Astrohaptices: Touching the Universe

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Abstract People with deafblindness may have space-related hobbies. These hobbies are a way of touching the Universe. The means of making these hobbies accessible include environmental description and social-haptic communication, in particular the astronomy-related subgroup, astrohaptices. The subsystem is evolving but already provides an important tool for the professionals. Astrohaptices can be used with various space-related events and activities. Furthermore, astrohaptices are zoomable to be used within our Solar System and elsewhere in the Universe. They provide tools for making the Universe more accessible for all.

Keywords Astrohaptices. Social-haptic communication. Deafblindness. Haptic exploration. Space exploration.

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1 Introduction – Social-Haptic Communication to Astrohaptices

During an interaction between a person with deafblindness and an interpreter, or a personal assistant, specific issues need to be addressed in relation to touch-based information as well as close interaction between two individuals. In every instance, but especially in the educational setting, people with deafblindness need to have hands-on contact and this can be expanded to other areas of the body, so-called neutral areas (Lahtinen, Palmer, Lahtinen 2010, 120; Lahtinen, Palmer 2012). Any interaction process needs to be agreed between both parties, and this may vary from one individual to another. In all aspects of communication there needs to be a permission to touch and to be touched – and an agreed understanding between both parties. This so-called touch profile may be situation-dependent and variable. In this article, we discuss touch-based methods in connection to space-related interests and hobbies.

People with a visual impairment may be interested in astronomy and space travel, too. Astrohaptices (Palmer 2020; 2021) together with environmental description (Lahtinen, Palmer 2012) offer a way to participate in space-related events even without vision. Astrohaptices are a subgroup of social-haptic communication (Lahtinen 2008). They are developed for a need of more accurate descriptive tools to be used when exploring astronomical objects and participating in space-related events. It uses neutral areas, the hands, the arms and the upper back. You can use it with static objects, such as photos or maps, or dynamically when describing a live event, such as a rocket launch.

Analysis of pre-existing touch-based communication and further development of social-haptic communication originated in the early 1990s via Riitta Lahtinen's work (Lahtinen 2008). By definition, social-haptic communication refers to the interaction between two or more people by touch messages in a social setting. These touch messages are called haptices. Over the years, the social-haptic communication system has been expanded to cover many themes, such as hobbies (football, ten-pin bowling, tandem cycling, riding) and healthcare settings (hospital haptices, rehabilitation-related haptices, home care haptices). In this article, we discuss haptices related to space and the Universe called astrohaptices. These use the body as a reference point related to an object, a photograph or a celestial object you can see either in the sky by naked eye or in an observatory using a high-powered telescope. This is also true for a live event where one can use a combination of IT, tactile models and astrohaptices to enhance the individual's experience in real-time adding to the thrill of the countdown and launch processes as well as the pre- and post-launch events. Furthermore, this will expand the integration of information from different senses together. Most often astrohaptices are used simultaneously to other means and methods of communication, such as haptic exploration and language-based environmental description, either with speech or signing.

2 Astrohaptices and Haptic Exploration

Usually astrohaptices are used together with haptic exploration. It means that you explore things with your hands. You can do that independently or with a guide. The objects can be part of a touch tour or shop items – or home-made. Home-made objects can be crocheted or made out of cardboard. Touch tour objects are most often replicas or scale models, sometimes miniatures for children. The latest technique is to use 3D printing in various ways.

For example if one studies the Apollo Lunar Module, the lander craft that landed on the Moon in 1969, the current models are often very delicate and need to be handled carefully. Normally one can start from the bottom up, feeling the spidery legs which may or may not be extended from close to open position. This depends on the model in question one uses to explore the details. The legs are supported by little cross-over struts covered in foil, this is called the descent part, which has a big single engine. So by exploring the object stage by stage one is able to build up a picture.

When visiting an actual vehicle mock-up or replica in the museum, it may not be possible to touch the exhibit, so through using a white cane with the help of an assistant or interpreter one might be able to get an idea of the dimensions of the object when standing next to it. Sometimes when exploring the dimensions of the vehicle or an object, one can actually walk around the exhibit to get an idea of the width and depth of it. Using the model replica and manual handling of the miniature model at the same time, it may be possible to explore the intricate details of the vehicle stage by stage.

