WEARABLE TECHNOLOGY:
A STUDY ON POST-HUMAN AND FUTURE APPLICATIONS

A Master's Thesis

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Graduate School of Economics and Social Sciences
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by

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ANKARA

September 2015

I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Media and Design.

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I certify that I have read this thesis and have found that it is fully adequate, in scope and in quality, as a thesis for the degree of Master of Fine Arts in Media and Design.

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ABSTRACT

WEARABLE TECHNOLOGY:
A STUDY ON POST-HUMAN AND FUTURE APPLICATIONS

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September, 2015

This thesis analyses the human-computer symbiosis through the role of technological advancements and developments on wearable technologies. It embraces the mutual relationship between men and the machine in a theoretical aspect and tries to narrate the correlation with a wearable sensor glove application. The interactivity of the current wearable technologies and human case profiles are touched upon. The main objective is to observe and uncouple the transitional stages of mobile media that carries today's human being to the prospective post-human.

Keywords: Wearable Technology, Mobile Media, Human-Computer Symbiosis, Transhumanism, Post-Human, The Quantified Self and Internet of Things

ÖZET

GİYİLEBİLİR TEKNOLOJİLER:
İNSAN ÖTESİ VE GELECEKTEKİ UYGULAMALAR ÜZERİNE BİR ÇALIŞMA

Ener, Üzeyir Arda
Yüksek Lisans, İletişim ve Tasarım Bölümü
Tez Yöneticisi: Yrd. Doç. Andreas Treske

Eylül, 2015

Bu tez giyilebilir teknolojilerdeki teknolojik ilerleme ve gelişmelerin insan bilgisayar ortak yaşamındaki rolünü analiz etmektedir. İnsan ve makine arasındaki müşterek ilişkiyi teorik açıdan kavrayarak aralarındaki korelasyonu giyilebilir sensörlü eldiven uygulaması ile aktarmaya çalışmaktadır. Güncel giyilebilirler teknolojilerin etkileşimlerine ve örnek insan profillerine değinilmektedir. Bu araştırmanın ana hedefi seyyar medyanın günümüz insanını gelecekteki insan ötesine taşırken ki geçiş dönemini gözlemlemek ve çözümlemektir.

Anahtar Kelimeler: Giyilebilir Teknoloji, Mobil Medya, İnsan-Bilgisayar Simbiyozu, Transhumanizm, İnsan Ötesi, Ölçülmüş Kişilik, Nesnelerin İnterneti

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The passion of a designer towards his profession does not diminish in time, on the contrary it matures and comes to fruition with every study and project. As a designer, I come to understand that collaboration between different fields and areas improves your ability to conceive better user experiences and products. Trying to empathise in every part of our lives is necessary to form a close link with your professors, colleagues, fiends and family.

This thesis has come to light with lots of drawbacks, struggles, persuasions and finally acknowledging the importance of studying systematically from the beginning. During this period the support of my family, my professors, my friends and especially my supervisor Asst.Prof.Andreas Treske has played a big role. I tried to empathise with them looking from the outside to my status and maybe I wouldn't be so understanding and helpful as they were.

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Knowledge should mean a full grasp of knowledge:

Knowledge means to know yourself, heart and soul.

If you have failed to understand yourself,

Then all of your reading has missed its call.

— Yunus Emre,

Turkish Poet

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CHAPTER I

PREFACE

The freedom of mobility and technological advancements brought about great change in human history, enabled interpersonal communication and circulation of information between entities. Traditional media preserved its existence by integrating with mediated forms of media and incorporating new features. The new media declared its dominance over the past mediums with the proliferation of mobile communication and computing technologies. Human-computer interaction(HCI), unveiled a new generation with a different set of intellectual thinking. The relationship between men and the machine required a new form of transition and communication. The accumulated knowledge and accustomed values from the past helped in forming the audio, visual and haptic interfaces. These interfaces function as a mediator, translate the otherwise ambiguous data for the user. In time, these

interfaces evolved with the computing machine by becoming more mobile and personal for the user. For the past couple decades the new area of wearable computing has introduced different variables for the new media. Eventually machine took its place on the body its user and establishing constant physical interaction, contact and attention. This symbiosis between men and the machine provides the person with self knowledge. In order to understand the future applications, it is essential to study and analyse the effects on the social, ethical, cultural and intellectual background of the new media age.

The implications of the cyborg-men and the machine symbiosis- is yet to be discovered with research and development of wearables as accessories, sport equipments, gaming applications and medical applications. A new experience and life style will emerge that will play an important role in shaping the new cultural norms, social and physical interactions and way of thinking. Embedded wearable technologies find their way on the users clothing and inside their bodies. This study is inspired from an experimental haptic wearable glove that converted sound to tactile vibrations, designed by Norbert Weiner a few decades ago for the hearing impaired. Mara Mills asserts “The hearing glove—a speech technology modelled on the cochlea but constrained by the limited sensitivity of human skin—tested the limits of

signal extraction and information compression."[1] The hearing glove was aiming to interpret the existing language to a new tactile language. In a similar way, this thesis applies tangible interaction methods and studies the collaboration between men and the machine and the extant gestural communication via functional wearable sensor glove design and its future application manner.

[1] Mills, Mara. 2011. "On Disability and Cybernetics: Helen Keller, Norbert Weiner, and the Hearing Glove," *Journal of Feminist Cultural Studies* 22(2-3): 74-111

CHAPTER II

WEARABLE TECHNOLOGY AS MOBILE MEDIA

2.1 The wearable nexus

Wearable technologies or wearable devices are devices that can be worn, placed or embedded in, on, under accessories, clothes or body of the user. The research area for the development of these devices via computational and sensory devices is called wearable computing. The first recognised wearable device in history is the wrist watch around 1500s.[2] In the beginning of the 21st century, the wearable devices began to be used by the consumer. People started to wirelessly from their cellphones from their bluetooth headsets. In 2014, the Edison chip that was developed by scientists and engineers in Intel made its debut. This chip is a microprocessor designed for

[2] Mann, Steve. 2014. Wearable Computing. In: Soegaard, Mads and Dam, Rikke Friis (eds.). "The Encyclopedia of Human-Computer Interaction, 2nd Ed.". Aarhus, Denmark: The Interaction Design Foundation. Available online on: https://www.interaction-design.org/encyclopedia/wearable_computing.html

the maker or do it yourself(DIY) movement. Microprocessors like the Intel Edison can be embedded in the wearable devices and clothing.

Wearable devices are varied from accessories, clothing, tracking devices, sensors, lenses, body tattoos, implants to exoskeletons(bionic body parts) that braces the body or replaces a missing body part of the user. With virtual reality glasses, like Google Glass people are able to experience and interact with their surroundings as never did before. Fitness trackers monitor their users to get detailed information about their biomedical data and identify any problems if needed. With built in sensors and trackers, people are able to keep track of their quality of sleep, food consumption, exercise, heart health and can make payments with it. This information will help users become more aware of themselves and have better lives(e.g. checking the heart rate of a healthy person frequently may not be so crucial but it is indispensable for a person with a critical heart condition). Wearables also assist users in their careers and in their work environment. Devices analyse their users during an activity(e.g. a football match) and produce valuable input to increase his success rate or performance for the next task.

Wearables also present its users with output information in the form of vibration-haptic feedback-or by audio to indicate the arrival of a message, an e-mail or a notification from a friend, a loved one or an application. In the case of a successful businesswomen, it is crucial to obtain relevant

information about her job instantly through notifications from her smart watch or accessory. Wearable technologies increase the experience, for instance with a haptic shirt the user can feel the emotion of the sport players during a game.[3] The issues concerning wearables are mostly on surveillance and data privacy. The information gathered by the wearable device can be misused by selling this information to third parties. The ethical and social aspects of the information needs a legislative action in order to protect the users from malpractice by third parties, companies and the state.

From the look of the global unit shipment forecast of Business Insider[4], wearable computing appears to be replacing the old media apparatuses with mobile wearable technologies. Media is taking yet another form, leaving its old shell. It is mediating on to the wearables at the same time transforming its user.

