Season's Greetings from SUITCEYES!

As we put 2020 behind us and head towards a new year, we wish to offer you our warmest wishes for the festive season! We would also like to take a moment to reflect on the achievements in SUITCEYES in this, rather different, year. The pandemic naturally affected our activities as well, and the progress made in the project this year. For one, it forced our consortium's partners to work without constant access to labs and equipment; furthermore, a series of user-centred sessions for ideation and testing out prototypes have had to be cancelled on grounds of public health. Electronic equipment has also been hard to come by due to occasional disruptions in the global supply chain. Therefore, as has happened with the vast majority of H2020 projects, **SUITCEYES has been extended** by the European Commission with a **new finishing date of June 2021.**

Nevertheless, work in the project is progressing on nearly all fronts. In 2020 we have accomplished to:

- improve computer vision algorithms for better recognition of scenes, objects and faces in lower lighting; with a covid added extra of detecting and recognising faces with masks on
- hold online co-constructive workshops for design of haptograms
- create multiple new prototypes to facilitate experimentation (chairable prototype) and use and functionality (e.g., the gaming vest)
- develop one-to-many haptic communication from distance
- develop a tactile board that can be used for communication with the HIPI system and with people
- conduct psychophysical experiments toward haptogram designs
- develop and extend gaming scenarios one of which - keep your distance - is particularly useful in current times
- produce scholarly publications and engage in other dissemination activities.

As we head towards the last six months of the project we look forward to bringing all the different elements of the project together for a successful conclusion to the project. For those interested in the final outcomes, among others, we will present our latest results in an exciting

event planned for **May 17-19, 2021** (12:00-17:00 CET each day -- see below). **Do save the dates already!** Looking forward to seeing you then.

MEETINGS, WORK AND INFORMATION

Project partners continued to meet even more intensively during covid-19, albeit online. Unfortunately, certain activities such as, for example, user testing has been postponed indefinitely given the continued impact of the pandemic globally. In this respect, the most significant setback to the project has arguably been the need to cancel a planned trip to EIKHOLT, Norway, where we would have been able to extensively test the project's technology with a significant number of users.

Image 1: October 2020 Online Consortium Meeting (partial view)

POLICY ANALYSIS ON DEAFBLINDNESS AND NEW TECHNOLOGIES

Until 2018 policy concerning new technologies and disability was extremely scarce, but recently this has changed and the topic has increasingly gained interest within policy makers during the last two years. Although technological development has outpaced law and policy, regulation is catching up. Aiming to provide both social policy recommendations and informing our project by identifying how such issues might affect the success and future of our "**haptic intelligent, personalised, interface**" (HIPI), we have overviewed policy across five European countries to provide reports on local policy and social issues regarding people with deafblindness and new technologies.

Results from this important work will be soon available through different documents and publications. Concerning our project, we hope these results and our HIPI will offer arguments to support changes and adjustments in policy and law in the European context, promoting access to these technologies.

LATEST DEVELOPMENTS OF OUR HAPTIC INTELLIGENT PERSONALISED INTERFACE ("HIPI")

In the following sections, we present the latest work in the components of our HIPI, such as haptogram design, visual analysis, perception and navigation, psychophysics and gamification.