Sometimes an object is inside a glass cabinet. Then it is not possible to touch these objects, so the assistant or interpreter has to describe tracing the dimensions (shape, size and height) of the object with the person with deafblindness hand-in-hand to get an overall impression. If one is exploring a Moon suit, it may be possible to map the different details (pipes, helmet, gloves and pockets) either by mapping them on the back of the hand or on the person's back according to their preferences. By doing this, the person with deafblindness is able to appreciate in a physical manner what it might be like to wear such a bulky suit on the Moon. There may be additional fabric samples of the materials used in manufacturing the layered garments worn on the Moon. In addition to the different textile samples the describer may show the layered joint patches and how they are assembled together.

Furthermore, some museums offer so-called touch tours where some replica objects may be felt and explored through touch. For example, during a visit to Space Expo Noordwijk near Amsterdam, the Netherlands, there is an opportunity to explore a replica Moon boot from the Apollo mission. Here again, one is able to use haptic exploration to feel the texture of the boot with the many layers plus the rubberised sole of the boot to protect the astronaut's feet. The experience to be able to touch these things enables the person with deafblindness to appreciate the skill and workmanship that goes into making these things protecting the astronauts from the extreme temperatures (at the lunar equator [120°C to -130°C], data from NASA Lunar Reconnaissance Orbiter, 2013).[1]

3 Studying Photographs and Images

When viewing images and photographs, be it in the museums, in periodicals, or online, a person with deafblindness can find it difficult to access these depending on their visual status, varying from narrow field of vision, peripherical vision, to total blindness. In many cases, people who experience narrow field of vision may have memories of seeing images in the past but now find it difficult to see these images in a short timeframe. To enhance the deafblind person's perception of photographs, an interpreter or a personal assistant can draw these images in a number of different ways, on their preferred body location outlining the object in the image, describing the details such as colours, and other related visual characteristics and intricate details of the object in question.

Outlining an image and additional details in it onto the body is often enhanced with linguistic information, be it signed or spoken – or a combination of both. Usually the more varied the description of an image is, the easier the information is to process. Sometimes the individuals prefer the description of the overall picture first followed by the details (Ojala 2011, 34), sometimes vice versa. The previous option follows the order commonly used in signed languages, whereas the latter version follows the order more commonly found in spoken languages. The difference is theorized to be due to the innate nature of these languages (on principles of cognitive grammar and especially figure-ground cognitive processing, please see Langacker 1987 and others). There are individual preferences on the order of description of details, and these often are due to the varying visual status. An interpreter is encouraged to follow the gaze of the individual they are interpreting for to give coherent additional information about

1 See https://science.nasa.gov/moon/weather-on-the-moon/.

the image for their client (Bruce, Tsotsos 2005). That is, if the client focuses on the top left corner of the image, then description needs to derive from that corner to be appropriate and coherent to what the person focuses on. Sometimes the interpreter needs to guide the person from one detail to another to help the scanning of the image and thus to get the whole perspective concerned.

Furthermore, the producer needs to understand various methods of social-haptic communication to allow the person with deafblindness experience what is happening in the image concerned. This involves both haptices, haptemes and environmental description combined together. For example if describing NASA's famous Man on the Moon 1969 picture that featured in the Times magazine cover of Edwin 'Buzz' Aldrin **[fig. 1]**, this image portrays him standing on the Moon with his left arm over his chest bent 90° and thus slightly covering the six connectors on his chest, and his legs apart, like standing at ease in the military pose to stabilise his walk as the Moon has 1/6 of the Earth's gravity.

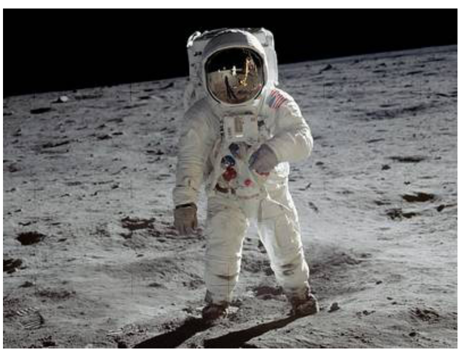

Figure 1
Man on the Moon (image credit: NASA/MSFC; published: 28 June 2018; historical date: July 20, 1969)

Figure 2
A figurine in resin depicting an astronaut on the Moon in a salute pose (photo credit: Andrew Reynolds)

In addition to Neil Armstrong being reflected on his golden visor **[fig. 1]**, behind Aldrin, one can see the blackness of the space with the lunar horizon, while the lunar surface[2] is littered around him with a number of craters along with some small rocks and bigger boulders. In terms of colouring, the Moon surface seems to be very dark grey and dusty with mix of granules similar to regions found in the Arizona desert in the USA.

