MOUTHPAD

HANDS-FREE DEVICE CONTROL AT THE TIP OF YOUR TONGUE

Quick info

Developed by: Augmental

Headquarters: USA

Year of Release: Pending

Awards: Forbes 30 under 30 Social Impact; Grand Prix: Innovation; Silver Lion: Health & Wellness (2023 Cannes Lions)

Website: https://www.augmental.tech

Product type: Wearable technology

Space technologies: Telecommunications; space exploration

Primary application: Mobility impairments

What does MouthPad do?

MouthPad is a wearable touchpad which is controlled by its user's mouth. Its creators refer to it as a type of "mouthwear" because it is an interface worn inside the mouth, similar to the use of headwear or wristwear. MouthPad is worn like a dental retainer, worn on the roof of the mouth and it uses an array of sensors to translate the user's actions into signals. For example, it includes a trackpad that sits on the palate of the user's mouth across which the user can move his or her tongue to control a cursor. Other sensors allow the user to press it on the palate to left click, and to sip – which is to suck or increase the pressure in your mouth – to right click. It also has capabilities for other interaction modalities like head-motion input. Each type of motion corresponds to an effect on the system to which MouthPad is connected.

Through Bluetooth, MouthPad can connect to a computer, phone, laptop, or any other Bluetooth device, allowing its user to control the device without using his or her hands. The only movements that are used to control the MouthPad are tongue, jaw, head, and breathing gestures, which means that individuals who are quadriplegic or who have certain neurodegenerative disorders can use MouthPad even when they cannot use their hands.

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>
> *- Tomás Vega, co-founder of MouthPad*

MouthPad is also being used to explore how it can assist astronauts aboard the International Space Station. Currently, the creators of MouthPad plan to implement their device in space so that astronauts can control Astrobee hands-free. Astrobee is a set of three free-flying cube-shaped robots developed by NASA; it helps astronauts perform a variety of daily tasks, including photographing experiments and projects aboard the ISS. Using MouthPad, astronauts would be able to aim Astrobee's cameras and take photos without needing to manually adjust the robots or use their hands to type commands into a computer. Augmental also plans to implement MouthPad more widely in space once it is deployed for Astrobee; currently,

the team is planning to test MouthPad in zero gravity simulation conditions to ensure it is fully functional even when astronauts are wearing rigid suits.

How does MouthPad work?

The sensors within MouthPad use an electrode array, which is a series of electrodes (conductors) capable of receiving and distributing charge. Each electrode periodically sends an alternating current outward, then measures where the returned charge is lower than what was emitted, as these are the areas where the tongue is in contact with the trackpad, thereby storing more charge. MouthPad then uses its Bluetooth connection with the device it is controlling (such as a computer or smartphone) to transfer that information and move the cursor accordingly. Other inputs (such as "sipping") use other types of sensors.

When MouthPad is connected to a device other than a computer (for example, to Astrobee or a joystick), specialized software packages can be installed which translate inputs into relevant actions on the connected device. For example, specialized software might instruct that when a user runs his or her tongue over the trackpad, a camera turns in that direction.

MouthPad comes pre-installed with basic software packages that enable its Bluetooth connection capabilities, and as updates are made to its software.

Each unit is made from dental resin and customized using 3-D scans of its user's mouth to fit as unobtrusively as possible. Due to the flexible material which each device is made from, it does not restrict the user's tongue or throat and thereby allows users to speak while it is worn. MouthPad's battery can be charged with a charging case, and it can be used for more than 5 hours before requiring another charge.

> *"It's awesome how one device can allow for such different applications, and in the end, our goal is to make something that helps you be successful in whatever you want to do. We as humans have different motivations and goals, so we make a canvas through which people can explore themselves and the world."*

Who can MouthPad help?

MouthPad employs principles of universal design so that it is useful to both people with disabilities and people without disabilities. That being said, it is particularly useful for individuals without fine motor control of their hands, as it can substitute a joystick, computer mouse, or other standard manually operated control mechanism.

Because MouthPad can be used with movement of only the tongue and jaw muscles, any individuals who cannot use other muscles (such as those with spinal cord injuries or conditions, as the tongue does not rely on the spinal cord) could benefit. Augmental has suggested that its product might be particularly helpful to people who are quadriplegic, individuals who have been partially paralyzed, and individuals with multiple sclerosis, muscular dystrophy, stroke, Parkinson's, or other neurodegenerative diseases.

MouthPad is designed, through graceful degradation, to remain useful to individuals with degenerative conditions throughout the progression of their condition. As co-founder Tomás Vega explains, "our goal is to create a system that will support you throughout your whole lifetime. A user might start with control of their entire head, and that works great because it's a very fast interaction. If you lose that, you can still use your tongue or your jaw, so you won't need to buy a new system and relearn how to use it. We believe that we are creating a symbiote, or an extension of the body that works throughout the user's life."

