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HOW DEPENDENT SHOULD ONE BE ON WEARABLE SENSORS FOR MONITORING OF THEIR HEALTHCARE

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Abstract

This paper was written to analyze the dependency of reliable sensors, both medical grade as well as commercially produced kinds. Various types of sensors were analyzed based on their working and other factors of 'dependency' were also taken into account. This paper further explores what we can conclude from a case study and evaluates the usage of wearable sensors and their future.

Keywords: Monitoring, Reliability of Technology, Accelerometer, Photoplethysmography, Electrodermal, Temperature

INTRODUCTION

Wearable sensors are body-monitoring sensors that are implanted in wearable objects like rings, watches, or directly into the body. As a result, they provide continuous real-time updates on body vitals like oxygen level, heart rate, blood pressure, etc. directly to the relevant parties for healthcare or research purposes. They have also found use in tracking physical activity, this concept being the base of products of major companies like the 'Apple watch' by Apple. These sensors not only provide invaluable information to medical bodies, but they have also been a vastly successful idea commercially. The market for wearable sensors has been amplifying expeditiously and is predicted to have nearly a 20% growth in the next 5 years. However, with such exponential growth, any product or idea related to medical care is bound to come under scrutiny for its reliability. After all, even a small percentage of inaccuracy here is equivalent to the safety of millions. This report aims to understand these sensors fully and make an educated statement on whether wearable sensors are truly reliable.

Theory

The technology used to detect vital levels and body movements is the main topic that comes under focus here. This report shall go over the most popular technologies utilized in these sensors and their reliability. In cases where the medical data is to be sent to a medical body, while the transfer of data is also a valid concern, more often than not in today's world, all of the data is transferred efficiently through a third-party warehouse. However, problems might arise when the wearer travels to a location far (a different country maybe) from the receiving medical body. The data might not communicate, or might do so partially, which can have grave consequences.

Types of sensors:

Accelerometer: An accelerometer is a sensor that mainly tracks physical activity. It detects gravitational and linear movements and records velocities. These are used in nearly every smartphone, smartwatch, and medical tracker. Accelerometer uses a crystal that gets stressed

when subjected to force due to motion. A voltage is produced and the reading is formed. This device uses a physical property of a substance to give its reading and hence is accurate for the most part. A federally funded study by John Hopkin Medicine researchers showed that accelerometer sensors are more reliable when it comes to the measurement of physical activity than most other methods that physicians use. However, while this device shows an accurate reading according to the motion it's put through, it does not mean that the reading is true for the wearer, especially the ones using smartphones and smartwatches. This is because this sensor is only built to judge the traditional motion of walking and running, and it even counts actions like moving one's arm around in the air. Hence, outputs like steps and calories burnt displayed in these devices might be heavily skewed. Gyroscopes are similar to accelerometers except they record angular motion rather than linear. They are reliable for the most part.

Photoplethysmography sensors: This is a sensor that records cardiac function by inspecting the flow of blood. It can give results like heart rate and blood oxygen level. The sensor involves projecting light onto the skin and recording the blood flow using this light. There are a number of factors that might interfere with the sensor and give an incorrect reading, like skin colour, amount of hair on the skin, how tightly the wearer has put the sensor on (it is usually worn on wrists), etc. Since light is the weapon of choice for this sensor, it is a given that external light, if it happens to shine upon the area under detection by the sensor, can give an inaccurate reading. This is especially a problem for non-medical sensors like on FitBits because the wrist can be easily exposed to sunlight (or artificial light), rendering the device near useless at times and hence making it completely unreliable. However, medical photoplethysmography sensors are usually fitted with velcro around the wrist or finger which makes them much more reliable for tracking cardiac health.

Temperature sensors- Temperature is one of the most common body vitals one sees on fitness trackers as well as one of the most important ones for medical bodies for tracking physical health. It uses a special device called a thermistor which changes the current in a circuit if the temperature changes. Since this is one of the oldest and hence most researched on body vital, the sensors today are very accurate. The best quality ones give accuracy up to 0.09 degrees Celsius. Owing to the fact that there aren't many disrupting factors, the temperature sensors on commercial fitness trackers are fairly reliable as well.

Electrodermal sensors- These are a relatively new type of sensor that can measure stress levels indirectly by measuring one's sweat production since the fear levels are directly linked to the sympathetic nervous system. These sensors have been proven through various studies to be fairly accurate in their readings. It has also been used in the process of studying diseases such as autism spectrum disorder.