2.2 Wearable technology as mobile media

As a form of mobile media, wearable technology looks bound to the roots of old communication forms for recognisability and yet, it is establishing a new communication experience embodied on the user. It embraces the traditional

[3] Wasserman, Todd. March 13, 2014. "Electronic 'Alert Shirt' Claims It Can Help Fans Feel Football Tackles" Available online on: http://www.contagious.com/blogs/news-and-views/12945725-football-with-feeling

[4] BI Intelligence. May, 2015. "The Wearable Report: Growth trends, consumer attitudes, and why smartwatches will dominate." Report available online on: http://www.businessinsider.com/the-wearable-computing-market-report-2014-10

style of the watch and augments its own interface with the digital touch screen. “In terms of our embodied engagement with mobile media, which simultaneously takes place in our everyday spaces (which have been “realised”) and in the ways this space is augmented by virtuality infused from our interfaces, the terms cannot be used in isolation from one another.”[5] The proximity of the wearable technologies on the user’s body, increases the interaction and communication. In addition to that, wireless sensors and trackers makes user more aware of his surrounding environment.

With the proliferation of mobile technologies, countless data is flowing around without our sense or knowledge. It became so easy to generate content with the help of new programs and applications on mobile devices that people have started to create their own. The professionals(movie stars, singers, artists, etc.) were obliged to move towards the media stream. Composing unique content using social media applications on mobile devices; like Facebook, Twitter, Instagram, Vine or Youtube have unveiled their own celebrities that are called phenomenons. They are people who have huge number of followers and supporters online. These people spend most of their time online making funny videos, sharing the work of others, messaging, poking, tagging and commenting on current issues, popular topics, each other or about life. A 9 year old kid named Evan has close to 2

[5] Farmon, Jason. 2012. “Mobile interface theory: embodied space and locative media,” New York, NY: Routledge

million subscribers on Youtube. He achieved this by introducing toys from his Youtube channel and he has over 1.5 billion views in total, on his videos.[6] All of this is possible with service providers like Vodafone or AT&T, covering their whereabouts with receivers and transmitters that will keep its users online with fast connection rates. Sim card plays a great role here for the identification and distribution of information to other users and service providers. Another application is wearable radio frequency identification(RFID) system. These RFIDs can be implanted in the skin as well for identification and communication with other devices. For example, engineers in Spain developed an RFIDGlove system to ease the inventory task process for the user.[7] Bluetooth and wi-fi technologies are also key elements for wearable computing. These wireless technologies lets user connect with his personal or surrounding devices and share data or connection easily. These technologies are embodied in the devices to provide better mobility for the user.

An opinion suggested by Paul McFedries is, 'whenever people use their phone to talk, email or use their credit cards, they are leaving a digital

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[6] EvanTubeHD. September, 2011. Available online on: https://www.youtube.com/user/EvanTubeHD

[7] Vasquez, Juan-Ignacia and et al. 2009. "RFIDGlove: a wearable RFID reader". IEEE International Conference on e-Business Engineering. Macau, China. Article Available online on: http://www.researchgate.net/publication/221648650_RFIDGlove_a_Wearable_RFID_Reader

exhaust.'[8] People are having trouble to sort out the relevant information from the non relevant in digital space. The applications and personal devices are sending notifications or alerts through out the day. Media corporations should be very careful following their users during this information transition to a new apparatus. Due to the content display size, the length of the information will be getting smaller. News outlets got used to delivering brief information through social media sites but the significance, desirability and personalisation of the delivered information from the news corporation will be the game changer.[9]

The interaction and experience of users on mobile media is going through a transition with wearables. These devices that are placed on clothing, on the different parts of the body, on non-human biologic creature, etc. increase our communication with our loved ones with haptic heart beat messages or keeping track of the mood of your baby with wearable sensors. The space incorporated by wearables expands both to inwards to the biological data of the person as well as outward environmental data. The information that was not available for the user unless he went to the hospital, is literally on hand. The first ones that adjust to the transition of mobile media will be more

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[8] McFedries, Paul. 2013. "Tracking the Quantified Self" IEEE Spectrum Opinion. Article available online on: http://spectrum.ieee.org/at-work/test-and-measurement/tracking-the-quantified-self

[9] Woods, Padraic. April 2015. "Future of wearables affects media, medicine." Available online on: http://www.inma.org/blogs/mobile-tablets/post.cfm/future-of-wearables-affects-media-medicine

experienced because of the allocated time on the system. These people will set the bar for future applications.

2.3 Historical development of mobile media

Some conditions had to be met for the distribution and mobility of information to be possible. First condition was to ensure the possibility of scribing the information on something mobile e.g. cuneiform. Second condition was the means of transportation to be advanced for the export of mobile information. Third condition was to establish the means of minimum labor necessary and essential infrastructure for the transportation of data to the masses. For information to be perennial and transferable people have discovered various methods such as engraving information on stone and wood that are long lasting and durable but hard to conceal and carry. Jason Farman in Historicising Mobile Media asserts,

> "People no longer had to travel to a site to read the writings inscribed on caves, monuments, or walls; instead, the ideas traveled broadly since the medium they were inscribed on was light and mobile. These changes are remarkably similar to the ones we're experiencing with mobile computing devices: we are seeing

a rapid increase in the speed and frequency of communication as well as an alteration in our conceptions of social space."[10]

In 1839, the daguerreotype photography was invented by Louis-Jaques-Mandé Daguerre. Daguerreotype played an important role in proliferation of mobile photography. People were able to see places they have never been, in daguerreotypes. "In 1833, Charles Babbage began designing a device he called 'the Analytical Engine.' The Engine contained most of the key features of the modern digital computer."[11] After the invention and introduction of cinematography 1890s, it became a public entertainment. People have embraced this change with enthusiasm and this brought about huge economic capital to the media sector. This economic capital and public acceptance made media structures gain massive power in political, social, cultural and economic spheres. In 1936, Alan Turing changed the world of computing with the Universal Turing Machine. Lev Manovich asserts "Even though it was capable of only four operations, the machine could perform

[10] Farman, Jason. 2012. "Historicising mobile media: locating the transformations of embodied space," *The Mobile Media Reader*. Ed. Noah Arceneaux and Anandam Kavoori. New York: Peter Lang. 9-22

[11] Manovich, Lev. 2001. "The Language of New Media," *The MIT Press*. Cambridge, Massachusetts: 19-71

any calculation that could be done by a human and could also imitate any other computing machine."[12]

Inventions of radio, telegraph, telephone and wireless technologies have increased mass communication and interaction. The 20th century led to many developments in mass communication systems and networks, establishing long range communication. People started to communicate with each other more frequently and faster. The invention of television has changed the experience of media completely, incorporating newspaper, magazine and cinematography in itself. Every household got one in order to follow the entertainment shows and the news in motion at their homes. The launch of the satellite technology paved the way to better quality in broadcast and reach more viewers. The game changer in mobile media history is inarguably the internet. Jay David Bolter and Diane Gromala explains,

> "The computer was not always regarded as a medium. It was Douglas Engelbart (the inventor in the late 1960s of the mouse and word processing), the creators of the ARPANET and later networks, and Alan Kay and his colleagues at Xerox PARC in the 1970s who did the foundational work to show how computers

[12] ———-.2001. "The Language of New Media," *The MIT Press*. Cambridge, Massachusetts: 19-71

could serve as a medium for communication and for representation (Hiltzik 1999)."[13]

Everything that people have produced in the past and is still producing, is being uploaded on the world wide web(WWW). After desktop computers, laptops became preferable in the mobile media domain for a while, and then with the development of smaller mobile technologies e.g. the smart phone, tablets, etc. the user span have increased. The virtual reality applications have changed the accustomed view of media and created a more immersive experience for the user.

Today, wearables are knocking on the door of the smart phone, trying to join forces and eventually replace its place as the number one mobile media tool in daily life. The embedded wearable technology field inside the human body, project's another dimension to be observed and it seems that there will be a significant change ahead of humanity waiting to be discovered.

[13] Bolter, Jay David and Diane Gromala. 2004. "Transparency and Reflectivity: digital art and aesthetics of interface design," *MIT Press*. Cambridge, Massachusetts: 1-7

2.4 Mediation and the quantified self

2.4.1 Mediation

Over time media and communication fields have become inseparable. Developments on method and production of these fields are sequential. These developments effect the individual user(receiver), the producer and the supplier as well as their cultural codes, social dynamics, political authorities and economical conditions. Mediation steps in to ensure a correlation between these transitions.

