Mobile Lorm Glove – Introducing a Communication Device for Deaf-Blind People

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ABSTRACT
Marginalized communities like deaf-blind people are excluded from several forms of communication. This paper introduces a novel system of interaction to support deaf-blind people's communication and therefore enhance their independence. We introduce the Mobile Lorm Glove: a mobile communication and translation device for the deaf-blind. The glove translates the hand-touch alphabet Lorm, a common form of communication used by people with both hearing and sight impairment, into text and vice versa. We will present a hardware prototype, created in a participatory design process, which enables the deaf-blind user to compose messages via fabric pressure sensors placed on the palm of the glove to be transmitted as an SMS to the receiver's handheld. Initiated by small vibrating motors located on the back of the glove, tactile feedback patterns allow the wearer to perceive incoming messages. We discuss related work, prototype design and interaction design and application scenarios. We conclude with an outlook into further research.

Author Keywords
Deaf-blind, Disability, Glove, Interaction, Lorm, Mobile Communication, Tactile Alphabet, Translator.

General Terms
Design, Human Factors.

INTRODUCTION
Deaf-blindness is a dual sensory-impairment with a combined loss of hearing and sight. The sensory condition of deaf-blind people varies depending on the reasons of their disability. It can be either congenital or caused by accidents or illness [5].

It is difficult for deaf-blind people to connect with the outside world because of the lack of a common language. Particularly people with deaf-blindness acquired late in life have the opportunity to use “Lorm” for communication with the outside world. Lorm, developed in the 19th century by deaf-blind inventor Hieronymus Lorm, is a tactile hand-touch alphabet, in which every character is assigned to a certain area of the hand (see Figure 1). The “speaker” touches the palm of the “reader’s” hand to sequentially draw the characters onto it by tracing lines and shapes.

Figure 1. The German Lorm Alphabet

This requires both interlocutors to be familiar with Lorm. Physical contact is indispensable. Those preconditions often lead the deaf-blind into social isolation and dependence on information relayed by people around them.

Based on these aspects, we want to provide a solution to possibly overcome this challenge. The Mobile Lorm Glove supports communication over distance, provides access to autonomous information and serves as an interpreter for people not familiar with Lorm.

The Mobile Lorm Glove evolved from an iterative research and development process in collaboration with members of two institutions: The Oberlinhaus (Babelsberg) and the ABSV (Allgemeiner Blinden- und Sehbehindertenverein Berlin). In order to get a direct insight into the deaf-blinds actual needs, requirements or barriers for interaction and communication, we approached the process with a participatory mindset. Members of aforementioned institutions were included into a participatory design
process as experts of their everyday life. Following initial observations and interviews, a crucial point was to qualitatively evaluate the participant’s responses regarding general ease of use of the glove, material quality and feel and responsivity of the sensor input.

We did so in intensive 1-on-1-sessions, where different elements of the glove, e.g. sensor input, output as well as the glove itself were tested and discussed. The participants provided us with remarkably precise details of sensor calibration and texture of the sensors and glove, which were similar throughout the group.

Based on these results, a functional prototype for further user-tests with the groups was developed.

RELATED WORK
There have been several research projects focusing on filling the gap in assistive technologies for deaf-blind communication. Mechanical hands for automated fingerspelling or different glove systems have been developed over the last decades implementing a variety of alphabets [5]. Some of them are discontinued. There are only a few focusing on wearable mobile devices and consequently a human-centered design approach.

A similar advanced glove system, the DB-HAND [6], implements the Malossi alphabet. Tactile switches on the surface of the palm need to be pressed and pinched whereas the Lorm alphabet uses continuous gestures. Malossi uses a set of discrete symbols that allows a less complex design because sensors and actuators do not require to be read or fired in clusters. While the pressure sensors of the DB-Hand stick out, the Mobile Lorm Glove uses flat fabric sensors to not constrain smooth gestures. After consultation with our deaf-blind partners we decided to render the alphabet on the back of the hand instead of the palm, in order not to obstruct the deaf-blind too much in their daily life. Furthermore the Mobile Lorm Glove provides vibrotactile feedback to confirm the user input.