All of these elements can be portrayed on the person's body by the describer, but the method of doing this depends on the individual's choices. Some people may prefer to have the background of the picture described first followed by the astronaut – or vice versa. This needs to be agreed by both parties beforehand.

For example, the describer may draw on the person's back the square outline of the picture, which may be followed by the actual figure using two hands or two fingers to draw the outline of the astronaut. Similarly, one might use the flat hand to depict the blackness of the sky followed by the Moon's horizon followed by the rocks and craters on the Moon. During the process, the describer may use either spoken language or one-handed sign language to tell more about colours and textures in the image background. Turning to the details on the astronaut, the describer may need to use a series of drawings to illustrate first the astronaut's visor followed by the elements on the suit configurations, such as hoses, buttons, cameras and features on the chest area. Moving down, they may also need to show the arm positions, cross the chest followed by the bulkiness of the gloves. At the same time, the describer may illustrate this onto the body of the person with deafblindness by in effect re-creating the movement and the posture of the astronaut.

2 Carrying astronauts Neil A. Armstrong and Edwin E. Aldrin, Jr., the Lunar Module (LM) 'Eagle' was the first crewed vehicle to land on the Moon. The LM landed on the moon's surface on July 20, 1969 in the region known as Mare Tranquilitatis (the Sea of Tranquility). Meanwhile, astronaut Michael Collins piloted the command module in a parking orbit around the moon. This photo is of Edwin Aldrin walking on the lunar surface. Neil Armstrong, who took the photograph, can be seen reflected in Aldrin's helmet visor. Armstrong was the first human to ever stand on the lunar surface. As he stepped off the LM, Armstrong proclaimed, "That's one small step for man, one giant leap for mankind". He was followed by Edwin (Buzz) Aldrin, describing the lunar surface as magnificent desolation. The Apollo 11 mission launched from the Kennedy Space Center, Florida on July 16, 1969 via a Saturn V launch vehicle, and safely returned to Earth on July 24, 1969. The Saturn V vehicle was developed by the Marshall Space Flight Center (MSFC) under the direction of Dr. Wernher von Braun. The 3-man crew aboard the flight consisted of Neil A. Armstrong, commander; Michael Collins, Command Module pilot; and Edwin E. Aldrin Jr., Lunar Module pilot. During a 2½ hour surface exploration, the crew collected 47 pounds of lunar surface material which was returned to Earth for analysis. With the success of Apollo 11, the national objective to land men on the Moon and return them safely to Earth had been accomplished (NASA Resources: Earth's Moon; see `https://www.nasa.gov/mission/apollo-11/`).

Figure 2 shows a model of the same image of the astronaut in the photograph, but this time the perceiver is able to feel the astronaut in 3D, also including the dusty Moon surface and the smoothness of the golden visor. This enables the person with deafblindness to have a very realistic image to a deeper understanding, including being able to feel the backpack and the cables connected – as well as the left boot where the soil of the Moon's surface has been rippled onto the boot. This also adds the bulkyness of the suit into the picture and how the bulky suit must have been restricting his movement on the Moon as well as his ability to work in the hostile environment. This is due to the fact that the Moon suit needs to have an in-built atmosphere to protect the astronaut inside.

4 Visiting Museums and Touching Objects

When visiting a museum, it is beneficial to start the visit by going to the museum shop first, since very often there are objects that are available to touch in various degrees, depending on the packaging. Even though some of these might be manufactured for children, it may provide a basic outline or shape of the object and thus create a baseline for the future description beside the actual object or objects on display in the museum. There may be various space capsule modules, such as Vostok, Soyuz, Mercury or Apollo available to touch and on display. It is always beneficial to discuss the availability to touch objects in the shop with the shop assistants. This can be useful, as it allows the person with deafblindness to have some preliminary idea of the exhibits on display in the exhibition.