Lev Manovich asserts "…, the computer media revolution affect all stages of communication, including acquisition, manipulation, storage, and distribution; it also affects all types of media—texts, still images, moving images, sound, and spatial constructions."[14] While we continue to use the printed media i.e. the news paper, the mediation of text to hypertext with computer media revolution ensured faster distribution of information to more users. The digital storage capacities of hardware have surpassed the traditional documentation. The traditional methods have not been set aside but mediated in different forms. The transformation from telegraph, to landline telephone, to cellular phones became computerised with new media and embodied various properties. The new media transition changed

[14] Manovich, Lev. 2001. *The Language of New Media*. London: The MIT Press

the social interaction and cultural communication. Roger Silverstone explains "Mediation involves the movement of meaning from one text to another, from one discourse to another, from one event to another"[15] New media gave new meaning to a broad aspect of people's lives.

The movement of meaning continues with independent users in the new media age. Every user with a computerised mobile device is able to create their own content in their own perspective. People use computerised media frequently in order to make a living, communicate and socialise. Therefore, interaction between user and the machine have gained importance in media and communication technologies. Mediation is necessary for users and institutions to continue decoding the social and cultural evolution, interaction and discourse that new media and communication will bring. Andreas Hepp argues 'mediation should not be considered just as a transfer of information but as a process of mediation in media communication generally'[16] (Hepp 2013: 37).

2.4.2 The Quantified Self

Our interaction with products helps us learn more about ourselves. We are connected to the digital world by our smart phones, tablets, computers and

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[15] Silverstone, Roger. 1999. *Why study the media?* London: SAGE Publications Ltd.

[16] Hepp, Andreas. 2013. *Culture of Mediatization.* Polity Press. Cambridge, UK.

other technological devices. According to the article of Melanie Swan, "The number of devices on the Internet exceeded the number of people on the Internet in 2008, and is estimated to reach 50 billion in 2020"[17] We are constantly leaving clusters of data online about our personal characteristics. People share what and where they eat, their current mood, their thoughts on particular events through mobile applications and online social platforms… Even if they don't share it, companies are sending people information or advertisement by looking at their online search patterns on their computer or smart phone. Our individual data is being tracked and observed by many different softwares without our recognition, that finds our sweet spot and gets their way one way or the other.

Advent of technology provided us with the possibility of knowing ourselves better. We are surrounded with sensors and gadgets that monitor our well being, the quality of our actions and enhancing our senses, performance, capabilities and quality of life. To know more about ourselves we used to need the consultation of another person and professional equipment but now we can self-monitor our condition and our progress with wearable devices. Gary Wolf and Kevin Kelly coined the term quantified self for this concept.

Gary Wolf asserted in his article "With new tracking systems popping up almost daily, we decided to create a Web site to track them. We called our

[17] Swan, Melanie. 2012. "Sensor Mania! The Internet of Things, 'Wearable Computing, Objective Metrics, and the Quantified Self 2.0," *Journal of Sensor and Actuator Networks* 1(3): 217-253.

project *the Quantified Self.* We don't have a slogan, but if we did it would probably be "Self-knowledge through numbers."[18](Wolf 2009)

There are some privacy concerns over the quantified data that people produce via sensors and gadgets. The data incorporated in the cloud, on the device and the transmitting data has all risk. Acquiring the digital and biological data of the person can be misused but the demand does not stop. [19] Prominent companies like Apple and Facebook build tight securities against data theft and establish strong privacy protocols. There is no guarantee for their individual data to be kept safe and private from prying eyes. The decision is up to the user whether to take that risk or don't.

[18] Wolf, Gary. September, 2009. "Know Thyself: Tracking Every Facet of Life, from Sleep to Mood to Pain, 24/7/365" Available online on: http://archive.wired.com/medtech/health/magazine/17-07/lbnp_knowthyself?currentPage=all

[19] Barcena, Mario Ballano, Candid Wueest and Hon Lau. 2014. "Security Response: how safe is your quantified self."Article available on: http://www.symantec.com/content/en/us/enterprise/media/security_response/whitepapers/how-safe-is-your-quantified-self.pdf

CHAPTER III

HUMAN COMPUTER INTERACTION WITH MOBILE MEDIA

3.1 Intangible user interaction with human computer interface

Intangible User Interaction is the relationship between the user and series of immaterial, visible or audio representations. These elements can be comprehended, translated and communicated through the input of a physical tool or the sensorimotor skills of the user. A typical user makes sense of this computational data with the Graphical User Interface(GUI). The user interacts with this interface by using a designated medium for control, gestures, position of his eyes or voice command. The system responds with an output information in visual 2D or 3D, audio representations or both.

The invisible hero that does most of the work behind the user interface is the numerical representations of the software, the command line interface(CLI). In 1981, Xerox company have developed a Star system which introduced the WIMP(Windows, Icons, Menus and Pointer), before GUI. The GUI took on a new significance with the birth and success of the Apple's famous Macintosh computers. Alan Kay argues "…the actual dawn of user interface design first happened when computer designers finally noticed, not just that end users had functioning minds, but that a better understanding of how those minds worked would completely shift the paradigm of interaction."[20] The effort was to make this new technology usable by everyone, not just specialists or researchers. To make it more usable a series of methods had to be developed. People pay more attention to graphical content rather then long text.[21] Multimedia(animation, graphics, sound, video, text) fused the best parts of the media into one piece, providing faster and effective transfer of information. The design and development of 3 dimensional virtual environments have increased the human computer interaction. Experience of the user have changed from static 2 dimensional space to immersed 3 dimensional environment. Cinema as one of the classical media tools have

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[20] Kay, Alan Curtis. 2001. "User Interface: A Personal View (1989)," In: R. Parker and K. Jordan (eds.) Multimedia: From Wagner to Virtual Reality. New York: W. W. Norton, *121–131*

[21] Healey, Christopher G. and James T. Enns. 2011. "Attention and Visual Memory in Visualisation and Computer Graphics," IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS 1-20. Available online on: http://www.csc.ncsu.edu/faculty/healey/download/tvcg.11.pdf

mediated with 3D graphics. This environment can be experienced at homes as well by providing a virtual reality glass.

Proliferation of personal computers and internet usage has amplified the design and development of graphical content. In 1990, Jakob Nielsen have developed *usability heuristics* with the help of Rolf Molich.[22] These heuristics played an important role in changing the perspective of the companies towards following a human centered approach. Companies wanted users to spend more time at their websites, read their content and prefer their services. Other intangible methods of user interaction with the computer through speaking or gazing an eye has extended the control potentials. Usability experts have started to use eye tracking technologies to design better user interactions and interfaces. This technology also used often in the marketing for testing the efficiency of commercials and products. The usage of voice user interface is mostly beneficial for handicapped users. These users can navigate the internet by giving voice commands or voice over technologies. Voice command technologies improved a lot. iPhone's Siri, the intelligent personal assistant is used by millions of users. Siri can acquire information from the internet, organise the user's calendar and schedule appointments, make recommendations, answer questions and adapt to users search and language pattern with the users permission. Another form of

[22] Wikipedia Contributors. September 2007. "Heuristic evaluation." Available online on: https://en.wikipedia.org/wiki/Heuristic_evaluation

intangible interaction with the computer is through gestures. Many gaming consoles and smart phones have started using gestural interfaces to create an immersive user experience with or without a medium between the device and the user. Microsoft Kinect presents its users with the opportunity to play games without using any medium, just their body gestures(hand and feet movements and face mimics as well).

These interfaces are now giving users advice on living healthier lives by only wearing a bracelet on their arms. Taking users places they have never been before and present things they never experienced before via virtual reality glasses. The curtain behind the intangible user interaction with the human computer interface is gradually getting thinner.

3.2 Tangible user interaction with product interface

Tangible User Interaction can be described as an action and reaction event in a digital or a physical environment. The product interface performs as a control mechanism for the user to convey or make the necessary input and observe the output on a digital or physical representation. This representation can be in visual, audio or haptic form.

A tangible product interface can help people learn quicker because during our growth, interaction with physical objects improves our sensorimotor skills. In Piaget's theory for cognitive development sensorimotor stage, he

asserts "…infants progressively construct knowledge and understanding of the world by coordinating experiences (such as vision and hearing) with physical interactions with objects (such as grasping, sucking, and sleeping)."[23] We start to make sense of our world with tangible representations of objects and their operation. The important thing here is to design the interaction of the user to relate and make sense of the system input and output. The more the experience is meaningful and familiar with the past experiences of the user the better.

