ASTROSKIN

DIAGNOSED BY A TANK TOP

Quick info

Developed by: Carré Technologies Inc.

Headquarters: Canada

Year of Release: 2016

Award: 2022 International Space Station Research Innovation Award for Human Health in Space

Website

Product type: Wearable technology

Space technologies: Space exploration

Primary application: Monitoring and diagnosis of assorted health conditions

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>
> *-Pierre-Alexandre Fournier, Astroskin's Creator*

What does Astroskin do?

Astroskin is a health monitoring system composed of a shirt, headband, and digital system. The shirt and headband contain sensors which register a variety of vital signs, including heart rate, breathing rate, respiration volume, pulse, oxygen saturation, blood pressure, temperature, cadence, and step count. By combining these indicators, the Astroskin data analysis tools can calculate more compound measures, such as heart rate variability, lung capacity, sleep quality, heat stress, G-force, and more. The sensors then connect to a device which can process and present the data. Because the shirt and headband system are unobtrusive, it can be worn even while the user is exercising, working, or otherwise physically occupied or confined.

Astroskin can be used for a variety of projects, from sports performance measurement to first responder safety to general research. One of its original uses, however, was in partnership with the Canadian Space Agency as a part of the Bio-Monitor system to measure the vital signs of astronauts aboard the International Space Station. It has also often been used for research purposes for a variety of health conditions and for monitoring of known health conditions.

How does Astroskin work?

Astroskin compression garments are made from flexible high-performance fabric with embedded sensors. Sensor placement varies slightly between the men's and women's garments due to different anatomy and structural needs, but generally is determined by the measurement needed, for example, sensors near the heart act as an electrocardiogram (ECG). The ECG sensors consist of electrodes, which are conductors which register when electricity from the heart runs through them, thereby measuring heart rate. Research applications of the ECG include detection of heart conditions, heart rate variability

and stress monitoring. An accelerometer contains piezoelectric components which can produce electricity when a mechanical force is applied. These materials measure motion through converting the force they experience from motion into an electrical signal proportional to the magnitude of the force. This can then be registered and converted to metrics such as step count or acceleration. Other aspects of the monitoring system, such as its built-in blood pressure monitor and thermometer, operate similarly to clinical versions of these devices but are built into the garment, making them less obtrusive.

The signals from the electrodes in the shirt and headband connect to a removable Astroskin recorder device within the garment (consisting of a Bluetooth radio and the accelerometer) which connects via Bluetooth to an app on the user's phone or computer. Here, following data encryption to ensure privacy, the raw data is converted to readable graphs and data through Astroskin's data synchronization software, then securely stored and presented in a dashboard which users can customize. Users are able to access the software and adapt it to their own data processing needs with support from the Astroskin team.

Who can Astroskin help?

Astroskin is a flexible product and can therefore be used for a variety of purposes. One application is in biomedical research; researchers can better understand different physical disabilities and health conditions by monitoring individuals with these conditions as they go about their daily lives. This is more helpful than traditional monitoring systems, which usually required visits to a hospital or clinic and therefore could not record vital signs during daily activities. Research using Astroskin can result in new treatments, assistive devices, or diagnostic processes which can help individuals with health conditions or disabilities live less inhibited lives.

Astroskin can also be used for diagnostic purposes in a research setting. Because it measures a variety of vital signs, it can measure the symptoms of conditions, then present the data in a format that doctors can use to diagnose those conditions. For example, the built-in ECG allows doctors to catch and diagnose many heart conditions simply by having their patients wear a garment for a day.

Finally, Astroskin can be used to monitor individuals with known health conditions or disabilities in order to measure treatment progress or overall condition. For example, an individual with generalized anxiety disorder or a panic disorder might wear Astroskin and use it to monitor breathing rate, registering an increased breathing rate as a sign that anxiety may be increasing and adjusting accordingly.

Traditional methods of measuring these metrics were more obtrusive and often only available in clinical settings, which not only limited their accessibility but also increased stigma. Astroskin, however, allows for constant monitoring and does not include visible sensors, allowing individuals to go about their daily lives without facing stigma or needing to take time off for clinic visits.

How is Astroskin being implemented?

Astroskin is currently commercially available. Notable users include the Canadian Space Agency as part of their 2019 Bio-Monitor system, which both ensured the health of astronauts in space and was used for research on the effects of space on the human body. Canadian, American, Italian, and Japanese astronauts have worn Astroskin to monitor their health in space, and aboard the ISS, four separate studies are currently using Astroskin. Astroskin and its non-space counterpart, Hexoskin, have been used in over 200 scientific publications and have had their results verified by many more, leading to tangible impact on biomedical research.