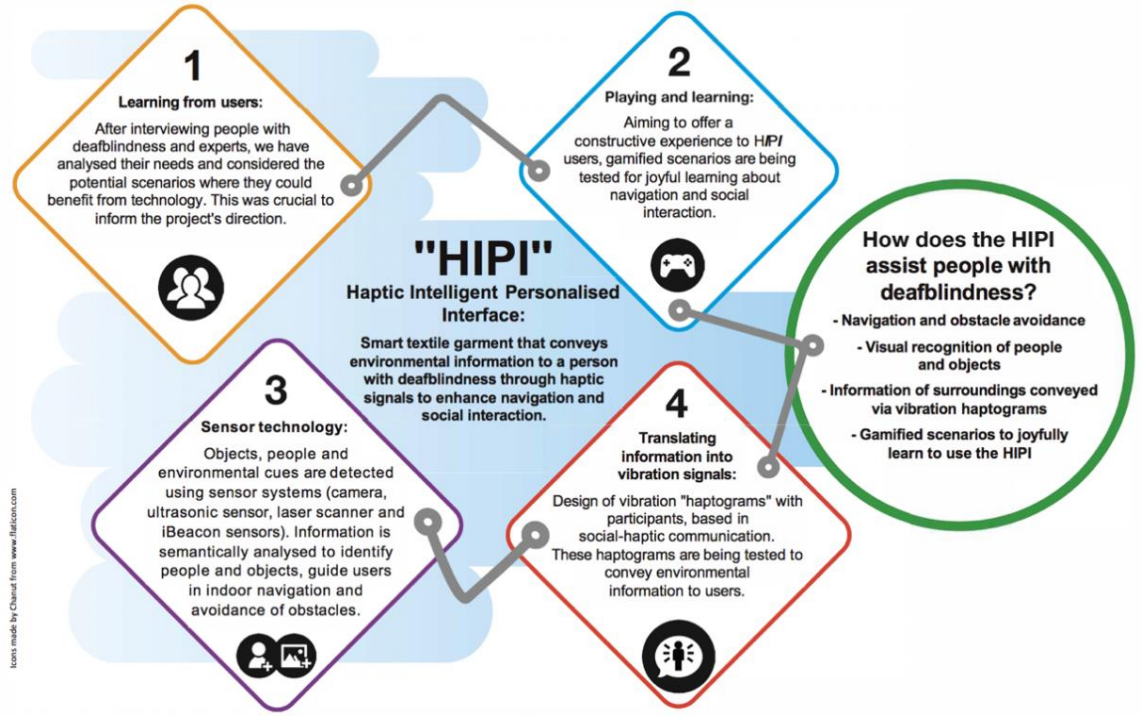

Image 2: Brief outline of the HIPI

HAPTOGRAM DESIGN

Exchange of ideas between two or more people is dependent on some form of language, where words to label concepts are constructed as symbolic representations of actual things. For people with deafblindness, tactile sign language is a common mode of communication. More recently, Social Haptic Communication (SHC) (Lahtinen 2008, Lahtinen and Palmer 2010) has also gained momentum. In SHC, a signer conveys messages to a receiver by hand movements and gestures on appropriate body parts of the receiver. Both SHC and tactile sign languages as modes of communication are social and require close human contact.

To enable the transfer of meaningful messages to a user with deafblindness from a distance, we are developing a vocabulary of haptograms, which are predefined patterns in terms of vibro-tactile stimuli. In other words, we are in the process of identifying vibrotactile patterns that are close enough to SHC signs to facilitate recognition, while at the same time they are

also their simplified version since we cannot fully re-create complete hand movements by a limited series of vibrations.

Our work started by collecting various documented SHC signs (e.g., Nielsen, 2010; Socialhaptiska signaler, and other sources). These were compared with those individual words and more complex messages that are intended to be used by our **haptic intelligent, personalised, interface (**HIPI). Thereby we could single out concepts important for our work yet without documented SHC signs. The steps of the user-centered co-design process were as follows:

- We worked closely with Ritta Lahtinen and Russ Palmer (a) for a review of SHC signs that are already used by others and potential adjustments and (b) for documenting the signs for the words of interest that lacked documented SHC signs;
- Meetings of participatory design were recorded;
- Signs presented by them were reproduced by graphical sketches;
- Finally, these sketches were converted to patterns of actuation, i.e. haptograms.

Due to covid-19, we have been unable to carry out the testing of these haptograms with actual users with deafblindness. Psychophysics experiments involving them will constitute the next phase of our efforts. Based on results of those experiments, our currently proposed patterns will be subject to modifications and improvements.[1]

Below we illustrate steps of the co-design process (Images 2-5).