Professor Hiroshi Ishii from MIT Media Lab, Tangible Media Group presents seven genres of tangible user interfaces. (Ishii 2008) All of these genres have important role in media and communication.

For example, tangible telepresence is an interpersonal communication with haptic feedback motors in the form of vibration or movement. A company called We:eX - Wearable Experiments made a haptic '*NL Fan Jersey'* wearable to let sport fans feel the impact, heartbeat, exhaustion, adrenaline and excitement of the players. Herewith, the company presents the user with an integrated experience and increased emotional communication with the sports player.[24]

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[23] Bernstein, Douglas and et al. 2012. *Psychology (9th ed.)*. Belmont, California: Wadsworth Publishing.

[24] We:eX - Wearable Experiments. 2014. *"NL Fan Jersey."* Available online on: http://wearableexperiments.com/nl-fan-jersey/

Figure 1. *NL Fan Jersey*

Tangibles with kinetic memory records the movement made by the user and then repeats the same movement exactly the same way user made it. These devices can help users observe and understand how the kinetic motions mathematical relationship translates into code. Another example is constructive assembly that paves the way to a memory based interaction between modular objects to develop the construction process and ease of repetitive movements. The product interface of Tokens and constraints consists of '*Tokens*' that are physical objects and '*Constraints*' that limits the tokens within the physical boundaries for different functions. Tokens can change in shape and dimension. The marble answering machine is a good example for us to understand the tangible user interface approach of tokens and constraints. The marble answering machine uses marbles to apply different tasks on the machine. "Dropping one of these marbles into a slot in the machine causes the recorded message to play. Dropping the same marble

into another slot on the phone dials the caller who left the message."[25] Interactive surfaces are also one of the most exiting tangible user interface approaches for collaborative working and simulation applications. The visual information is projected or visualised on the work space for user to manipulate the physical object on the workspace and have immediate response. The continuous plastic tangible user interface is different in nature among other approaches. The interaction surface can be formally configurable during the process. This system gives the opportunity to play with the environment as the user wishes and analyse the newly configured terrain quickly. The last genre of tangible user interfaces is augmented everyday objects. Designers can augment an object by giving it a new digital feature to bring a new interaction with new representation.

Figure 2. *musicBottles*

[25] Sharp, Helen, Yvonne Rogers, and Jenny Preece. 2007. *Interaction Design: Beyond Human-Computer Interaction (2nd ed.).* Hoboken, New Jersey: Wiley

musicBottles project in the MIT Media Lab Tangible Media Group is a very fun example for this genre. They have associated glass bottles with music and all the bottles have a cork. When the user removes the cork from the bottle, designated music starts to play. When the user removes the bottle as a whole from the surface, the user removes the type of music as a whole.[26]

Ultimately, tangible user interfaces have various types of interaction waiting to be discovered. The computational data embodies in a physical form with tangible user interfaces. The old data mediates with the new forming a continuous alliance.

3.3 User experience: Awareness of self

The user experience term was first mentioned by the cognitive scientist Don Norman in 1995 but the methodology goes way back when human ergonomics was argued in ancient Greece.[27] To understand the behavioural patterns, evaluate the performance, increase the interaction, accessibility and usability of products, systems or services(PSSs) for the user, it needs to be designed for the user experience. The PSSs that are not designed for the user experience could cause trouble for the user and fail to work.

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[26] Ishii, Hiroshi, Ali Mazalek and Jay Lee. 1999. "Bottles as a minimal interface to access digital information" *MIT Media Laboratory*. Cambridge, Massachusetts: 1-2

[27] Treder, Marcin. February 11, 2014. "The History of User Experience Design," Available online on: https://medium.com/@marcintreder/the-history-of-user-experience-design-5d87d1f81f5a

For a system to be usable, the user experience designer have goals to follow. These goals are to achieve "effective to use(effectiveness), efficient to use(efficiency), safe to use(safety), having good utility(utility), easy to learn(learnability), easy to remember how to use(memorability)"[28] PSSs. Today, user experience design is used frequently for the digital media and mobile device applications. One of the reason is the increased number of internet usage from mobile devices. The latest data from SmartInsights shows that mobile media usage is higher than desktop.[29] These devices have various screen sizes from notebook PC to wearable watch, that is why online services or systems need to be designed user friendly and responsive for compatibility. Prominent companies like Apple, Google, Amazon and Facebook have all realised the importance of user experience for their PSSs and are making great investments. The influential interaction makes these companies preferable. The user experience of PSSs are achieved after many different research, analyses, interview, focus groups, user testing, prototyping and final testing. The user experience field embodies designers, engineers and social scientists that are working in collaboration to achieve the best result. These experts develop user scenarios in order to help them understand who the user is, why does the user come to use the product,

[28] Sharp, Helen, Yvonne Rogers, and Jenny Preece. 2007. *Interaction Design: Beyond Human-Computer Interaction (2nd ed.).* Hoboken, New Jersey: Wiley

[29] Bosomworth, Danny. July 2015. "Mobile Marketing Statistics 2015."Available online on: http://www.smartinsights.com/mobile-marketing/mobile-marketing-analytics/mobile-marketing-statistics/

service or system and what are the users goals? Afterwards they apply a series of analysis. The most common and popular analysis is the Jakob Nielsen's and Rolf Molich's Heuristic Evaluation in UX. After different analyses the design phase of the PSSs begin with creating the information architecture, the interaction design and visual design. Unger Russ and Carolyn Chandler explains "An information architecture is responsible for creating models for information structure and using them to design user-friendly navigation and content categorisation."[30] The PSSs begin to take form and then the trial version or the prototype is put to tests. The test changes according to the type of the PSSs. User testing is one of them that lets the user try the PSS and sign a confidentiality agreement and get paid afterward. As a result the experts learn if the PSS is successful, needs improvement or failed. These tests are repeated depending on the goals and results.

By the virtue of UX, users are becoming more aware of their habits, behaviours, emotions and interaction with the PSSs they use. The experts learn a lot during this fundamental cycle and help both the companies and consumers, and at the same time achieve better user experiences.

[30] Unger, Russ and Carolyn Chandler. 2009. *A Project Guide to UX Design: For user experience designer in the field or in the making*. Berkeley, California: Peachpit Press

3.4 Daily applications of wearable technology

According to an analysis by Business Insider, over 30 million units of wearable products were shipped in 2015.[31] In this part, three different wearables are selected for their specific areas of usage. Apple smart watch is a product for general usage, Jawbone UP4 fitness tracker is a product particularly for bio tracking and Oculus Rift is a product for entertainment. The features of these products have been investigated in order to understand what is envisaged for the user of today? Do these products offer an advantage for the user? What are the differences of these products from their predecessors?

3.4.1 Apple smart watch

Apple introduced its first wearables device on 10 September 2014 on of their extraordinary keynotes. It is the most personal device of the Apple family. The individuality, personalisation and customisability is emphasised on the device. The interaction with the watch interface is performed by physical input via digital crown(with turning and pressing), a button below the crown and the touch screen. The product works in collaboration with one of the

[31] BI Intelligence. May, 2015. "The Wearable Report: Growth trends, consumer attitudes, and why smartwatches will dominate." Report available online on: http://www.businessinsider.com/the-wearable-computing-market-report-2014-10

most successful products of the company, the iPhone. Apple presents its users with a user guide to give detailed information and solve problems quicker.[32] The product interacts with its user via audio, visual and haptic feedback.

Figure 3. *Apple Smart Watch*

The product design is customisable from outer material, size and strap selection. The most significant part of the watch is the user interface. Apple designed a series of videos to explain how to use the device and publish them through their sites and other online websites.[33] The watch face awakens when user raises his arms to look at the time or use the device. There are several animated watch faces designed for the liking of the user. The digital crown let users to reach apps, scroll up and down screen and pan view inside the application. The touch screen enables users to move around the applications menu and make selection. There is also a new feature named the

[32] Apple Watch. 2015. "Apple Watch: User Guide." Apple Inc. Available online on: https://manuals.info.apple.com/MANUALS/1000/MA1708/en_US/apple_watch_user_guide.pdf

[33] Apple Watch. 2015. "Welcome to Apple Watch." Apple Inc. Available online on: http://www.apple.com/tr/watch/guided-tours/

force touch and it enable users to push with their fingers on the screen to come up with different options on the interface. The user is able to communicate with their friends and loved ones with instant text, animated or haptic messaging. Inside the watch there are sapphire lenses, infrared and visible light LED's along with photosensors detects users pulse rate. The watch brings out an inclusive information of the user's daily activities using its gyroscope, accelerometer, GPS and Wi-Fi. The activity features are very detailed for people who wants to lead a healthy life and it rewards its user thus gamifying the exercise experience. Most common apps that are used by the user can be reached from the glances by swiping upward when the user is on the watch face. The button under the digital crown help users to reach their most preferred friends to contact them via a call, a text, animated or haptic message. The watch incorporates Apple's intelligent personal assistant Siri as well. The notifications that come to the user's phone is notified through haptic, audio or visual outputs. These outputs can be turned off from settings to give the ability to choose for the user. The intangible and tangible features are designed for the optimal user experience and satisfaction.