Astroskin comes in a women's version (consisting of a headband and tank top) and a men's version (consisting of a headband and sleeveless shirt). Both versions come in a range of sizes (XXS to 4XL) to fit a variety of body shapes and types. It is made from lightweight, machine-washable fabric with an antibacterial coating to prevent odour and can be worn for up to 48 hours at a time.

An "Astroskin Kit" consists of an Astroskin shirt, headband, Astroskin data recorder, an iOS app, data analysis software packages, and charging cable.

An Interview with Pierre-Alexandre Fournier, Astroskin's Creator

What was the inspiration behind Astroskin?
Astroskin is a smart garment that we've created to monitor health. The project started a few years before we started working with space agencies, in 2011, and at the time we were still working on Hexoskin prototypes, which just include the shirt. Just a couple of years before, we had moved from working on more traditional sensors that you would strap somewhere on your body with cables and electronics to a design that is more patient centric. This means that it's not just a device that is designed for a clinician to record vital signs, but it's really a product that is designed for the patient to use in a real-life context without the stigma associated with traditional medical devices that have boxes and cables sticking out of them. We had many prototypes and iterations ready, so we were starting to build all the tools necessary for this technology, and we had a plan to expand it beyond what the existing suit does, meaning cardiac and respiratory monitoring.

We had this plan to expand it and add more sensors to it, but we were looking for a use case so that people could invest in the product, and at the time the Canadian Space Agency was looking for a solution to monitor the vital signs of their astronauts. They needed the monitoring to occur in a way that wouldn't interfere with the work astronauts are doing in the space station, meaning they needed to have their hands free to conduct scientific experiments and go around the space station without being hooked up to a monitor or piece of equipment connected to the wall. The vision behind the Astroskin and what became the Astroskin, the product that is used in the space station today, was to build a complete vital sign monitoring system. The goal was that people could use it in their daily lives or in a performance context, because the system has to provide the same type of monitoring that you could have in an intensive care unit, except instead of being strapped to a bed with a bunch of wires, it's something that you can just wear to do your work and other activities.

How does Astroskin work?
Astroskin is made to be wearable, so it's made to look like other things that you could wear. Fundamentally, it's a garment like a shirt (or a tank top for women) with textile-based sensors in it, and a headband (or hat or beanie) with an optical sensor located on the forehead. The forehead is a great location to put an optical sensor because you get great readings. There's also a device that connects to the garment and the headband that records signals from all sensors, meaning ECG, breathing effort, blood oxygen levels, blood pressure, temperature and movement. It's a complete, vital signs monitoring system similar to what you would have in the hospital in an acute care setting.

How does Astroskin incorporate space technologies?
When we built the first prototypes for the Astroskin system, they were not ready to fly, so there was another contract to fund that work that started in 2016 where we redesigned the system and adapted it for space. It was a lot of work between Montreal, where our headquarters is, and Huntsville, Houston and other places to redesign and qualify the product for space. There's a lot of red tape if you want to bring something to the space station and address safety concerns. Eventually, we made the first Astroskin system, which included a space-grade computer that is part of the space station today. That computer is used to send the data from the Astroskin to Earth, and it was part of the contract that flew in December 2018 with the SpaceX resupply mission. It was commissioned in January 2019 by Canadian astronaut David Saint-Jacques, and we've sent 15 payloads so far. There's a lot of demand for it. Aboard the ISS, there are four clinical trials currently ongoing, mostly focusing on the cardiovascular and respiratory systems, and we have many more astronauts planning to participate in these research projects in coming years.

What challenges have you faced in Astroskin's development?
At first, demand for Astroskin came from space agencies because there was a need to conduct research in space and learn more about physiology in microgravity. After that, though, we immediately received a lot of interest from the research community. The challenge, then, was to design a product that was space grade but that could also be used for medical research on Earth, meaning that we had to make the design suitable for general medical research as well. We also had to establish the price point and the manufacturing process so that Astroskin made sense as a product for applications other than space medicine research.

Do you have a favourite feature of Astroskin?
I think the strength of the Astroskin is really the possibility of recording all these vital signs at once with a single system. Usually you would have to hook up different devices to measure all the different signals we measure, and then you would have all these files that don't necessarily have the same time stamps, so you would have to do a lot of manipulation to merge the data together. I think that's the strength of the system, but if I had to pick one feature that I think is especially exciting, it's the fact that it can measure blood pressure continuously. The system can return a systolic blood pressure measurement at every heartbeat, basically because it measures the speed of the blood coming out of the heart through the arteries in your neck then correlates it with the systolic blood pressure. There's so much research to be done on measuring blood pressure continuously because the gold standard today is that you have to sit in a certain way, your arm has to be held in a certain way, you have to not move, and then it has to be measured in a very specific way to be somewhat accurate. It's not accurate at the unit level; the accuracy is like ± 10 mmHg (more or less depending on the device). There's also a lot of research to be done, for example, on hypertension, particularly for pregnant women, and many other health conditions related to blood

pressure and the cardiovascular system in general. I think this is a feature that's exceptional because there are not many products available today that can do that, and the Astroskin is an open research tool has been validated by many independent university researchers that have worked with the system as well as NASA. So it's a great product for people conducting research on blood pressure in general.