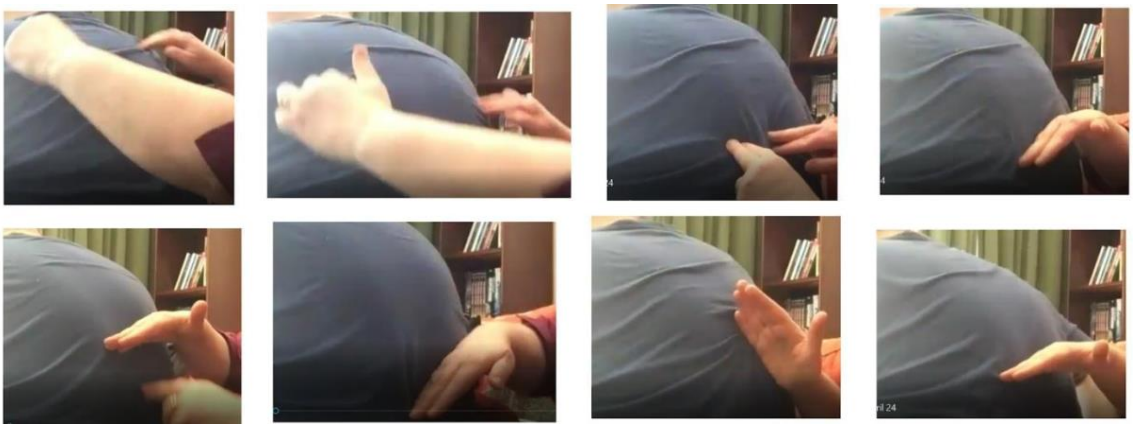

Image 3: Social haptic communication signs were demonstrated and recorded.
[In this instance, the message conveyed on the back of the receiver was “ROOM”. The position of the “DOOR” was also indicated.]

[1] Lahtinen, R. M. (2008). *Haptices and Haptemes: A Case Study of Developmental Process in Social-haptic Communication of Acquired Deafblind People.* (PhD PhD), University of Helsinki,

Lahtinen, R. M., & Palmer, R. (2010). Environmental Description: For Visually and Dual Sensory Impaired People. *A1 Management*.

Nielsen, G. (Ed.) (2010). *103 Haptic Signals - a reference book*.

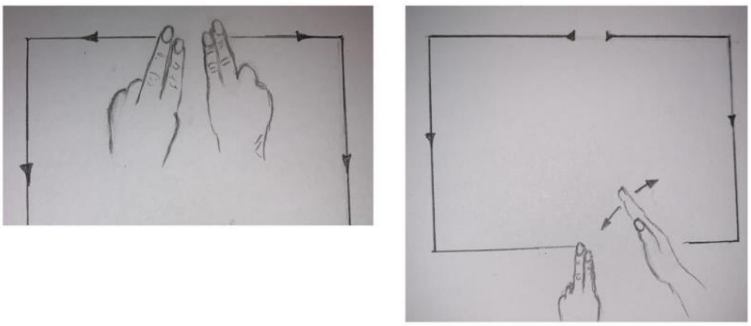

Image 4: Based on the recordings, field notes and sketches were developed.

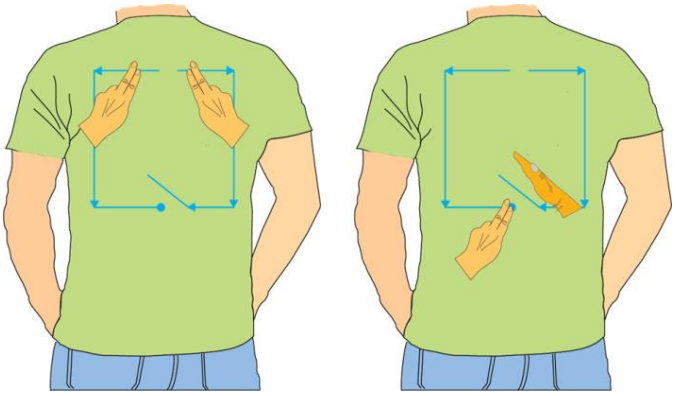

Image 5: Formalised sketches were then drawn.

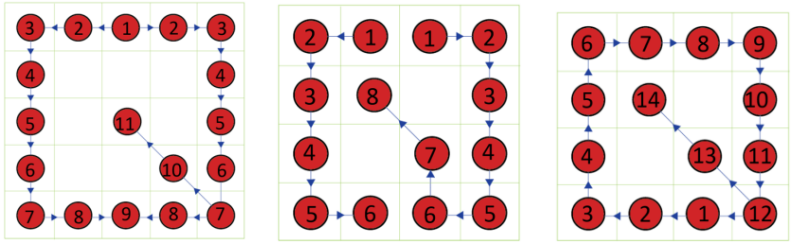

Image 6: Haptograms that closely represent the hand movements were developed. Alternative designs are experimented with to ensure perceptibility. Numbers indicate the sequence of vibrotactile actuators activated.

VISUAL ANALYSIS

In terms of computer vision, with the inclusion of a camera in the vest it is possible to detect and recognise objects of varying size as well as people, which are in the camera's field of view. Additionally, the scene location is recognised, granting the ability to understand at which type of indoors environment the user is at whether it is an office or an elevator. Due to the covid-19 pandemic, an additional module has been developed, with the assistance of the face detection module, which shows if a face mask is worn properly.