In time, the watch will change the way people communicate and interact with each other. New haptic communication will produce new ways of signals and interactions between users. Media outlets will design their

content specifically for the watch interface to appeal to wearable users. There are also several issues that the watch consists. In the case of frequent stimulation by the device with haptic and audio notifications, can result in constant visual check for the information. People who are not accustomed to this type of communication either will get tired of it or get used to this interaction over time.

3.4.2 Jawbone UP4

On 15 April 2015, Jawbone Company introduced its UP4 fitness tracker wristband with an announcement from their blog. This device tracks the activity, sleep condition, heart health of the user. It gives advice on food consumption according to the user's food logs and how to reach the user's goals with its smart coach. Users are also able to make their payments over their smart phones.[34]

The company present its users with two product design model options and planing to increase variations in the future. The UP application on users smart phones guide its users to understand the data gathered via the smart coach of the UP4 fitness tracker into insights that improves over time as it gets to know its user. The user can get more information from the app on

[34] Jawbone. 2015. "UP4: a fitness tracker so advanced it pays." Jawbone Co. Available on: https://jawbone.com/store/buy/up4

health articles by tapping into the 'learn more' option. Sleep mode or activity mode can be activated both from the touch sensitive face of the device or the application on the phone. The device has a haptic vibration feature to wake its user up or for a notification alert. User interface of the application presents a clear and efficient design for the user to move around the application, follow his goals and achievements and reach related applications that work well with UP application to increase the interaction and experience of the user. There are collaborative devices that work well with product to put on more data with Internet of Things(IoT). The user can even track the activity of his dog from his smart phone via attaching an activity monitor to its collar. Adding gamification elements which the UP4 comprises, to fitness trackers is also very important for the encouragement and motivation of the users.

Figure 4. *Jawbone UP4*

Wearable fitness trackers are an endorsement for the quantified self of its users to learn more about themselves. A simple fitness tracker changes the eating habits for the better, improves the sleeping condition and increases

the activity of its user. It offers a permanent change for its users and ensure a healthier future. The main concern is the privacy of this data which can get into the hands off data mining companies or sinister people that can abuse the information. A great deal of companies wants to learn about the mood and emotions of people in order to use it to sell more products. Technology has its disadvantages but the growing demand on the wristband shows that people are embracing the technology.

3.4.3 Oculus Rift: Virtual reality glasses

Oculus Rift made its debut in 1 August 2012 on Kickstarter.[35] It is a virtual reality head mounted display. It is mainly used for entertainment, e.g. movies, games, real life simulations, social communication or on other relevant applications. The product can work with various controllers and also has a unique controller named Oculus Touch specifically designed for the Rift.[36] The actual product will be released in the first quarter of 2016, the developer kit was introduced to developers and consumers on consumer electronic shows.

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[35] Henderson, Rick. June 2015. "Oculus Rift in pictures: See how it's changed since 2012 Kickstarter debut." Available on: http://www.pocket-lint.com/news/134237-oculus-rift-in-pictures-see-how-it-s-changed-since-2012-kickstarter-debut

[36] Oculus. 2015. "Rift: next generation virtual reality." Oculuc VR, LLC. Available on: https://www.oculus.com/en-us/rift/

Figure 5. *Oculus Rift and Oculus Touch*

The company designed a sensor to be placed in front of the user to track his movement and position(sitting down or standing up). The product head mount is adjusted automatically with springs on the sides to fit the head of the user. Eye view of the lenses is announced to be more than a 100 degrees wide. The head mounted display contains an embodied headset to increase the interaction and experience with sound. Outer material of the product is made of fabric to give the feeling of a wearable clothing to the user. Interface of the device is a virtual representation of a physical location and it is designed for the ease of use, simplicity and efficient for the user experience. Information regarding the device's performance will be visible to the user on the home interface. Via the hand controller Oculus Touch, the user can make hand gestures and perform tasks in the virtually represented space with their hand e.g. grab or throw things. The sensor which guides the orientation of the head mounted display, also guides the location and movement of the controllers and number of sensors can be increased to expand the interaction

range. The controllers let users realise the tasks that can be accomplished in the real world. There is a community in which the user can meet with other Rift users, communicate and collaborate with them on projects or play games.

The Oculus Rift head mounted display takes users from the real world to a virtual representation of a real or a designed environment. The immersive experience gives the feeling that the user is actually taken to that virtual environment.[37] The more time passed in the virtual world, the more real the experience become for the user. Virtual reality applications will pave the way to many possibilities in the media, production, design and development fields. For example, via the virtual reality glasses the physical disability of a person can be removed and they can experience walking or other tasks they cannot accomplish in real life. It will change long distance communication interaction, and will introduce a more communicated world via the virtual environment.

[37] Chan, Norman and Will Smith. June 18, 2015. Interview with Oculus' Nate Mitchell and Pulmer Lucky. Available online on: https://www.youtube.com/watch?v=asduqdRizqs

CHAPTER IV

POST-HUMAN MEDIA

Post-human and media became interrelated after the embodiment of new media on human body. "Located within the dialectic of pattern/randomness and grounded in embodied actuality rather than disembodied information, the post human offers resources for rethinking the articulation of humans with intelligent machines."[38] In this chapter, there are three case studies on human and machine symbiosis that questions the future of humans not just in technological aspect but in intellectual, ethical, cultural and social concept. Steve Mann was selected as a case study for his major influence on wearable computing. Neil Harbisson is for his unique condition of seeing sonochromatic, which he got over with incorporating a wearable device into his brain to identify colours through sound notes. The last case study is on

[38] Hayles, N. Katherine. 1999. *How we became posthuman: virtual bodies in cybernetics, literature, and informatics.* Chicago, Illinois-The University of Chicago Press

Chris Dancy, a man who has tens of wearable devices on his body and living with many other sensors around his home environment.

4.1 Case study: Steve Mann(scientist)

Steve Mann is a Canadian scientist that dedicated his life to the development of wearable technology and virtual reality applications. He is the founding member of the MIT Media Lab Wearable Computing Project and is called the father of wearables! His work is mainly on surveillance of people, which led him to develop the terms 'sousveillence' and the 'veillance contract'. He has been wearing an augmented reality glass that enhances his view, records his life and documenting information for more than 35 years.[39]

His exploration with wearables begins with his grandfather teaching him welding at the age of 4. This experience led him to invent High Dynamic Range imaging(HDRi) using a special welding helmet(the EyeTap) design using cameras which creates a mediated reality environment through the cameras.

He experimented with the field vision of surveillance cameras, visualising the sight vision of the camera using a light bulb thus creating an augmented reality. He developed a wearable camera necklace in 1998 calling it the

[39] Mann, Steve. March 2013. *"Steve Mann: My "Augmediated" Life." Available on:* http://spectrum.ieee.org/geek-life/profiles/steve-mann-my-augmediated-life

6ense(sixth sense), becoming the surveillance camera himself which he calls the sousveillence(surveillence of the wearer). Steve Mann has been improving his EyeTap VR Glass device for more than 35 years and he is wearing it constantly. The EyeTap records the life of its user and provides feedback if necessary.

Figure 6. *Steve Mann wearing his EyeTap VR Glass*

In 1980's, he had to use radio communication systems for communication. During the mid 80's and early 90's he mainly worked with cameras and enhancing view with different sensors and added different properties to his glass e.g. heat sensors. His development on the EyeTap Glass immensely improved over time and gotten smaller over the years that become the current glass Steve Mann is wearing today. The last generation EyeTap, uses one eye for the camera and sees as the same viewpoint as the other eye to prevent confusion and health problems on the eyes.

