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Epidermal Electronic Systems

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Introduction

Modern society brings to life a vast array of technologies many of which were not even conceptualized fifty years ago. Amazing strides have been accomplished in biotechnology in the past decade alone, which advances medical aptitude exponentially. Biotechnology has created a cancer spit test, a speech restorer, and an autonomous wheelchair (Wenner). One of the most interesting biotechnologies recently revealed to the public is called an epidermal electronic systems or, EES. The epidermal electronic system is an electronic patch which has the ability to monitor heat rate, brain waves, and muscle activity (Ma). Once EES is able to be mass produced, hospitals hope to use it instead of bulky electrodes (Kim, Epidermal 842). Gamers look forward to the possibility of this technology changing the face of video games. The countries involved in the development of the epidermal electronic systems anticipate that it may have future spying capabilities. The epidermal electronic system is primarily aimed at biotechnology but has the capabilities of crossing into other fields.

Background

The epidermal electronic system is an electronic patch that adheres to the skin using the Van der Waals force (Kim, Epidermal 838). The Van der Waals force allows the patch to adhere to the skin without the use of any external bonding agents. The use of the Van der Waals force allows this technology to "blurs the distinction between electronics and biology" (Koshy). One of the scientist on the team developing this technology is John Rogers, a professor at the University of Illinois at Urbana-Champaign (Yong). When interviewed about the EES, John Rogers stated the primary goal of this technology "was to develop an electronic technology that could integrate with the skin in a way that is mechanically and physiologically invisible to the user" (Koshy).

The epidermal electronic system has been developed with a variety of different capabilities. The current medical uses for the EES are to monitor heart, brain and muscle activity (Ma). The expectations for this technology are to replace bulky electrodes in monitoring patients both inside and outside of the

hospital (Kim Electronic). The epidermal electronic system would not require any machines to supply them with energy and would allow easy use outside of the hospital. The EES has also been tested with voice recognition software and was able to register vocal commands with over 90% accuracy (Koshy). Along with medical and gaming uses, this technology could be used in spying. The technology has the ability to monitor heart rate which would give interrogators information about whether or not a person is lying, while being investigated.

Potential Benefits

The construction of the epidermal electronic system allows it to maintain its own energy source. EES is embedded with miniature solar panels which are able to harvest UV light which provides a fraction of the energy (Koshy). The rest of the energy needed is absorbed by the process of induction, taking up energy from electromagnetic radiation (Koshy). Since this device is self powered, patients that need to be monitored for extended periods of time do not have to be confined to a bed. Unlike electrodes, EES can be worn for extended periods of time without irritating the skin or the patient (Kim Electrnoic). The Van der Waals force allows the patch to adhere to the skin at a molecular level making the patch mechanically invisible to the patient (Koshy). In essence, EES is similar to a temporary tattoo in that there is very little weight to it, has no external wires, and doesn't need to be connected to an outside power source.

EES will also benefit the gaming world. In test trials with voice recognition, gamers were able to complete a voice activated video game with greater than 90% accuracy (Koshy). Gamers will be able to use this patch instead of using large bulky headsets which are subject to interference from the gamers' surroundings. EES, combined with the current technology of thermal video game cameras, video games could become more interactive allowing for full body motions and voice commands to influence the game.

Legal and Ethical Issues, Security Concerns

Legal and ethical issues that may arise as a result of this technology are closely related to the security concerns. The technology can be expanded on to include new ways of monitoring people and new spy technology (Hartmann). EES was developed for medical uses but much of the technology, which may be programmed in this patch, can be used for a variety of different uses. The EES could be placed on a person without their knowledge (Hartmann). A person could be bumped, or the EES is lightweight enough to be released to float into a crowd (Hartmann). After the chip adheres to their skin, everything from their heart rates, brain waves, and even what they are saying could be monitored. Future patches may even include a global positioning system, Wi-Fi access, and eventually even miniature cameras (Hartmann). If a person were to become chipped with this type of technology, their right to privacy would be violated.

Another major issue concerning the epidermal electronic system is the engineering. Even though EES shows major benefits opposed to electrodes, the body still sees EES as a foreign body. Challenges with engineering include how the patch adheres to the skin. The Van der Waals force allows the patch to adhere to the skin in at a molecular level which brings up the concern of toxicity (Koshy). Many precautions are taken to prevent toxicity; however there may be drawbacks from long term exposure to EES (Koshy).

Social Problems

The technology behind the epidermal electronic system has not lead to any social problems so far. However, as the technology advances and new uses for the epidermal electronics system develop, it may cause major social impacts. Since EES is thinner than a human hair it makes the technology very flexible for future uses. One of the prospects for this technology is integrating it into contact lenses. If EES is incorporated into contact lenses, people would be able to see information transmitted directly to their eye. This could become a distraction and detract from the social lives of everyone using this technology. The technology may develop so video games feel more interactive, and may make

television seem more realistic. These advances will make society more mechanical as people become absorbed in the technology instead of interactions with other people.

Further Required Research

Research is still required for this technology to reach its full potential. This potential for the epidermal electronic system is still based in medical technology. EES has the potential to assist in the treatment of different diseases and aliments. A futuristic application for EES is the development of an electronic bandage (Koshy). An electronic bandage could be used for the treatment of burn victims to quicken the healing process. The epidermal electronic system may also provide a source for treating diseases of the larynx (Koshy). The EES may also find future uses in sleep by helping patients with sleep apnea, and babies who need neonatal care (Hartmann).