Because MouthPad leaves the ears, eyes, and hands free, it can be used alongside various aids, such as white canes, hearing aids, glasses, etc. It does not require sight or hearing to operate, making it useful to individuals with multiple disabilities.

How is MouthPad being implemented?

MouthPad has been released as a Beta Package, with multiple test users (some with disabilities and some without) replacing their daily devices with MouthPad. Due to limited production capabilities, Augmental is currently offering a waitlist. MouthPad remains under development, with Augmental testing new features such as bite controls, and new versions will be released in the future.

An Interview with Tomás Vega, MouthPad's Co-founder

Could you start by telling me about the motivation behind creating MouthPad? What inspired you?

I've been working in the field of assistive technology for 11 years. When I was in high school, I worked with people with multiple sclerosis (MS), and I realized that although the human body is so strong, in many ways, it is also quite fragile. In a matter of months, your life can have a 180-degree change. As a result, when I went to undergrad, I studied computer science and cognitive science so that I could build systems designed to augment the human body and compensate for its weaknesses and limitations.

I started creating interfaces for a wide range of disabilities at UC Berkeley. There was a lot of support, exposure, and talented engineers with whom I could collaborate. I started working with speech at Apple, doing research and development for Siri, but I became frustrated with the methods that we had of analyzing and using speech. I ultimately realized that if you make an interface that is designed following universal design principles, it can work not only for those who have permanent disabilities but also for everybody.

I wondered how we could improve and expand our capabilities with computers so that we can compensate for and extend beyond our biology. I decided to attend graduate school at MIT Media Lab's Fluid Interfaces group because where else in the world were they doing things like that? It was exactly what I wanted to do. I also had the opportunity to work for a summer at Neuralink on implants. When I was there, while I knew that brain implants might be able to help so many people who right now are constrained in their own bodies, I also realized through talking with friends who had severe hand impairments that it wasn't that straightforward. Not all of them could get a craniotomy, for example, to get an implant because of the risks of surgery. One risk is obviously infection, but the largest risk is upgradability, which is such a fundamental concept in all the hardware that we use. With phones, for example, every few years you need to buy a new device because new versions quickly become so much better than the last version.

I went back to MIT, fascinated by what was going on at Neuralink, but with the goal of creating something that could work *now* to provide independence. I knew this couldn't work for everybody, because those who have certain neurodegenerative conditions lose all their motor abilities. Generally, though, that was my goal: something that was as expressive as an implantable BCI and that overcame many of the limitations of invasive procedures.

I was thinking about the brain and the homunculus, which is this creature that represents the number of neurons that are devoted to controlling and sensing different areas of the body. I realized that the tongue (as a combination of 8 muscles) was as dexterous as the finger, and it fatigues less in theory than other areas of the body. I started wondering, "Why don't we use the tongue to control computers?" and began to combine that into my work. My thesis was in collaboration with Bose (the headphones company) on using jaw and teeth tracker gestures. We used in-ear and back-of-ear sensors, which were quite limited, although they worked in some contexts and for some people's conditions. I combined the tongue concept with the jaw concept to create the MouthPad.

We have capabilities for around eight dimensions of control, which is unprecedented in a wearable input device. As of today, we have six users; three of them have replaced their assistive devices for some activities, and some of them have completely replaced what they used in the past. We're seeing our device interface with the world, which is awesome. For example, one of them uses their MouthPad to read a book to their kids. Previously, they couldn't have their kid on their lap while using their chin joystick to turn the page on the iPad e-book, but now they can. Some of our users are playing games, others are working. We're working with an 18-year-old student who wants to be a mechanical engineer, and our goal is to help her use CAD software so that she can be at the same level and baseline as everybody else.

It's awesome how one device can allow for such different applications, and in the end, our goal is to make something that helps you be successful in whatever you want to do. We as humans have different motivations and goals, so we make a canvas through which people can explore themselves and the world. We are transitioning from a world of atoms to a

world of bits, where to be part of society, you also must participate on the Internet. It is our shared town hall where we learn, create, share and connect, and we want everybody to be able to participate in this with an interface that is invisible so that it doesn't prevent normal human-to-human interaction and so that there's no stigma. It'll be expressive, not limited by very narrow ways of interacting like a joystick on your chin, and it'll accommodate your situation, and it's flexible so that whatever your condition, you can find a way of using MouthPad for your own needs.

Since we are focusing on how to apply space technologies to accessibility, could you please talk about that connection? You mentioned that you're testing MouthPad in zero-gravity to work with the Astrobee robots.

We are in talks with the Space Exploration Initiative at the Media Lab because they allow us to try new systems in a context that is usually hard to reach, considering we are not in space. We are quite excited to see how our device fares. Can it provide a way to control systems that is unaffected by zero gravity? This is important because if you, for example, flip a switch or turn a knob, you are not only turning a knob, but you are exerting force on an object, and that can lead to unwanted movement or rotation or displacement.