The Lormer [7] is the only known previous attempt to address the issue of remote Lorm communication. It is not a mobile device and only supports text to Lorm. It renders Lorm using a mechanical stylus that traces lines to a hand resting on a metal grid similar to a kitchen sieve.

PROTOTYPE DESIGN
The Mobile Lorm Glove is a hand glove made of stretchy fabric equipped with an input unit on the palm of the glove (see Figure 3) and an output unit on the back of the glove (see Figure 4). The control unit is integrated in a case mounted on the forearm.

Input Unit
The input unit consists of a matrix of 35 fabric pressure sensors similarly as described in [1]. 34 of the round shaped pressure sensors, which are 10mm in diameter, correlate with the different characters of the Lorm alphabet. The rectangular sensor located on the wrist of the glove is needed to signal the completion of an entered character.

Figure 2. Positioning of the sensors (l.), positioning of the vibrating motors (r.)

This sensor does not only differ in its shape and size, but also in its texture to clearly distinguish it from the other pressure sensors. The sensors are made from piezoresistive fabric, which changes its electrical resistance under mechanical pressure. The pressure sensors and the glove are stretchy so they can fit tightly to ensure maximal operating comfort. The predetermined pressure points can easily be traced along an embroidered tactile guidance system depicting the patterns of the Lorm alphabet (see Figure 2).

Figure 3. Input unit on the palm of the glove

Output Unit
The output unit is defined by a matrix of 32 shaftless coin vibrating motors each with a diameter of 8mm, an operating frequency range of 200Hz and an operating voltage range of 3.3V designed for haptic vibrating feedback functions in handheld applications. Their location is again based on the patterns of the Lorm alphabet (see Figure 2). They serve as direct feedback for the input sensors and translate incoming text messages into Lorm patterns.
Control Unit
The sensor matrix of the input unit and the actuators of the output unit are connected to the control unit via flexible wires. The control unit and the power source are integrated in a case with an adjustable Velcro strip to be mounted on the forearm (see Figure 4). Two rocker switches on the case are used to turn the device on or off and to switch between input and output.

The controller is designed of four 8-bit shift registers and four darlington transistor arrays controlling the 32 vibrating motors with an ATmega328 microcontroller. To implement the control of the motor intensity pulse-width modulation (PWM) is used. The sensor data is transmitted to the microcontroller using a matrix design of two 8-channel analog multiplexer/demultiplexer. A Bluetooth module mounted on the controller board manages the data transmission between the Mobile Lorm Glove and the handheld of the user.

INTERACTION DESIGN
Traditionally, the deaf-blind shows the palm of a hand to the „speaker“, who uses the tips of his or her fingers to lorm onto it. There are regional differences regarding the choice of the hand or even the side of it that is lormed onto. Considering our deaf-blind co-design partners in Berlin, we chose to implement their way of lorming, i.e. into the palm of the left hand. We decided to place the vibrating motors on the back of the glove in order not to obstruct the deaf-blind too much in their daily life.

The computerization of the hand-touch alphabet Lorm, that is needed in order to provide remote communication possibilities, led to a slight transformation of the alphabet. These derived adaptations are crucial for the hardware design and interaction design of the prototype.

Lorm to Text
The deaf-blind user wears the Mobile Lorm Glove on the left hand and uses the tips of the fingers of the right hand to lorm onto his or her own left hand to compose text messages. The left hand is open with its fingers slightly spread.

The sampling of input data uses event-triggered interrupts initialized by the pressure sensors. The received data is then compared with the entries in a look-up table. Each character is then serial-processed to the handheld of the user via a bluetooth connection.