The aforementioned modules that comprise the primary Visual Analysis tool are deployed on a remote server which receives the camera feed and executes the powerful and computationally heavy algorithms. However, since a scenario where the communication between the camera and the server is not possible due to the absence of an internet connection is not far-fetched, an alternative architecture as a backup solution has been developed. In this backup solution, the modules for object and scene detection, which are more lightweight in this version, are executed locally, without relying on the communication with the server.

Every single module was developed with the notion that it will help the user understand her surroundings better. With this in mind, the user can ask specific questions regarding objects and scenes of interest such as the location of an object, the recognised objects or the current location, scene-wise, of the user. Additionally, information about the proximity of an object or another person is also provided. Hence, in a situation that the user needs to find her cell phone, it will be possible to know if it is in her field of view and how far it is.

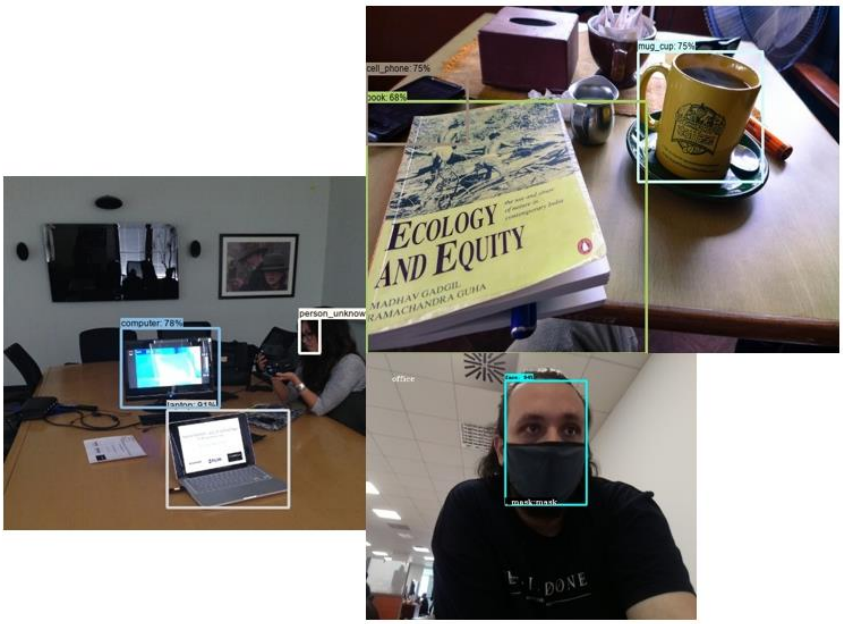

Image 7: Examples of object recognition

PERCEPTION & NAVIGATION

Work on WP4 encountered setbacks due to the departure of one of its main researchers. Work went on nevertheless, and despite the pandemic since February, we have:

- Produced prototype circuit boards for the sensors and actuators
- Tested embroidered circuits from HB for sensors and actuators and

Begun designing connection methods for sensors and actuators

PSYCHOPHYSICS

Social Haptic Communication (SHC) with vibration – To provide social context, SHC is often used in addition to finger spelling or tactile sign language. We have been working on automating SHC. How does this work? The person receiving the messages has a set of vibration motors that are attached to the back of a vest or to the back of a chair. When a message is received, the vibration motors will switch on and off in a pattern that resembles a social haptic sign. This way a spatial pattern can be traced and for instance, a cross or a question mark can be drawn. Although such patterns can be displayed using vibration, they do feel very different from when another person traces them with the finger. We are collaborating with social haptic communication users to construct vibration patterns that are as recognisable as possible. An advantage of using this technology is that messages could be displayed to all members of an audience simultaneously (one-to-many communication). This means only one person is needed to send the messages. Moreover, this person does not even have to have knowledge of SHC as the SUITCEYES system does the translation.