We started to talk to some developers who are making Astrobee, a robot that is used in different space station applications, and the team mentioned all these issues. Additionally, they mentioned that a lot of astronauts are on the space station working, either on an experiment or fixing machinery, so their hands are busy, but they need to operate the systems around them. One of these systems is Astrobee. To take photos, they want to move Astrobee in a direction to get a better angle while their hands are busy.

The goal is to eventually try MouthPad in the space station and add value to people who are doing cutting edge experiments. Astronauts are at the forefront of wearable interfaces. Space relies heavily on operating instruments, and I foresee that augmented reality is going to play a huge role in the future of space. I've never used a space suit, but from what I've heard, it's extremely rigid and includes thick gloves. It's quite hard to operate in that suit, so we hope to provide a nimble, swift, and reactive interface for astronauts to manipulate instruments and interact with intelligence. Robot-human interaction is not as easy or seamless as it seems in Star Wars or other movies. We need to talk, to walk, to innovate, and to find ways of enabling our astronauts to do the best work that they can do.

Has it been at all difficult convincing people that it's important to develop products that work for accessibility? Have you faced any challenges when creating the product?

People understand that assistive technology is important, but aids are very hard to develop because there is limited funding. That's why most companies with these goals have had difficulties. I think that accessibility products could be feasible if investors are informed of the power of universal interfaces and universal design. As I shared at the beginning of the interview, by making devices that can be used by those who are most constrained, we will create systems that will work for everybody.

I'm trying to share with investors that we are solving an important and widespread problem. We created a company out of this small to medium market, and we found our niche where we can engage with both general consumers and those with disabilities. We're excited about the interaction paradigm shift from "looking down" interfaces like phones that hinder our human-to-human interaction to headset interfaces. We've seen Google, Samsung, Apple, and others announcing that they are releasing artificial reality interfaces in the next few years, and once that is adopted and ubiquitous, we will need better ways to interact with computing power when we are on the go. Our hands are utilized to interact with the physical world, and relying on this will lead to a mutually exclusive choice between the physical and digital worlds. That should not be the case; we should be able to swiftly transition into this world. We think that we are positioned to provide value to everybody in the future.

We also already see everybody using AI tools such as ChatGPT. I have a screen devoted just to ChatGPT because it's a cognitive prosthesis for me. If we really want to utilize AI on the go in dynamic contexts, we'll need a better way of using speech. Right now, speech is quite limited because of three main reasons. One is that when we are in noisy environments, it doesn't work right because the signal to noise ratio is bad. Meanwhile, when we are in silent spaces, it's either not appropriate to speak, or in some cultures it's frowned upon to use a speech interface. That was a

big issue we were trying to solve at Apple with Siri. Another problem is that speech interfaces are not private. Everybody wants to use their technology and interface with AI systems in privacy. That's just not possible right now, even though we rely on speech.

Right now, we are incorporating sensors to enable something called silent speech. You'll be able to basically whisper or just simulate moving your mouth without any volume in a way that is private. We're also adding audio feedback so that you can listen to your device without blocking your ear canal. This is not only interesting to us because it transitions our mouthwear from assistive to universally useful, but also because it provides an amazing benefit to our current users. Many of them utilize speech interfaces every day, and when they're in the workplace, for example, they are frustrated because they feel that they are annoying all their coworkers when they speak out loud, or when they are in public it is too noisy to use a speech interface. By expanding the context of speech interfaces for those with disabilities, we will also expand interfaces for everybody. We're navigating between the accessibility space and other spaces.

I think that humans have the inherent ability to have empathy. Empathy is intrinsic, but it's also trained, so we need to be exposed to people who are different. People who live all their lives in privilege and aren't exposed to different ability levels don't lack the capacity for empathy; they just aren't aware. I think that it's our duty as people who work in this field to teach others to think about it. That's why it's so important to create interfaces that can be used by everybody. You show how it can be life-changing for those with disabilities, but also it helps them relate and see how they can benefit from something when they don't have any disabilities.

Are there any questions I didn't ask or parting thoughts you'd like to leave the audience with?

MouthPad utilizes flexible electronics to adapt to the shape of the mouth. We are all different, and our goal is that by customizing interfaces to the shape of your mouth, we can reduce the impact on speech so that you can use our system alongside speech interfaces.

We've worked with many people with disabilities: spinal cord injuries, muscular dystrophy, and many other conditions. Our goal is to combine all the different interaction modalities that they use into "one device to rule them all" so that it can be flexible enough to accommodate different abilities.

Credit: Augmental

ABOUT

This article is part of the "From Space to Earth: innovations enabling accessibility on Earth" project under the United Nations Office for Outer Space Affairs Space for Persons with Disabilities initiative. This project aims to raise awareness of the benefits of space technologies, spinoffs and related innovations in addressing challenges of disability, and to foster international and interdisciplinary collaborations on technological solutions to advance accessibility and empower persons with disabilities. This project contributes to the implementation of SDG 10: Reduced inequalities.

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