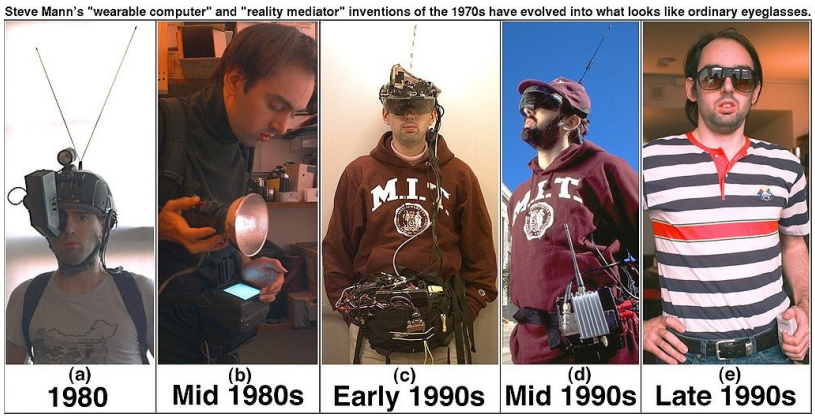

Figure 7. *Development of Digital EyeTap over the years*

The years of wearing the Digital EyeTap has provided an incredible experience on the virtual reality and wearable technology field to Steve Mann, but also some downsides as well. Many places he visited to perform daily operations has prohibited him from entering or ended up with an assault. He tried to explain that the medium is a part of himself and he cannot take it off. The medium helped him record these events to take action against them and fight for his rights. The post-human experience he went through is because people are not used to be surveilled by other people who are not store owners, government officials etc. but he argues in one of his conferences in TEDxToronto "When A makes a recording of something and forbids B from doing so, that B should not be able to use that recording as evidence in court".[40] He developed the veillence contract for this issue to

[40] Mann, Steve. 2013. "Wearable Computing and the Veillance Contract." Speech delivered at TEDxToronto. Toronto, Canada, September 26. Video available online on: www.tedxtoronto.com/talks/tedxtoronto-2013-talk-dr-steve-mann/

protect the integrity of the person who is accused but do not have any means to clear himself from the accusation.

Steve Mann shines a clear light to media reality from the first person point of view with his personal experience. The hegemonic power on information and control of the state or the predominant is being balanced via having the right to equal opportunity and right through technology. The post-human experience and interaction of Steve Mann with his inventions and new cultural norms will have a positive influence on the future of humanity.

4.2 Case study:Neil Harbisson(cyborg artist)

Neil Harbisson is a sonochromatic cyborg artist. He was born with a disease called achromatopsia which causes him to see monochrome colours. His life changed when he started to wear a device that translates colours into sounds and later he implanted that device surgically under his skull. He now has an antenna hanging above his head to perceive colours with sound. He has been accepted as a cyborg by the government of United Kingdom and founded a cyborg foundation that is based in United States, New York to help people become cyborgs as well.[41]

[41] Wikipedia Contributors. May 2012. "Cyborg Foundation." Available online on: https://en.wikipedia.org/wiki/Cyborg_Foundation

Figure 8. *Neil Harbisson Sonochromatic Cyborg Artist*

The artist defines his antenna as the 'eyeborg'. Via the eyebrow, the user can see all the human eye can see and can't see by upgrading his software to recognise infrareds and ultraviolets as audio input. Neil paints sound of music, paintings, famous faces and speeches as well. The colour mediates into audio vibrations through the medium that his attached to his brain. In fact, his brain translates the data to visualisation not the medium.

Neil Harbission explains in an interview,

> "First, I felt that the eyeborg was giving me information, afterwards I felt it was giving me perception, and after a while it gave me feelings. It was when I started to feel colour and started

to dream in colour that I felt the extension was part of my organism."[42]

The interaction of the user is extraordinary because his brain gets accustomed to a new language of sound and he can now communicate through it and associate tangible and intangible objects with sound. The normal sound has become colour for him e.g. the telephone tone felt green. Its as if the artist is transferring the user interface of the sounds he sees on his artworks. One of his recognised artwork is the two famous speeches in history made by Martin Luther King and Adolf Hitler. The artist ask viewers which belongs which speaker and he asserts people mostly get it wrong. Neil Harbisson believes that technology will change how people sense and experience. People will want to update themselves rather than their products in the future. In the future, post-human user experience will tempt people to become a better or different version of their selves.

Understanding of media evolves and mediates over time by changing the medium and the mediator as well. Our way of communication, way of perception, way of expression and all in all the definition of human will change or mediate.

[42] Bryant, Ross. November 20, 2013. Interview with Neil Harbisson. Available online on: http://www.dezeen.com/2013/11/20/interview-with-human-cyborg-neil-harbisson/

4.3 Case study: Chris Dancy(mindful cyborg)

Chris Dancy, is referred to as the most connected man on earth. According to an article, he is wearing and using close to 700 sensors, devices, application and services on his body and home environment.[43] The quantified self notion reaches its significance with Chris Dancy. Via the wearable and other devices, the user record data on his social, health and activity input.

The gadgets Chris Dancy uses, not only gathers data but improves the quality of his life, increases his productivity and rehabilitate his health. Tracking and recording every moment of his life, resulted in the discovery of the link between his actions that prevents him to be a better version of himself. The weather, the lighting in the environment, his daily activities was all connected and was sparking off a reaction in need of fixing. His daily habits and interaction with the world changed after the sensors and wearables. He separates the data he gathers into three parts. The alterable soft data and, hard and core data which are unalterable. The soft data is how he present his personality and character on the web, hard data is the things around him like his heartbeat, the weather, the lighting in the environment etc. and the core data is the genetics. Everything that he records and tracks helps him to get to know himself and his body better.

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[43] Kelly, Samantha Murphy. August 21, 2014. Interview with Chris Dancy. Denver, Colorado. Interview available online on: http://mashable.com/2014/08/21/most-connected-man/

Figure 9. *Chris Dancy the Mindful Cyborg*

People are able to uncover the information they were not able to do before the technologic sensors and trackers. They usually went to a hospital to acquire this kind of data. The augmenting interaction between the user and the computer started to change the social behaviours of people. The data gathered by this technology can also be used in court as an evidence to reach a verdict. The quantified self movement have been embraced by the public starting with the e-mails and pagers and from the looks of it will continue its incremental growth.

4.4 Embedded wearable technologies

The first recorded history of an embedded wearable technology into the human body is a pacemaker implant on 1958.[44] A few years later the cochlear implant was successful and restored the sense of hearing of a hearing impaired. These embedded technologies were around for decades but now there are many other cheaper, smaller and multi functional applications and sensors that make life easier for users. As wearable technology can be embedded inside the body of the user, it can also be embedded in products as well.

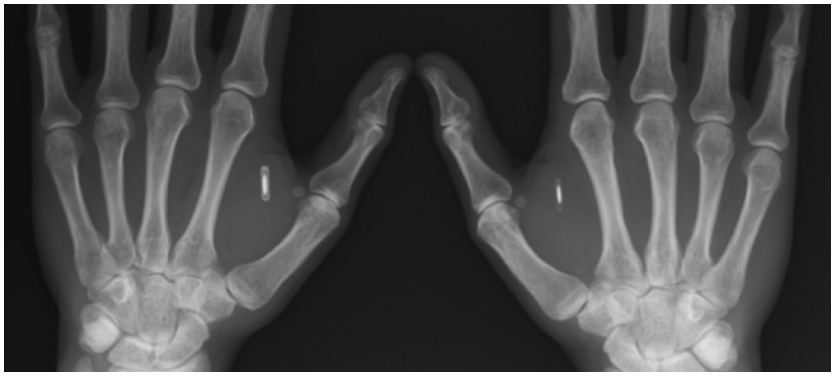

Figure 10. *Xray view of NFC Implants in the hand*

In order to explain and understand embedded wearable technologies, we need to know about the Internet of Things(IoT) as well. The IoT is the connection and communication of objects or systems that establish a vast network through wireless technologies. One of the first person on earth to use IoT with implanting a Radio-frequency identification(RFID) chip into his

[44] Forbes, Lindell. 2007. "Artificial Pacemakers." UMC Health System. 1-28 Available online on: http://www.umchealthsystem.com/downloads/ems/Artificial_Pacemakers_5-07.pdf

body. He was able to control the lights, doors and also his computer via this transmitter. (Warwick 2003) [45] Another technology that is working in similar to RFID is near field communication(NFC). NFC is when you get two device with NFC properties together or in proximity to each other. The most important property of these chips is, they do not need to be charged. People are implanting these devices into their bodies and also their pets as well, and it is called the biohacking.

