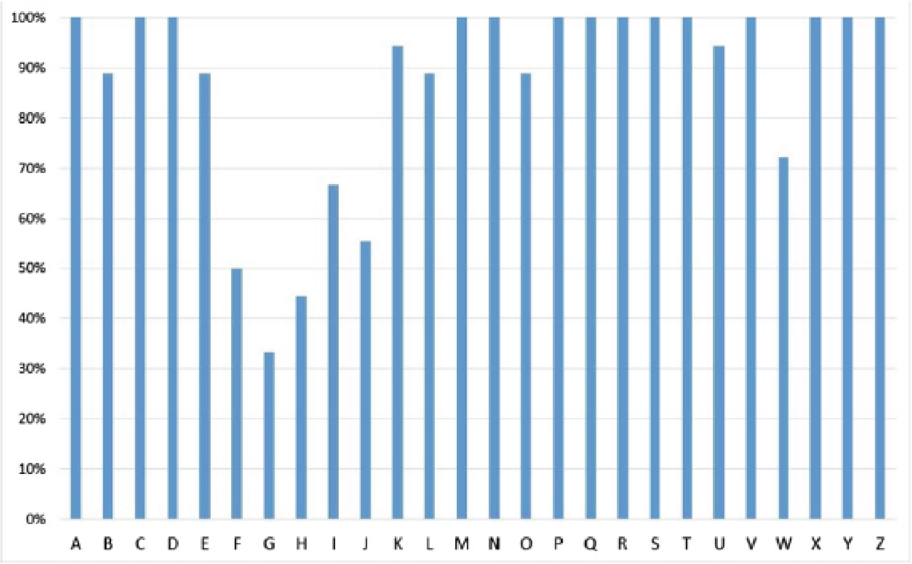


Figure 8: Performance in recognizing output: data about individual areas and about intensity.

- 763 correct answers were obtained out of 1071 responses, showing an accuracy of 71.24% in recognizing the area in which vibration occurred.
- Fig. 8, performance is strictly related to the location of phalanxes.
- Proximal and distal phalanxes show the highest similarity and very good performance ranging from 70.5% to 92.6%.
- Medial phalanxes have the worst results, showing an average accuracy of 49.28%.

- **Task 2**, which focused on the input features. Specifically, the objective of the study was two-fold, that is, (1) to evaluate the accuracy in detecting input, and the time spent by users to understand the communication system.
- Obtained 408 correct answers out of 468 responses, showing an accuracy of 87.17%.



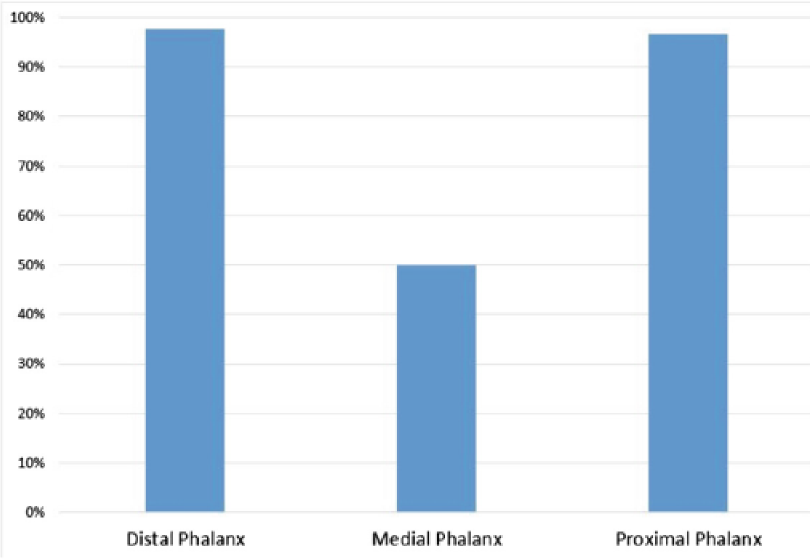


Figure 9: Performance in task 2: difference in phalanxes

- Figure 9 shows the accuracy for each letter: as in the previous task, the proximal and distal phalanxes have the best performance, with 97% and 98% accuracy, respectively.
- The medial phalanx shows accuracy level of about 50%.