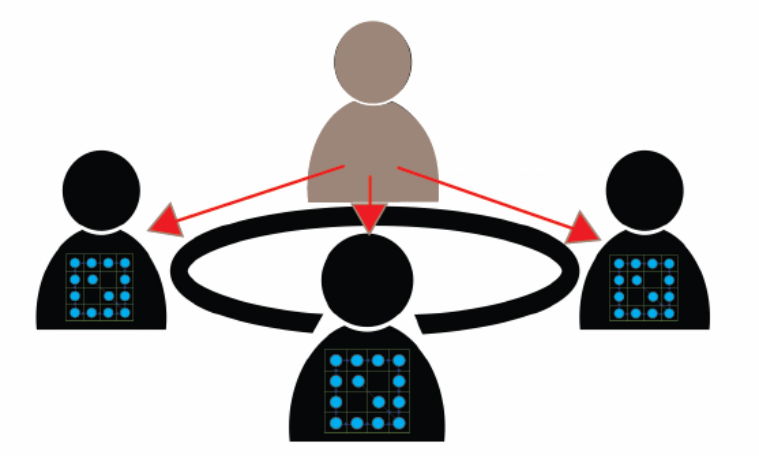

Image 8: Example of 1-to-many communication

Astrid Kappers also presented recent research results in a virtual talk at Eurohaptics, the major European conference on haptics in Leiden last September. The presented research was performed at TU/e in Eindhoven and concerned perception of direction. We studied how well participants can judge the direction indicated by two sequential vibrations presented on the back. Participants indicated the direction by adjusting a sort of clock dial. It was found that directions felt to be closer to the horizontal than they actually were. This type of bias can cause distortions when trying to draw a shape on the back of another person. We therefore have to take such biases into account when translating social haptic symbols into vibration patterns. Correct estimation of direction is also important when providing information for navigation.

Image 9: Partner TU/E participates in online EuroHaptics conference

GAMIFICATION

In February 2020 we conducted a hands-on workshop during which we brainstormed and planned iterations for the second version of our Keep Your Distance gaming vest. The improved wearable took into consideration the feedback received from users that tried the navigation game using the Keep Your Distance 1.0 vest.

Image 10: One of the prototype vests developed by our consortium

Based on the findings of our co-design workshop, we introduced the Tactile Board: a communication device that supports individuals with deafblindness in communicating with other persons by using haptic messages that are then translated into speech or text. The device allows individuals with deafblindness to initiate social interactions without the direct need of an interpreter. The Tactile Board will be presented during the upcoming 19th

International Conference on Mobile and Ubiquitous Multimedia (MUM 2020) that will happen at the end of November.

Image 11: The tactile board (left) communicating with the vest (right)

In the end of October, we presented two short papers at the 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS 2020). The first paper, "Exploring Low-Cost Materials to Make Pattern-Based Lock-Screens Accessible for Users with Visual Impairments or Deafblindness" focused on using different materials to make touchscreens accessible to users with multisensory disabilities.

Image 12: Different low-cost materials for pattern-based lock screens

The second paper, "Keep Your Distance: A Playful Haptic Navigation Wearable for Individuals with Deafblindness" demonstrated our navigation game that encourages individuals with deafblindness to navigate independently by following haptic signals being provided around the waist area. We are happy to share that the Keep Your Distance system received the "People's Choice Award" at ASSETS 2020. The video (https://www.youtube.com/watch?v=Vr7OQK5OBWY) received the highest number of likes and engagement, and a special recognition was given during the conference's ceremony.

Finally, during the summer students at Offenburg University of Applied Sciences worked on a documentary film about SUITCEYES. The film features interviews with local members of the Deafblind community and the research being developed by different project partners, including a visit to Borås in Sweden. The film is due to be released soon.

DISSEMINATION

We recently developed new publicity material to better reach our project community. A leaflet describing our latest developments to potential HIPI users was prepared in print and pdf screen reader version. Aiming to reach all potential users, we developed alternative accessible formats, such as an easy-to-read version of the leaflet with simplified text

(available in print and screen reader version), and plain large-print document that can also be printed in Braille on demand.