A website called the 'Dangerous Things' has commercialised biohacking and is helping people hack themselves safely by presenting them with safe gadgets and guidelines. Another embedded wearable technology is the smart tattoo. Smart Tattoos are also working with NFC technology. The user can monitor his health, unlock his smart phone or car, open the door of his house, etc. Other developing technologies also contributes in the embedded wearable technologies as well. By using 3D Printing, people are able to print human organs. The bioprinting works only with the cells scientists can produce and add on each other and can embed technological properties on the organ as well. The most developed embedded technology is the cochlear implants that restores the hearing sense for the user. It is implanted under the skull, it takes the sound from outside and transmits the sound under the skin

[45] Warwick, Kevin. 2003. "Cyborg Morals, cyborg values, cyborg ethics," *Kluwer Academic Publishers* 5: 131–137

and sends the signal to the cochlear organ in the ear that stimulates the nerve.

Embedded wearable technologies inside the body and the functions of the devices will increase in variety over time. People will augment their senses, their knowledge and will be able to upgrade themselves. The cultural and social concepts will mediate into something new and different. The experience and interaction of the people with their surroundings shift form. Eventually, everyone will adapt to this change and others who lag behind will be seen as divergent.

4.5 Future of wearable technology

The future of wearable technology is moving towards the under and over the skin embedded wearable technologies. The market is estimated to grow 80 billion dollars by 2020.[46] The human and machine symbiosis has already begun and its repercussions on the social and cultural changes is an ongoing discussion. Post humanist or trans humanist movements are a great source and its future progression of this discussion.

The transhumanism concept is allegedly coined by the Biologist Julian Huxley in 1927. Transhumanism concept is the enhancement of body and

[46] Nusca, Andrea. February 24, 2015. "The key to an $80 billion wearables market? Invisibility." Available online on: http://fortune.com/2015/02/24/invisible-wearables-market/

mind of the person through developments on science and technology. Another concept similar to transhumanism is introduced by Professor J.C.R. Licklider(1990) from Massachusetts Institute of Technology.

Licklider asserted in his article The Transactions On Human Factors In Electronics(1960),

> "Computing machines can do readily, well, and rapidly many things that are difficult or impossible for man, and men can do readily and well, though not rapidly, many things that are difficult or impossible for computers. That suggests that a symbiotic cooperation, if successful in integrating the positive characteristics of men and computers, would be of great value."[47]

Decades ago, the machine could only execute the tasks the user issued to it but now the cooperation between men and the machine has increased. We started to use in most part of our lives. People are online with their computers, smart phones and tablets close to 8 hours a day. Today, elements of mobile media are also wearable, implantable and ingestible by the user. Transhumanist movements have issued a Transhumanist Declaration to

[47] Licklider, J.C.R. 1960. "IRE Transactions On Human Factors In Electronics: Man Computer Symbiosis" HFE-1: 4-11

envision the possible future of humanity preserving its values, morals and ethics paving the way for the future entities, human or non human.

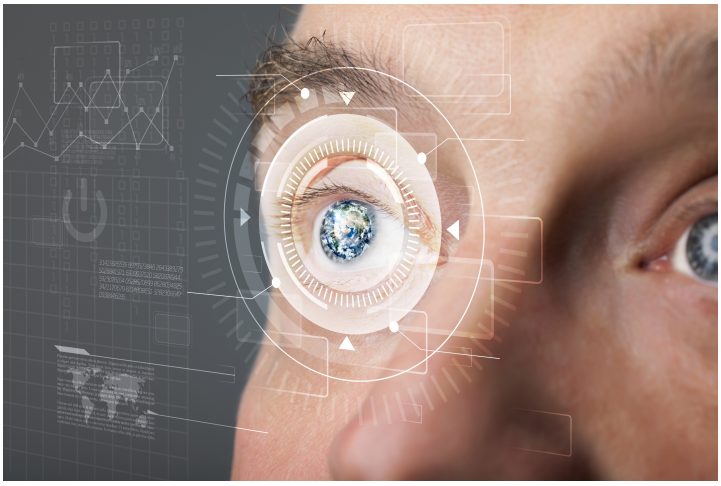

Figure 11. *Future Wearable Eye Lens Concept*

This subject have been embraced by comic strips, thus raised the future generations with the dream of having exoskeleton armours, super powers, enhanced senses, etc. Biohacking activists, grinders, cyborg foundation, World Trans Humanist Association, Humanity+ and other organisations are trying to spread the idea and philosophy behind this concept. In 1998, a professor in Reading University named Kevin Warwick has surgically implanted a silicon chip into his left arm. He then observed the things he can do with it and his interaction with surrounding elements. He explains his experience in his book Ethics and Information Technology "If I had to draw one conclusion from my experience it would be that when linked with technology inside my body, it is no longer a separate piece of technology."[48]

[48] Warwick, Kevin. 2003. "Cyborg Morals, cyborg values, cyborg ethics" *Kluwer Academic Publishers* 5: 131–137

Our behaviours, habits, values, life styles and way of communication alters depending on the opportunities and developments. People are adapting very quickly to the emerging developments physically, mentally and emotionally. Men and machine are continuing their existence interdependently and one cannot achieve to be better without the other.

Future of wearable technology is filled with question marks. People are trying to find answers by do it yourself(DIY) methods on themselves or doing extensive research and building scenarios. The environment and population we live in will be much different from today and we will be obliged to keep up with the time. Some are going to resist and form their own communities. The time will show which of the parties will be predominant over the other.

CHAPTER V

EMBEDDED WEARABLE APPAREL DESIGN PROJECT

The study on embedded wearable technologies are developing in different areas. The study focuses on the embedded wearable technologies on medical field. First, it is necessary to analyse the existing tangible and intangible interfaces and the user experience that the products on the market offers for the user. After analysing the products we can identify the pros and cons about the applications. Apparel design is a complicated area in wearable design technologies. Finding the appropriate materials, technologies and tools for the user is hard but it is harder to achieve the acceptance of the user. In this chapter, many different application of wearable thermometers and their competitors have been analysed. After the analyses, an embedded wearable apparel design has been suggested as an alternative and a question

for the progression of this field. Lastly, the future of this application was questioned and projected for further debate.

5.1 Wearable temperature devices

TempTraq Wearable Thermometer

TempTraq is a wearable thermometer from Blue Spark Technologies. The patch sticks on the body of the infant like a band aid. The thermometer is applied on the infants axillary cavity to monitor the most accurate temperature information for 24 hours. The thermometer sends the data to the parents smartphone via bluetooth and avoid the parents from constant visit to the patients bedroom but at the same time alienates the infant from the parent. The mobility of the device and the application presents a freedom for the parent but a questionable freedom to be favoured.

Figure 12. *TempTraq Wearable Patch Thermometer*

The thermometer interacts with the parents through the application on their smart phone. The user interface of the application is updating the temperature information continuously. New profiles can be added on the application depending on the care taker of the child. In the case of high temperature the device sends off an alert to notify the parent. The application also provides a note taking feature to record other relevant data e.g. when did the patient get its medicine, ate his food, etcetera. The patch notifies the user when it is time to renew the patch. The relevant information on the application can be shared with a professional to be analysed anytime.[49]

iThermonitor

iThermonitor is another wearable thermometer patch that is placed on the axillary cavity and sends data to cloud for the parents to keep track of the infants's temperature and medicine schedule on a smart phone application. The user can set up alerts for high temperature readings to intervene in time. These patch thermometers are like a useful parasite that clings on to the patients body and radiates information for the main user.

The idea behind these thermometers is to take the temperature of the patient without disturbing them but many parents have stated that they were getting the day off from work to look after their child. The mobility and place of the

[49] TempTraq. 2015. "TempTraq." Blue Spark Technologies Co. Available online on: https://www.temptraq.com

device removes the pestering of the patient but also removes the emotional need to look after a loved one.