Additional non-medical devices which can be developed from epidermal electronic system are devices capable of being motorized by body movements, self-charging batteries, and more efficient wireless communicators. We may also be able to create ultra-thin television displays and flexible solar panels (Koshy).

Major flaws in the engineering of the epidermal electronic system is, since it adheres to the skin using the Van der Waals force, the continual shedding of skin cells allows the patch to only stay attached to the skin for only a few days (Yong). The engineering of the patch will eventually lead to it being able to be worn months at a time. Another drawback is the EES is expensive to produce. Rogers, one of the scientists involved in the development of EES, hopes that one day EES will be able to be mass-produced (Yong).

Conclusion

The epidermal electronic system is a leap forward in medical technology. There are many advantages and disadvantages associated with EES. Many of the issues revolving around the safety of EES will be resolved as the technology improves and continues to develop. On the other hand, many of

the social and security issues will only increase as the technology becomes more advanced and is developed for other uses outside of the medical community. It is a fine line between the technology used to monitor hospital patients and the technology used to interrogate prisoners. The many uses of the epidermal electronic system range from medical, to gaming, to spy uses. Each of these fields will be benefited as the information about this device expands. The impact it will have on society depends on which direction this technology follows.

Hartmann - Geeky Science - The Ultimate Spy tool | Thom Hartmann - News & info from the #1 progressive radio show. (n.d.). Retrieved October 4, 2011, from http://www.thomhartmann.com/bigpicture/hartmann-geeky-science-ultimate-spy-tool

The Ultimate Spy tool is a video about EES. Geeky Science covers much of the background information involving epidermal electronic system. The major component of this information is the security. He talks about how this technology could be used for spying. Hartmann addresses the future uses for this technology in the field of spying.

Kim, D.-H., Lu, N., Ma, R., Kim, Y.-S., Kim, R.-H., Wang, S., Wu, J., et al. (2011). Electronic Skin. *Science*, *333*, 838-843. doi:10.1126/science.1206157

Kim discusses the size of the epidermal electronic system. It is thinner than a human hair and has many uses that can result from how thin it is. The major concern with this technology it that because it attaches to the skin with the Van der Waals force as skin cells are shed the force weakens. This only allows the patch to stay attached to the skin for a few days at a time.

Kim, Dae-Hyeong, Lu, N., Ma, R., Kim, Y.-S., Kim, R.-H., Wang, S., Wu, J., et al. (2011). Epidermal Electronics. *Science*, *333*(6044), 838 -843. doi:10.1126/science.1206157

The Epidermal Electronic System known as EES does not adhere to the skin like temporary tattoos instead it uses the van der Waals interactions to adhere to the skin. There are a vast array of devices included in this hair thin patch which include; electrophysiological, temperature, and strain sensors, as well as transistors, light-emitting diodes, photodetectors, radio frequency inductors, capacitors, oscillators, and rectifying diodes. It supplies itself with power with mini solar cells and wireless coils. Along with working for medical purposes it contains sufficient information for an unusual type of computer game controller including voice activated game play.

Koshy, J. P. (2011, August 12). And now, a sensor for your skin. Retrieved September 9, 2011, from http://proquest.umi.com/pqdweb?index=0&did=2423012431&SrchMode=1&sid=2&Fmt=3&VInst=PROD&VType=PQD&RQT=309&VName=PQD&TS=1315593164&clientId=31810

Recently a team created of American, Chinese and Singaporean scientists have created an electronic patch similar to a temporary tattoo. This patch has been programmed to do a small array of tasks including; monitoring heart rates, brain functions, muscle activity, and can be used with Wi-Fi ports. The name of this patch is the *epidermal electronic systems.* The device is also able to power itself by drawing power from transmitted electromagnetic radiation and miniature solar collectors.

Ma, Z. (2011, August 12). An Electronic Second Skin. Retrieved September 27, 2011, from http://www.sciencemag.org/content/333/6044/830.full

This article give more background information on the technology. The epidermal electronic system is thinner than a human hair. These devices are almost completely weightless, not connected to any external wires. The epidermal electronics system is made out of a special silicon based substance. This is why the epidermal electronics system is able to bond to the skin using the Van der Waals force.

Wenner, M. (2009, December 18). 20 New Biotech Breakthroughs that Will Change Medicine - Popular Mechanics. Retrieved September 27, 2011, from http://www.popularmechanics.com/science/health/breakthroughs/43034074

This article shows new and upcoming biotechnologies and gives a brief explanation of these technologies. This was used in the introduction to show the different technologies developing in this field.

Yong, E. (2011, August 11). “Electronic skin” could replace bulky electrodes : Nature News. Retrieved September 27, 2011, from http://www.nature.com/news/2011/110811/full/news.2011.473.html

This article is about the medical uses for the epidermal electronics system. They hope this technology will develop far enough along that it will replace bulky electrodes in the hospital setting. The article also includes quotes from one of the developers who made the epidermal electronic system. Rogers is a professor at a university in Champaign Illinois. He has been working on this project for about six years now. He is sharing where he hopes the technology will go in the future and will help develop the technology to get to that point.