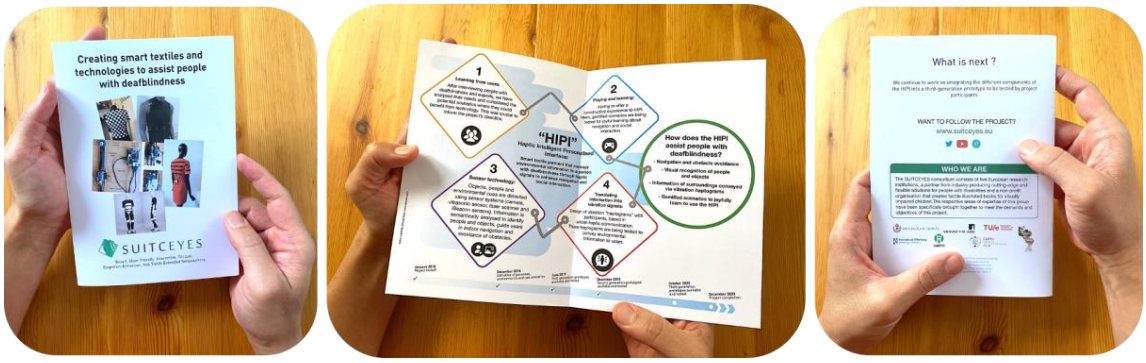

Image 13: Leaflet in print and screen reader version for potential HIPI users

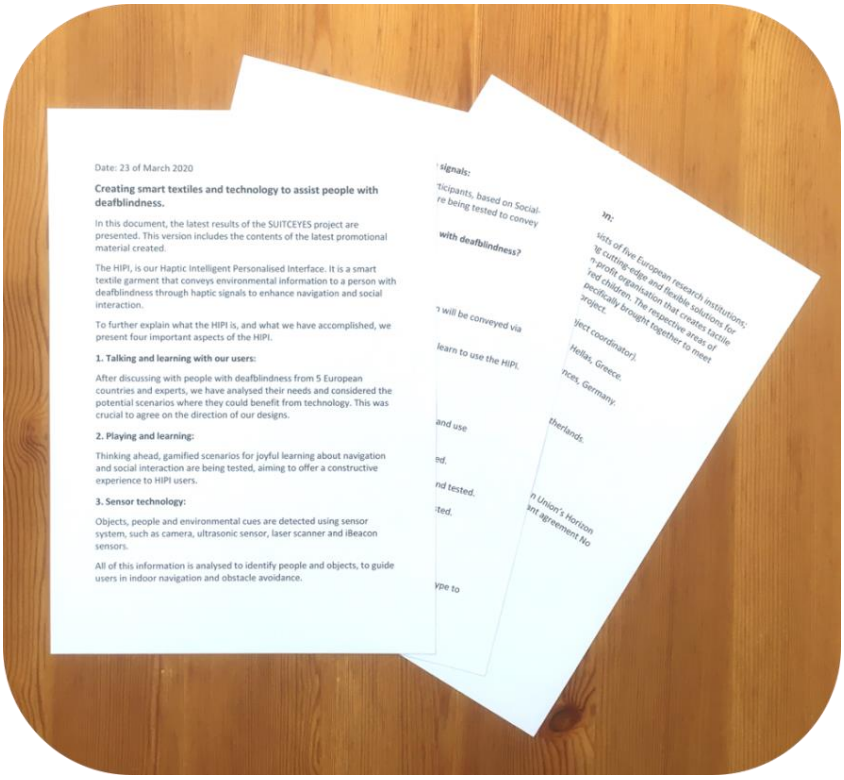

Image 14: Leaflet contents in plain large-print text for potential HIPI users

Finally, a project poster (A3) that can be folded into an easy-to-carry size, features the project's most recent developments to inform the academic and industry audiences.