This was the individual analysis of the most popular sensors used commercially and medically. However, the reliability of sensors does not include only accurate readings and proper data transfer. Data theft is a major issue in today's world and protection of privacy is also a reliability factor to be considered. At the moment, data from wearable sensors is not valuable enough to be targeted by hackers. But as their usage rises and new features (and hence information) are introduced, the data might become subject to cybercriminals. This is also especially dangerous since today, most of this data is transferred via basic modes of transfer like Bluetooth or WiFi with little to no encryption. This data can also be sold to large companies once it becomes important enough.

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Experimental

A study on EMG and IMU sensors (physical activity monitors) of 8 healthy construction workers was done and results were analyzed. The aim of this experiment was to test the reliability of the sensors by checking whether the physical activity data and body level monitoring given as output by the sensors matched the reality. A Myo armband of roughly 100 grams of weight was used and the data was transferred through Bluetooth Low Energy wireless connection. If the user is stationary for more than 30s, the device would go into an idle state. The device was tested and the subjects were made to get familiar with it. A total of 7 experiments were conducted, all testing various aspects of the sensors.

RESULT

The results given by the sensors were analyzed and cross-examined with conventional sensors. The results were plotted on tables.

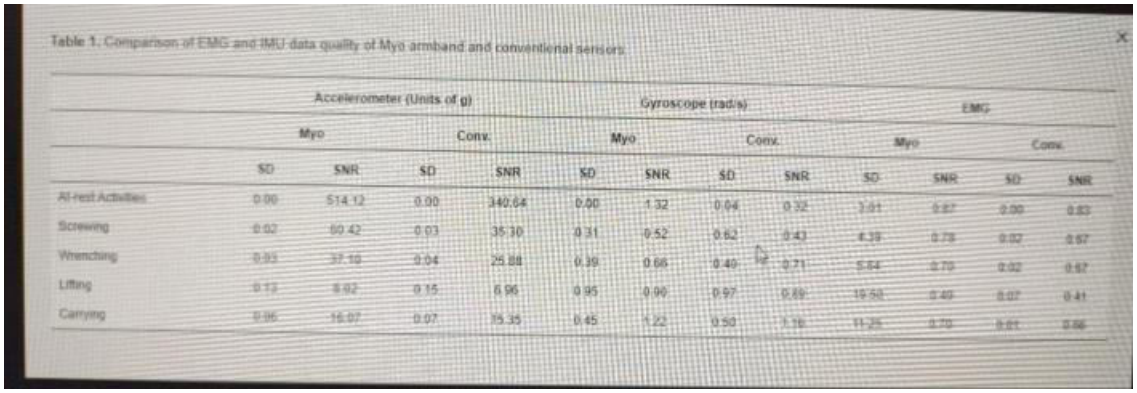

Table 1. Comparison of EMG and IMU data quality of Myo armband and conventional sensors

	Accelerometer (Units of g)				Gyroscope (rad/s)				EMG			
	Myo		Conv.		Myo		Conv.		Myo		Conv.	
	SD	SNR	SD	SNR	SD	SNR	SD	SNR	SD	SNR	SD	SNR
At rest Activities	0.00	514.12	0.00	340.64	0.00	1.32	0.04	0.32	3.01	0.87	0.00	0.83
Screwing	0.02	60.42	0.03	35.30	0.31	0.52	0.62	0.43	4.39	0.73	0.02	0.57
Wrenching	0.03	37.10	0.04	25.88	0.39	0.66	0.40	0.71	5.64	0.70	0.02	0.57
Lifting	0.13	8.02	0.15	6.96	0.95	0.90	0.97	0.69	19.58	0.40	0.07	0.41
Carrying	0.06	16.07	0.07	15.35	0.45	1.22	0.50	1.16	11.25	0.70	0.01	0.66

Figure 1. Table comparing reading of EMG and IMU sensors with conventional sensors

DISCUSSION

The study assessed the reliability and quality of the sensors. The general result was that the sensors were perfectly reliable and their data matched with the data measured through conventional means. It detected different intensities and weights as well and the point of wearing of the sensor was shown to have positional freedom as well. The sensors were deemed accurate and trustworthy for all fields and could even be used for generating data models.

CONCLUSION

Wearable sensors are the future of healthcare monitoring. The convenience and precision they provide is of great benefit to the medical system, as it enables patients to continue on with their life as usual and thus frees up hospital beds, all while still being under the same monitoring. However, this is just regarding the sensors created for medical use with absolute precision. Commercially sold wearables yet have a long way to go before they can be called reliable. This paper is meant to highlight the issues that might possibly arise with an item as sensitive as this. To conclude, wearable sensors are dependable to a great extent if and only if they are crafted with great care and quality, and while the mass-produced ones are not up to the mark yet, they undoubtedly will be with the current trend of technology.

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