Conclusion and Personal Critics

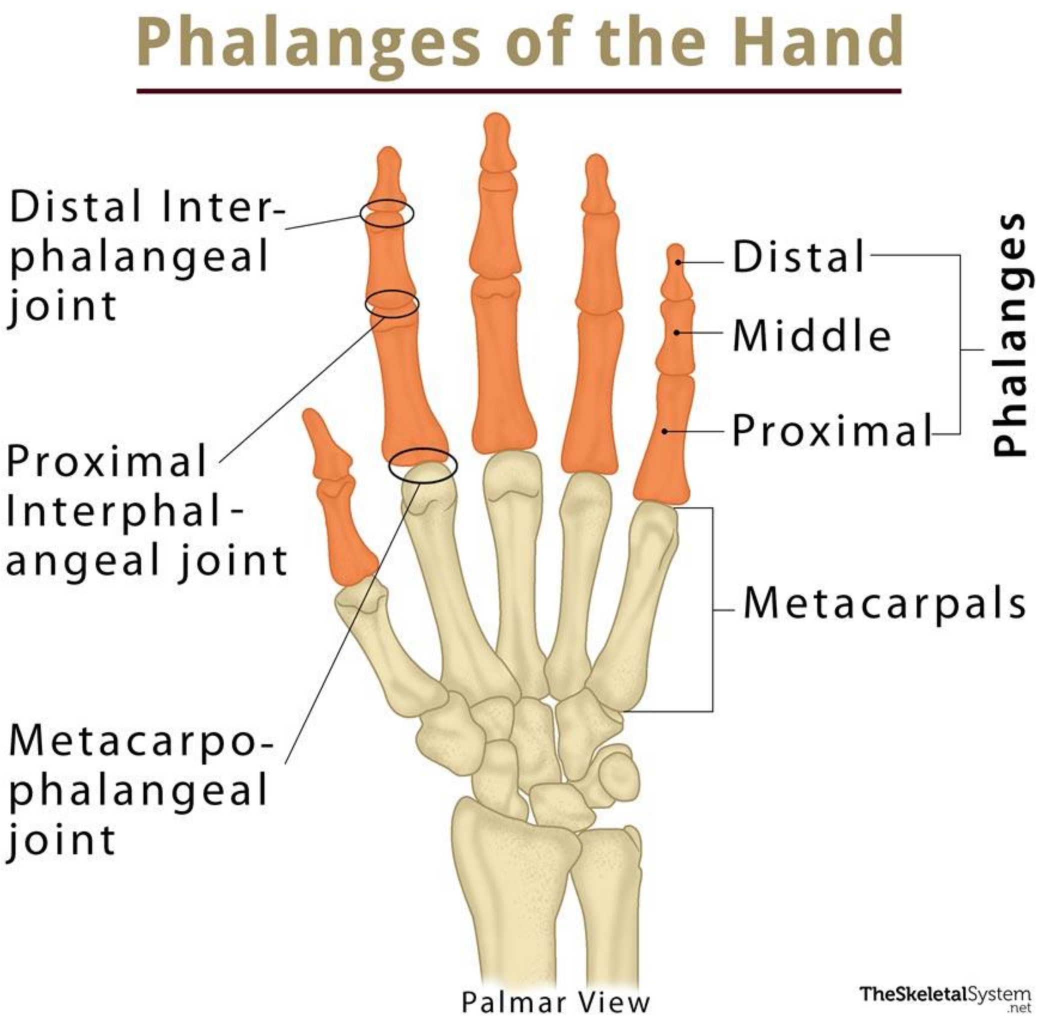
- dbGLOVE, a wearable device for enabling blind and deaf-blind individuals to communicate with others and interact with the world by means of a natural interface that reproduces already-existing touch- and gesture-based alphabets adopted by different communities of people suffering from multisensory conditions.