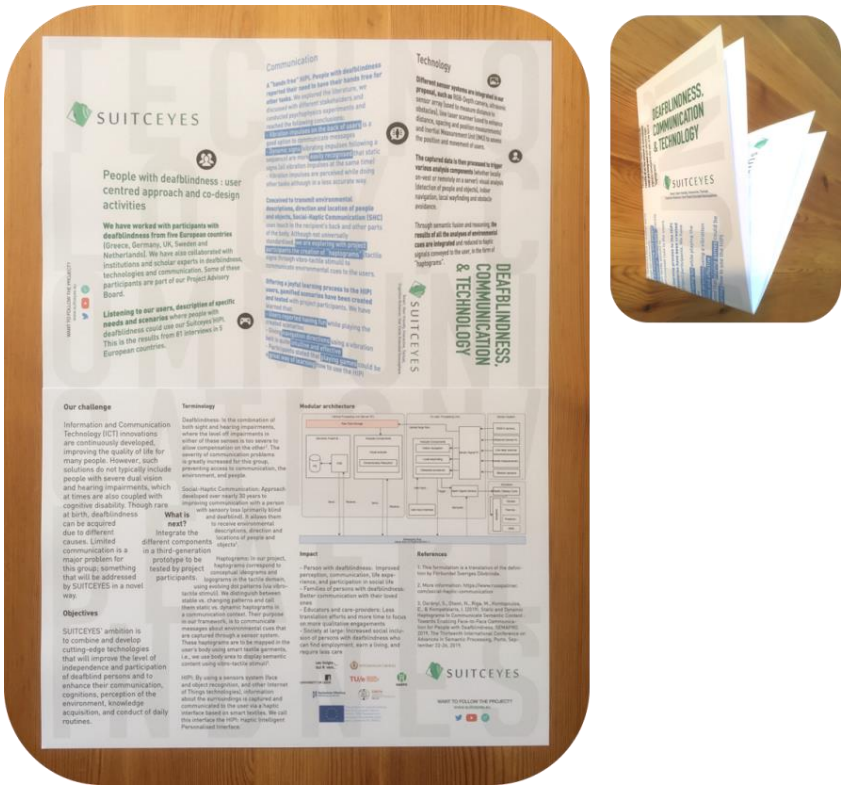

Image 15: Poster addressed to our academic and industry audiences

DISSEMINATION ACTIVITIES AT A GLANCE (2020)

The **Swedish Minister for Culture and Democracy** visited HB on Feb. 7th and was given a presentation of SUITCEYES.

Partner HARPO, exhibited the project at **California State University Northridge (CSUN) Assistive Technology Conference**, Anaheim, California, 9-13 March 2020.

Colleagues from HSO presented two papers at the **The PErvasive Technologies Related to Assistive Environments (PETRA) 2020 conference**, virtual, 30 June – 3 July 2020 and received the best poster award. They also presented papers at the **DIS2020 More than Human Centred Design**, virtual, 6-20 July 2020; **The 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS)**, virtual, 26-28 October 2020; and **19th International Conference on Mobile and Ubiquitous Multimedia (MUM 2020),** virtual, 22-25 November 2020.

A joint paper by multiple colleagues was presented by a colleague at HB at the **3rd International Conference on Human Interaction and Emerging Technologies (IHIET 2020)**, virtual, 27-29 August 2020

SUITCEYES was also represented at the **Eurohaptics 2020 Conference**, Leiden, 6-9 September 2020 through colleagues from TU/e, while unfortunately an interesting workshop that was also planned and ready had to be cancelled due to Covid.

HB colleagues attended and presented a paper at the **ISIC2020 – The Information Behaviour Conference**, virtual, 28 September – 1 October 2020 which won the best paper award.

RECENT SCHOLARLY PUBLICATIONS (2020)

Theil, A., Buchweitz, L., Fuentes, M. & Korn, O., *Co-Designing Assistive Tools to Support Social Interactions by Individuals Living with Deafblindness*, **In Companion Publication of the 2020 ACM on Designing Interactive Systems Conference (DIS' 20 Companion). Association for Computing Machinery**, New York, NY, USA, 79–83, 2020, https://doi.org/10.1145/3393914.3395869

Lindell E., Theil A., Guo L., Olson N., Korn O., Persson NK., *Physical Add-Ons for Haptic Human-Surrounding Interaction and Sensorial Augmentation*, **In: Ahram T., Taiar R., Langlois K., Choplin A. (eds) Human Interaction, Emerging Technologies and Future Applications III. IHIET 2020. Advances in Intelligent Systems and Computing**, 2020, vol 1253. Springer, Cham. https://doi.org/10.1007/978-3-030-55307-4_28

Darányi, S., Olson, N., Lindell, E., Persson, N.-K., Riga, M., Kontopoulos, E., Kompatsiaris, I., *Communicating Semantic Content to Persons with Deafblindness by Haptograms and Smart Textiles: Theoretical Approach and Methodology*. **International Journal on Advances in Intelligent Systems**, Volume 13, Numbers 1 & 2, 2020, 103-113, http://www.iariajournals.org/intelligent_systems/tocv13n12.html

Nandkumar, K., Schulz, A. S., and Korn, O., *Wearable or HMD?: how to support tactile navigation*, **In Proceedings of the 13th ACM International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '20). Association for Computing Machinery**, New York, NY, USA, Article 78, 1–2, 2020, https://doi.org/10.1145/3389189.3397644

Korn, O., Gay, J., Gouveia, R., Buchweitz, L., Schulz, A.S., and Umfahrer, M., *Tactile navigation with checkpoints as progress indicators? only when walking longer straight paths*, **In Proceedings of the 13th ACM International Conference on PErvasive Technologies Related to Assistive Environments (PETRA '20). Association for Computing Machinery**, New York, NY, USA, Article 32, 1–8, 2020, https://doi.org/10.1145/3389189.3392605