The sense of scale for the person with deafblindness comes from understanding the dimensions of their own body. This is true for every astrohaptice model described in this article. This innate knowledge of the dimensions of your own body is enhanced by the general knowledge about the Universe, which may differ greatly from one person to another. In terms of scale one might use the basic model of the Solar System astrohaptices **[fig. 4]** and its relation to the Milky Way astrohaptice model **[fig. 5]**. This enables the person with deafblindness to understand the layout of our Solar System where the planets are in relation to one another and understand how vast in scale the Milky Way is when the Solar System is represented on the little fingernail of the person **[fig. 5]**. This allows the person with deafblindness to get a deep perspective, which would not otherwise be possible to appreciate.

There may be different diagrams of flight trajectories, such as that of the Voyager probe visiting various planets in the Solar System. This is where one could benefit from the Solar System astrohaptices (see § 5) since the Voyager spacecraft travelled around various planets for the gravity-assisted 'sling-shot manoeuvre' to save fuel **[fig. 3]**. Sometimes there is a full-scale replica of the spacecraft hanging from the ceiling as well.

The describer may start with description of the probe itself. There may or may not be a small touchable model. If there is not, then one needs to improvise on description of the probe. By guiding the receiver's hand, one can draw the outline of the probe and its main parts to give an idea of the dimensions of the probe itself. The Voyager has three main parts: the high-gain dish-shape antenna that sends the signal back to Earth, then there are two long boom sensor platforms, sensing out magnetosphere and plasma in space. Perhaps the most intriguing part of the Voyager probe is the Golden Disc, that includes description of where the probe originated from and various audio samples of humanity as a species for the extra-terrestrials to find and play.

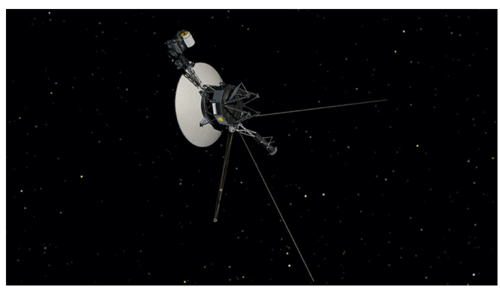

Figure 3
This artist's concept shows NASA's Voyager spacecraft against a backdrop of stars (image credit: NASA/JPL-Caltech)

Once this description has been done, it may be useful to get an idea of how large the probe is. This can be done by walking underneath the exhibit from the main body of the probe to the end of the longer boom structure and there might be further descriptions on the way. The final stage would be to describe the trajectory of the Voyager probe within the Solar System by using the Solar System astrohaptices (see § 5). The Voyager probe trajectory will be outlined by the producer's index finger around the planet placeholders in succession. This is an example of how-to explore spacecraft flight paths within our own Solar System with astrohaptices.

In order to demonstrate the location of the Voyager probe today, one can zoom out from the Solar System astrohaptices and use the Milky Way (see § 5.1) astrohaptices model instead. Currently, Voyager probe is located somewhere in the interstellar space beyond the Oort Cloud and travelling towards the Proxima Centauri. The use of this astrohaptic model of the Milky Way to demonstrate Voyager's flight trajectory gives the person with deafblindness a good illustration on how vast the Universe is. This is how the different structures of the Universe can be portrayed on a zoomable astrohaptices system.

5 The Universe and Our Place in It

There are many space-related documentaries on television and a wide variety of images and diagrams of our home planet, the Earth in the Solar System and its place in the wider perspective, our home galaxy, the Milky Way. Not only do these TV programmes rely heavily on the imagery on screen, but also the presenters very rarely describe what is actually on screen, especially when it comes to diagrams. This is where the astrohaptices were conceptualised in the first instance – to find the Earth in the Solar System. The Solar System astrohaptices are not only a stationary representation of the Solar System but can also be used dynamically when describing orbits, locations, flight paths – whatever is happening out there in the Solar System, including the latest space weather events.