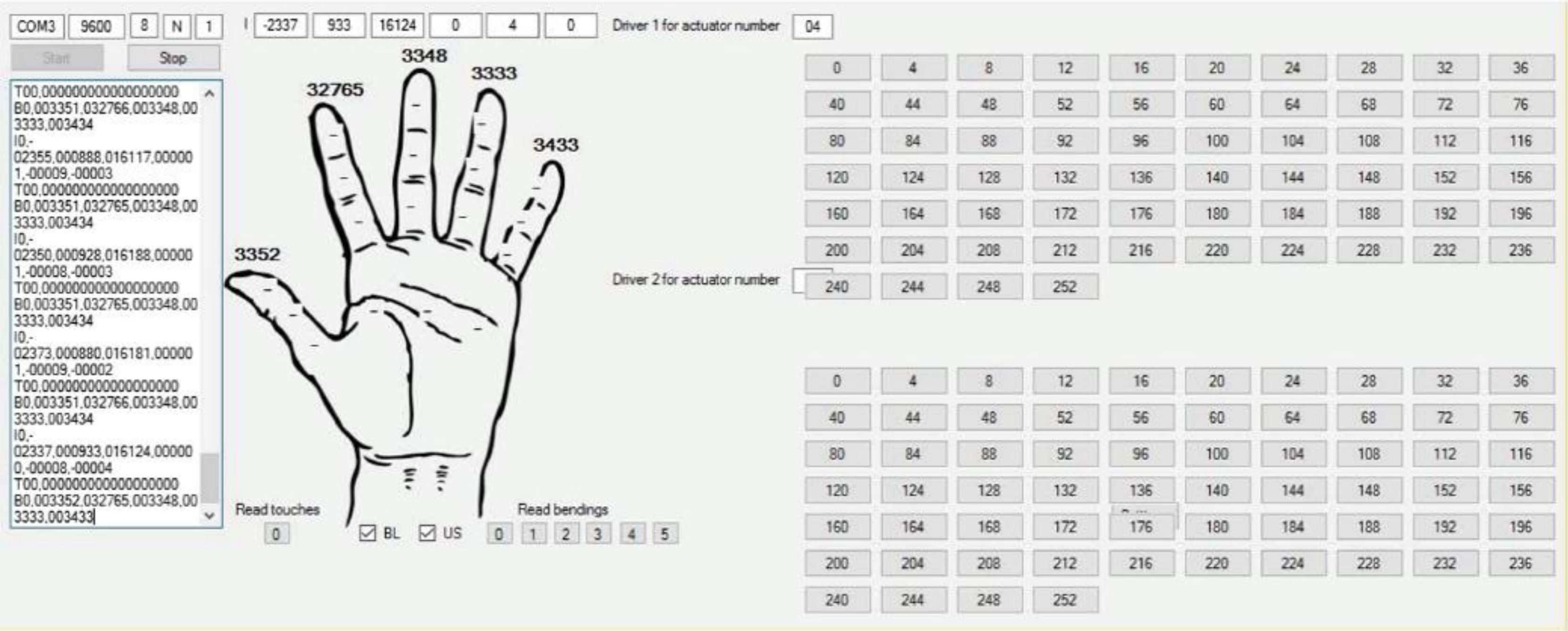
References

[1]. Caporusso, N., Cinquepalmi, G., Biasi, L., Trotta, G.F., Brunetti, A., Bevilacqua, V.: Enabling touch-based communication in wearable devices for people with sensory and multisensory impairments. In: 1st International Conference on Human Factors and Wearable Technologies (2017).

[2]. Caporusso, N.: A wearable Malossi alphabet interface for deafblind people. In: Conference on Advanced Visual Interfaces, pp. 445–448 (2008). doi:10.1145/1385569.1385655

[3]. Bieling, T., Gollner, U., Joost, G.: Mobile lorm glove – introducing a communication device for deaf-blind people. In: Tangible, Embedded and Embodied Interaction, Kingston, ON, Canada, (2012)


Phalanges of the Hand
Distal Inter-phalangeal joint
Proximal Interphal-angeal joint
Metacarpo-phalangeal joint
Distal
Middle
Proximal
Phalanges
Metacarpals
Palmar View
TheSkeletalSystem.net


COM3
9600
8
N
1
-2337
933
16124
0
4
0
Driver 1 for actuator number
04
Start
Stop
T00,000000000000000000
B0,003351,032766,003348,00
3333,003434
I0,-
02355,000888,016117,00000
1,-00009,-00003
T00,000000000000000000
B0,003351,032765,003348,00
3333,003434
I0,-
02350,000928,016188,00000
1,-00008,-00003
T00,000000000000000000
B0,003351,032765,003348,00
3333,003434
I0,-
02373,000880,016181,00000
1,-00009,-00002
T00,000000000000000000
B0,003351,032766,003348,00
3333,003434
I0,-
02337,000933,016124,00000
0,-00008,-00004
T00,000000000000000000
B0,003352,032765,003348,00
3333,003433
3348
3333
32765
3433
3352
Driver 2 for actuator number
0 4 8 12 16 20 24 28 32 36
40 44 48 52 56 60 64 68 72 76
80 84 88 92 96 100 104 108 112 116
120 124 128 132 136 140 144 148 152 156
160 164 168 172 176 180 184 188 192 196
200 204 208 212 216 220 224 228 232 236
240 244 248 252
0 4 8 12 16 20 24 28 32 36
40 44 48 52 56 60 64 68 72 76
80 84 88 92 96 100 104 108 112 116
120 124 128 132 136 140 144 148 152 156
160 164 168 172 176 180 184 188 192 196
200 204 208 212 216 220 224 228 232 236
240 244 248 252
Read touches
0
BL
US
Read bendings
0 1 2 3 4 5