Kappers A.M.L., Bay J., Plaisier M.A., *Perception of Vibratory Direction on the Back*, In: Nisky I., Hartcher-O'Brien J., Wiertlewski M., Smeets J. (eds), **Haptics: Science, Technology, Applications. EuroHaptics 2020. Lecture Notes in Computer Science**, Vol 12272, pp. 113-121, 2020, Springer, Cham., https://doi.org/10.1007/978-3-030-58147-3_13

Plaisier, M.A., Holt, R.J., and Kappers, A.M.L., *Representing numerosity through vibration patterns*, **IEEE Transactions on Haptics**, 2020, https://ieeexplore.ieee.org/document/9072549

Plaisier, M.A., Vermeer, D.S., and Kappers, A.M.L., *Learning the Vibrotactile Morse Code Alphabet*, **ACM Transactions on Applied Perception** 17, 3, Article 9, 2020, https://doi.org/10.1145/3402935

Giannakeris, P., Petrantonakis, P.C., Avgerinakis, K. et al., *First-Person Activity Recognition from Micro-Action Representations using Convolutional Neural Networks and Object Flow Histograms*, **Journal of Multimedia Tools and Applications (MTAP)**, 2020, https://doi.org/10.1007/s11042-020-09902-6

Olson, N., & Maceviciute, E., *Information worlds of people with deafblindness*, **ISIC 2020**, University of Pretoria, South Africa, in press, 2020 * Best Paper Award *

Plaisier, M.A., Sap, L.I.N., and Kappers, A.M.L. *Perception of vibrotactile distance on the back*. **Sci Rep** 10, 17876 (2020). https://doi.org/10.1038/s41598-020-74835-x

Gay, J., Umfahrer, M., Theil, A., Buchweitz, L., Lindell, E., Guo, L., Persson, N.-K., and Korn, O., *Keep Your Distance: A Playful Haptic Navigation Wearable for Individuals with Deafblindness*, **In The 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '20)**, October 26–28, 2020, Virtual Event, Greece. ACM, New York, NY, USA, https://doi.org/10.1145/3373625.3418048

Buchweitz, L., Theil, A., Gay, J., and Korn, O., *Exploring Low-Cost Materials to Make Pattern-Based Lock-Screens Accessible for Users with Visual Impairments or Deafblindness*, **In The 22nd International ACM SIGACCESS Conference on Computers and Accessibility (ASSETS '20)**, October 26–28, 2020, Virtual Event, Greece. ACM, New York, NY, USA, https://doi.org/10.1145/3373625.3418020

Theil, A., Buchweitz, L., Gay, J., Lindell, E., Guo, L., Persson, N.-K., and Korn, O., *Tactile Board: A Multimodal Augmentative and Alternative Communication Device for Individuals with Deafblindness*, **In 19th International Conference on Mobile and Ubiquitous Multimedia (MUM 2020)**, November 22–25, 2020, Essen, Germany. ACM, New York, NY, USA, https://doi.org/10.1145/3428361.3428465

Kassiano, V., Stavropoulos, T. G., Nikolopoulos, S., Kompatsiaris, I., Riga, M. (2020) *Spatial Awareness for the Deafblind in Natural Language Presentation using SPIN Rules: A Use Case in the SUITCEYES Platform*. **eTELEMED 2020 : The Twelfth International Conference on eHealth, Telemedicine, and Social Medicine**. https://www.thinkmind.org/index.php?view=article&articleid=etelemed_2020_3_240_40096

FUTURE DIRECTIONS

As the project nears its end in mid-2021, and with difficulties posed by covid-19 seeming unlikely to lift by then, our consortium's attention is focused on bringing all technologies together in order to present a multitude of prototypes that will for example cater to different parts of the body. These prototypes will be open enough to serve as a platform for future research. We aim to present all of our results, and discuss issues of deafblindness in general, in our final online symposium to take place in May 2021. More information below, registrations to participate are now open and we hope you will join us!

SYMPOSIUM

Living through Touch – Smart Haptic Communication for Inclusion, Accessibility and Participation

Date: May 17-18-19, 2021

Time: 12:00-17.00 CET

Venue: Online

Participation is free. **Register here!**