Of course, the description of the Solar System starts from its centre, the Sun. In our astrohaptic model, the Sun is located along the outside of the left lower arm from wrist to elbow. The planets are placed on the fingertips when the hands are side by side in the front, fingers spread, palms facing down and thumbs touching each other **[fig. 4]**. The innermost, so-called terrestrial planets in order are Mercury (left little finger), Venus (left ring finger), Earth, our home (left middle finger), and Mars (left index finger). The outstretched thumbs together represent the Asteroid Belt between Mars and Jupiter. The outermost planets, the gas giants, Jupiter, Saturn, Uranus and Neptune occupy the fingers of the right hand, respectively. The former planet Pluto, which has been downgraded into a dwarf planet, occupies the right little finger knuckle in this model. If one expands this Solar System model to include also the lesser-explored outer edges of the Solar System, we have included the Kuiper Belt and the Oort Cloud as the main structures in this model. The Kuiper Belt occupies the area from the right little finger knuckle to the right elbow along the lower arm while the Oort Cloud respectively stretches from one shoulder to the other. This is a simplistic way to get the planets in order. However, if you want to go further out to the Milky Way, there is a zoomed-out astrohaptices set for it (see § 5.1).

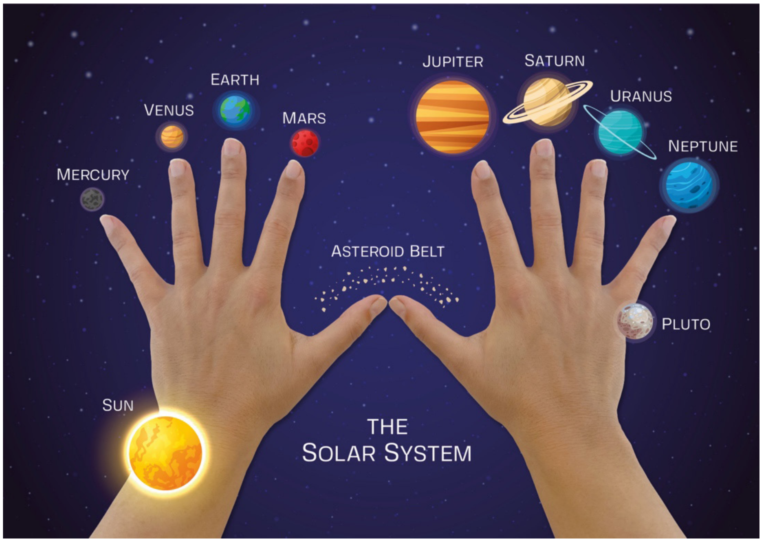

Figure 4 Solar System astrohaptices (image credit: Palmer 2020; reprint with permission)

Figure 5 Milky Way astrohaptices (image credit: Palmer 2021; reprint with permission)

5.1 The Milky Way and the Universe as Astrohaptices

Astrohaptices present a simplified yet powerful version of the various structures in the Universe. We can take our home galaxy, the Milky Way, as an example of this. In the previous section, we had the Solar System spread out through fingers and hands, but in this example we will zoom out and present the Solar System diminished on the small fingernail of the right hand **[fig. 5]**. Now the Kuiper Belt is represented on the first joint of the small finger, and the Oort Cloud is located on the knuckle. Zooming out, moving up towards the wrist, illustrates moving deeper into interstellar space. There we encounter the nearest star to the Sun called Proxima Centauri, which in this model is situated at the place where the wristwatch is. Then we move even further out and deeper into space to locate the Kepler system with nearest exoplanets, halfway between wrist and elbow, up the arm. Exoplanets are planets found outside our own Solar System. Astrohaptices can be used for example in comparing an exoplanetary system with our own Solar System to gain a deeper understanding of the scale and size of the planets and their orbits in the other system. For this type of comparison, one uses the Solar System astrohaptices **[fig. 4]**.

Kepler system was the first star system we found with exoplanets, and some of the planets are located in so-called habitable zone within the system. If we now leave the Kepler system and venture even deeper towards the centre of the Milky Way, the next important waypoint in our journey is the brightest star in the night sky, Sirius, the Dog Star. In our astrohaptices model, it is located on the elbow. We chose the waypoint to be included in our model because it is one of the brightest objects in the night sky, and it may be noticeable even by people with visual impairment.

5.2 Galactical Structures and Deep Space Objects

If we now venture into the centre of the Milky Way, it has a central bulge including millions of stars tightly together. The overall structure of the Milky Way is similar to a firework 'Catherine Wheel', and thus the Milky Way is categorised as a spiral galaxy. The outstretched arms in our model represent the spiral arms of the Milky Way. Just think how small our Solar System is compared to the vastness of our home galaxy. Simultaneously, the model gives the precise location of our Solar System (on the fingernail) within the galaxy. As mentioned before, the head of the receiver portrays the central bulge of the Milky Way. Then the shoulders represent the inner part of the Milky Way where the spiral arms attach, a bar-like structure around the central bulge.