Have you worked with any individuals who either had chronic health conditions or a disability when developing or testing Astroskin?
If you look at the Astroskin story, it started with the Hexoskin shirt, which is a simpler system. We learned a lot about designing for people with different body shapes and health conditions through Hexoskin, and then all that knowledge was used to design the Astroskin for space. Then, once we developed the product, the Astroskin has been used by dozens of research groups to study different health conditions. At the design level for Astroskin specifically, it was mostly designed with healthy people testing it, but with the knowledge of the design rules that we've developed for existing smartshirts. In our user community, researchers, hospitals, universities, government agencies, and pharma companies are using it for people with health conditions.

With Hexoskin, we did quite a lot of work with the Cirque du Soleil in Montreal, which was special because many of their performers and artists have extreme body morphology. They have tall people, big people, people with huge shoulders, small people, and more. We worked with them because they wanted to monitor the workload on their performers, who were performing up to three or four hundred times a year, sometimes doing 2 or 3 shows per day without backup. If someone gets hurt, he is just out of the show and could for example need six months of rehab. We worked with them and saw so many different types of body shapes. It was a big learning experience for us, and it prepared us to work with people with disabilities and different health conditions.

Do you have any plans for either future features or future applications of Astroskin?
On one side, there's the physical product we've been working with for ten years now. It's been ten years of testing, use, and validation, so we have a lot of feedback on how to make it easier to use, and we have plans to work on the next version of it. On the other side, which is even more interesting, are the software functionalities that we can provide with the platform, meaning digital biomarkers. Essentially, what are the vital signs saying? The statistics and patterns that we can recognize tell us something about specific health conditions, their progress, how they can be treated, how we can measure treatment, and all that. We're very involved in research there; there are over 100 clinical trials and projects running on our platform currently. One opportunity that we see is that there are about 4,000 documented rare diseases today that either don't have a clear way to diagnose them or don't have a treatment plan, and these are just the documented ones. Some of these diseases only affect a few people, but if you add all the patients for the 4,000 rare diseases, even just in the US, it's millions and millions of patients. There's so much research we need to do to understand what's going on with these people, and I think a platform like Astroskin, where you can monitor all the vital signs at once, can provide clues on how to better diagnose these conditions and track their progress. If we can do that, we can also improve the way we run clinical trials to find new treatments for these conditions. I think that work is very important. Another way to see it is that we want to make medical discoveries and medical evidence more accessible and affordable for researchers. I think it's something that motivates everybody on the team when they wake up in the morning to start working.

Can you describe Astroskin in one sentence?
I think one thing that's very important about the Astroskin is that it's an open research platform. The researchers who work with the platform have access to every single data point — every sensor, raw data, every waveform, any result of an algorithm —that's recorded. It's a very transparent platform, and it's built for open innovation and collaboration. It's very rare that you have a validated system with high resolution sensors that is this transparent because often with these kinds of devices, you cannot export your files and access all the data. I think it's one of the reasons why our platform has been embraced so widely in the research community, and that's why today we have a scientific paper published approximately every week using data from our platform. That community building that we're doing, putting research teams in contact with each other, and such is very important to us. We try to help everybody do research faster and more efficiently.

Is there anything I haven't asked that you'd like to share?
I'd like to add notes about two things. First, on the note of accessibility, space was originally reserved for pilots. Neil Armstrong and Buzz Aldrin were both pilots. Later, it was not just pilots but also engineers and researchers who still needed the skills necessary to fly spacecraft. In the future, though, I think there will be more diversity in space travel. In addition to traditional pilots, with the rise of space tourism you'll also see a lot of older astronauts in orbit, meaning a lot of people who wouldn't pass NASA's medical screening. I think the research ongoing with the Astroskin will help us better understand the risk of space travel for people with disabilities and health conditions. This is especially important as we prepare to increase our permanent presence in space, especially in lower Earth orbit and on the Moon.

My second note is that there's a show on Disney Plus with the actor Chris Hemsworth. It's called Limitless with Chris Hemsworth, and it's about health, resilience, and longevity. Chris Hemsworth is wearing the Astroskin during one of the challenges to test his tolerance to stress, which is extremely cool to watch.

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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