In traditional Lorm, individual characters are signaled by touching different touch marks. Some characters require single touch, some a second touch that follows at the same spot after the first one. In our participatory design sessions we discovered a significant difference regarding deaf-blind people’s speed of lorming. Due to this individual speed it is not possible to use a time interval to distinguish between two different characters using the same touch mark. Therefore we included a rectangular sensor on the wrist of the glove that must be touched after the completion of each entered character, in order to confirm it. For ergonomic reasons this is preferably done with the thumb of the right hand.

Other characters are formed by a stroke from one mark to another. This is achieved by a continuous movement along the tactile guidance system. Depending on the intended character two to four pressure sensors are thereby crossed. Each combination generates a unique character.

When a sensor is touched, a vibrotactile feedback is generated by the corresponding vibrating motor on the back of the glove to confirm the input. To provide appropriate user comfort we avoided to place motors on the knuckles. This lead to not having exactly as many actuators as sensors.

Due to limitations based on the used sensor system of the glove, arabic numbers need to be written out. In the traditional Lorm alphabet their outline is written in the palm of the hand.

A soft hit onto the palm using all fingers of the right hand signals the end of a word in traditional lorm. Due to our current sensor matrix architecture, multi-sensor combinations are not intended. We solved this by touching the rectangular sensor twice.

Text to Lorm
Once the wearer of the Mobile Lorm Glove receives a text message, it is forwarded to the glove from his or her handheld device via bluetooth and translated into the Lorm alphabet. Initiated by the small vibrating motors, tactile feed back patterns allow the wearer to perceive the incoming messages.

Character by character is processed to the control unit and converted into a sequence of motor addresses and PWM signals to control the motors at the requested intensity. The PWM signal provides 32 levels of intensities similarly as
described in [4]. To simulate the sensation of a continuous movement with discrete actuators, the human sensory phenomenon called the “funneling illusion” [2] is applied. The funneling illusion is implemented as proposed in [3] using linear cross fading from one motor to another by continuously changing their intensities in opposite ways.

The actuators on the glove are placed in varied distances. In order to provide the same velocity of stimulus the duration of the stimulus is adjusted in proportion to the distance of two actuators.

The user's tactile sensitivity and the speed of lorming vary. Therefore the maximal applied intensity and the speed of lorming can be adjusted individually to serve the user's needs.

APPLICATION SCENARIOS

The Mobile Lorm Glove provides two particularly innovative ways of communication for deaf-blind people. It supports mobile communication over distance, e.g. text messages, and it enables parallel one-to-many communication.

Communication over Distance

When communicating with a deaf-blind person, physical contact is no longer the only way to do so. The wearer of the Mobile Lorm Glove can now compose text messages and send them to a receiver's handheld. The received message can either be directly read from the handheld or translated into Lorm alphabet using the Mobile Lorm Glove.

Simultaneous Translation

The Mobile Lorm Glove functions as a simultaneous translator and makes communicating with others without knowledge of Lorm possible. As a result, it empowers deaf-blind people to engage with a broader spectrum of people, thus enhancing their independence.

When communicating with a person without knowledge of Lorm, the wearer of the glove composes text messages as described earlier. The written message appears on the screen of his or her handheld and can be read by the other person or translated by any text-to-speech software. This also works vice versa.

Until now, when socializing, every deaf-blind person needs a personal translator. The newly developed device also enables parallel one-to-many communication, which can be especially helpful in school and other learning contexts.

CONCLUSION AND FUTURE DIRECTIONS

We received an overall positive feedback from our deaf-blind partners. The lightweight device with its textile interface caused quite an euphoria. It is hard to really put oneself into the position of a deaf-blind person, therefore it is particularly important to develop such devices in a participatory design process to provide maximal usability.

A main concern for the future is to decrease the thickness of the glove by replacing the used flexible wires with e.g. stretchable printed circuits.

Our next step will be a study with the aim to verify the functionality and effectiveness of the system in real life situations. A situated long term study is needed to reveal how the proposed system will affect user behaviour in everyday life.

We also want to extend the existing system to provide an interface to access a broader range of information e.g. from websites, e-books or audiobooks. It should also serve as an interface to compose e-mails or to chat with someone.

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REFERENCES