Furthermore, the Milky Way, as many other galaxies, has a black hole in the very centre of the galaxy. That may be either included in the model we have used by opening the mouth or one can study the black hole separately. In that instance, we have developed an astrohaptice for the black hole – a closed fist with the thumb tucked in.[2] The fingers in this model represent the fast-churning matter around the event horizon and the thumb represents the matter disappearing into the black hole.

6 Stargazing with Astrohaptices

It is possible to use haptices to support the functioning low vision, either stargazing at home, or when visiting an observatory where the visitors are allowed to view celestial objects through a big telescope. It is possible where the telescope has two eyepieces, one for a wider view and another one for a more close-up image of the target. The person with deafblindness can stay on the close-up eyepiece and use their time to focus on the object while the describers alternate on the wider eyepiece. The describer looking through the eyepiece verbalises the scene to the other one who draws the image on the back of the person with deafblindness. Or if the person with deafblindness is a sign language user, the description may have to be repeated twice, first with hands-on signing and the other time with simultaneously drawing on their back.

Closer to home, one can use fixed objects when locating celestial objects in the sky. One example of this is to use the top of the roof to direct the gaze to the full moon (Lahtinen, Palmer, Lahtinen 2010). Here the pointing is shared, that is the celestial object is pointed at the both the describer's and the recipient's hands together. Usually the easiest to locate in the night sky is the Moon, be it full or half. A full Moon is easier to locate, but that may bring glare. If there is a strong tendency for glare, then half Moon may be a more beneficial target for stargazing. The half-moon shows the details more in-focus and clearer, especially near the terminator (the edge of the shadow of the Earth on the Moon).

When the Moon has been located in the night sky, one can use that dynamic point to find other bright objects in the sky, such as the planets Venus, Mars or Jupiter. Depending on where you live, the location of these planets varies in the night sky. The describer or interpreter may want to use a sky chart map on a smartphone. However, it is advisable to use the smartphone and its app inside before going out, as using a lit-up mobile app outside will destroy the night adaptation of the eyes and the darkness re-adaptation process takes 15-20 minutes. Another option for the interpreter is to take a physical star map outside.[3] The map is most often readable also in the dark when the eyes have finished the adaptation process for darkness. You can hold on to the map with one hand and use the other for the shared pointing of the objects with the person with deafblindness.

The star charts are a very useful tool for finding constellations and interesting areas across the night sky. Furthermore, one can use tactile models of constellations (more about readability of tactile maps, please see Ojala, Lahtinen, Hirn 2016) to learn more and to discuss the deep space objects within specific areas, if there is a deeper interest in them. One can also find the locations of the newest finds of the various space telescopes in the sky by using the celestial mapping system (see §§ 5-5.2 above).

7 Conclusions

This article has focused on some of the basic astrohaptices that may be applied when sharing a space-related event with a deafblind person. There may be other areas of interest, such as planetary exploration, live launches or recovery procedures. Today one can also enjoy live broadcasts from the ISS and new discoveries taken by various imaging probes or robotic space vehicles on Mars and perhaps in the future on other planets as well – or our Moon. However, this enables some educational prospects for deafblind people to explore and have a more equal access to a wider media-related information and space-related exhibits displayed in museums. Astrohaptices complement the other accessible facilities in the museums, such as tactile maps, audio descriptive tours or touch tours. These accessibility options are emerging now, as there seems to be more awareness on accessibility among the museum staff when it comes to making their museum more attractive to a wider audience with different types of disabilities.

8 Future Developments

There is scope for expansion in the astrohaptices system, and we welcome other space enthusiasts to help us explore the Universe through astrohaptices even further. This offers one way of bringing the Universe within touching distance. Should anybody be interested in a workshop around astrohaptices development process, please contact the authors on (`https://www.russpalmer.com/`).

3 Thanks to Giorgio Grigi, who initiated the creation of a Black Hole haptice by his question at Hapticconf 2023 in Venice, Italy.

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