Figure 13. *iThermonitor Wearable Patch Thermometer*

The interaction of the device with the patient and the main user is successful but the barrier it creates between the patient and care taker is forgotten. The user interface lets you in on the treatment by showing the change in the temperature information before and after the medicine.[50]

Sproutling Baby Monitor

Sproutling Baby Monitor is a wearable baby monitor. It is able to track the heart rate, skin temperature, motion and position of the infant. The device can be charged wirelessly. The wireless charge station has its own sensors that keeps track of the environment of the patient. There are various sizes of ankle braces so that the infant can keep using it growing up. The device

[50] iThermonitor. 2015. "iThermonitor." Raiing Co. Available online on: http://ithermonitor.co.za

works together with a mobile application to help the parent keep current and detailed information of their infant. The wireless data input increases the mobility and interaction with the device.

Figure 14. *Sproutling Baby Monitor*

This wearable monitor has a technological advancement over its predecessors. The most prominent feature of the device that it is able to tell the mood of the infant. Another important feature is the response time in taking the temperature of the patient. In the event of a high temperature, it immediately notifies the parents. The bracelet can be used simultaneously by three or more users. Position of the infant is also very important for the health of the baby during the sleep. The motion sensors in the device is another important feature that notifies the parent when they were not paying attention. This monitor presents the main users-the parents-with mobility to live down being a parent and enjoy being a couple. The user experience

increases with the number of features and assist the users to be better parents.[51]

iTherm

iTherm is a wearable band thermometer for infants or kids. This thermometer is also sending data by using bluetooth to an application to monitor the child's current heartbeat and temperature. It warns notifies the parents in the case of a high temperature. The most prominent feature of this product is the battery life that lasts up to 18 months.

Figure 15. *iTherm Wearable Band Thermometer*

In the current wearable technology market, wearable bands are very popular. The quantified self of the infant starts in the early days of their lives. The ease of use can be favoured by the parents but the individual data of the infant will be online even he wants it or not. The iTherm band and the others are changing the way the parents are taking care of their children. The social

[51] Sproutling Baby Monitor. 2015. "Meet Sproutling." Sproutling Co. Available on: http://www.sproutling.com

relationship and cultural background mediates along with technological developments.[52]

iFever

iFever is a wearable thermometer by Vipose company. It connects to the parents smartphone and sends the data to an application. It provides 24 hour data of the infants skin temperature and stores it to the cloud. It warns the parents in the event of a high temperature as well.

Figure 16. *iFever Wearable Thermometer*

This wearable thermometer is similar to every other thermometer bracelet on the market. Bluetooth is irreplaceable for the mobility in most of this wearables as in the example.[53]

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[52] iTherm. 2014. "iTherm: monitoring temperature for kids." iTherm Co. Available online on: http://www.ithermapp.com

[53] iFever. 2014. "iFever: Bluetooth intelligent thermometer." Shenzen Vipose Inc. Available online on: http://www.vipose.com

iSense

iSense wearable thermometer is taking the skin temperature of the infant from the abdomen. One of the most accurate place to take a skin temperature is through the axillary cavity not the abdomen. The device connects to the parents smartphone sends the temperature data to the application.

Figure 17. *iSense Wearable Thermometer*

As a different feature the thermometer kept the traditional small indicator on the product that shows the temperature data of the user. The device notifies the parent in the case of a high temperature and the time of the medication of the patient.[54]

Owlet Smart Baby Monitor

Owlet is a wearable sock thermometer for the infant. It presents the parents the most broad data information they need taking care of their infant. The device is focused on child sickness. The device sends the heart rate, oxygen

[54] Moreni, Edoardo. November 22, 2013."iSense Wearable Technology For Babies" Available on: http://greatpreneurs.com/isense-wearable-technology-babies/

level of the infant and also a notification in case of an emergency to the parents smartphone. At the same time the parent is able to track the skin temperature, sleeping position and sleeping quality from the application.

Figure 18. *Owlet Baby Monitor*

It works in collaboration with a base station that alerts the user in a critical situation. The experience after the hospital is very stressful for the parents because of the inexperience of the parents. The various output information from the Owlet relieves the stress of the inexperienced parents. [55]

Pacif-i Wearable Thermometer

Pacif-i is a suckable wearable thermometer differentiates it from the others. It is embedded with the smart bluetooth-Bluetooth 4.0- and its radio strength is much less than a smart phone. The parents can track the skin temperature of their infant from their smart phones, are able to track the medication time and set an alarm for high temperature rates. One of the key features that

[55] Owlet. 2015. "Introducing the Owlet Smart Sock." Owlet Baby Care Inc. Available online on: https://www.owletcare.com

differentiates it from the other wearable thermometers is that its machine washable and the location of the device can be tracked by phone incase of losing.

Figure 19. *Pacif-i Wearable Thermometer*

Children or infants usually throws out their pacifier's from their mouth and it could be hard to take the temperature when the child is in a cranky mood. The idea behind the device is very smart and cloud based operation system makes it easy to keep track of your babies health.[56]

Red Cross Pacifier Thermometer

Red Cross pacifier thermometer is another suckable thermometer. It embraces the traditional approach of previous thermometers and combines the new with the old. This thermometer does not connect to the users smartphone.[57]

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[56] Pacif-i. 2015. "Pacif-i Smart Pacifier." Blue Maestro Limited. Available online on: http://bluemaestro.com/pacifi-smart-pacifier/

[57] Red Cross Pacifier. 2008. "American Red Cross Digital Pacifier Thermometer." Learning Curve Brands, Inc. Available online on: http://thefirstyears.com/products/american-red-cross-digital-pacifier-thermometer

Figure 20. *Red Cross Pacifier Thermometer*

Lunar Baby Thermometer

Lunar Baby Thermometer has grasped the emotion behind the process of taking the temperature of a patient. Parents are usually taking their children temperature by kissing their foreheads or holding their palms against their foreheads. This thermometer is placed between the parents index finger and middle finger. While the bottom part of the device is leaned on the forehead of the infant the top part will indicate the results to the user on a screen. This wearable thermometer is worn for a short time by the parent and not the patient.

This thermometer design is separating itself from other wearable thermometers by thinking of one of the most common emotional gestures when taking a temperature of a patient. The device has a natural form that goes between the two fingers and does not use wi-fi or bluetooth. The

physical interaction between the parent and child is the most important thing in this process for the well-being of the patient.[58]

Figure 21. *Lunar Baby Wearable Thermometer*

Dr.Hug Wearable Thermometer

Dr.Hug is a concept wearable thermometer. The reason behind it is called a doctor is that it gives the parents advice on how to medicate the patient based upon their condition. In this concept the machine started to give suggestions for the patient to get better without a doctor. The device tracks the condition of the baby continuously and sends the information to all of the smart phones the user assigned from the application as the other thermometers.[59]

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[58] Kong, Duck-Young. 2008. "Lunar Baby Thermometer." Available online on: http://www.duckyoungkong.com/Lunar.html

[59] Lee, Jaehyuk. June 2014. "Dr.Hug: Thermometer for infant." Available online on: https://www.behance.net/gallery/16361817/Dr-Hug

Figure 22. *Dr. Hug Wearable Thermometer*

eSkin Thermometer

eSkin is a digital tattoo thermometer that soon to be taking its place on the shelves unveiled by VivaLnk. The user can read the skin temperature by taking their smartphones closer to the wearable sticker and the tattoo transmits the skin temperature. It lasts 15 days and the parent can wash the child while he is still wearing the thermometer.

This wearable is indicating to the future of wearable thermometers. After a few years we can expect under the skin thermometer or ingested pill that lasts on body energy and the user can learn his temperature or his biological reactions in his body anytime he wants by thinking it, pressing somewhere on his body or by some other method. The symbiosis between men and the machine is not happening in the future but today.[60]

[60] eSkin Thermometer. 2014. "eSkin Thermometer: The kid friendly, wearable thermometer that works with smart phones." Vivalnk, Inc. Available online on: http://vivalnk.com/eskin-thermometer/

Figure 23. eSkin *Wearable Tattoo Thermometer*

Home Used Medical Devices

Braun Thermoscan 7

The Braun Thermoscan 7 is an in-ear thermometer and is debatable if it can be considered a wearable device or not. The in-ear temperature reading is also one of the most accurate methods to measure the temperature of a patient. This thermometer can take the body temperature in a few seconds and it has an age precision feature. Clinical research shows that a normal body temperature of an adult can be a critical temperature for an infant. The parent can select the age of the infant with the help of a button on the device. The device keeps nine past readings in its memory. It also has a guidance system for accurate positioning in the ear. The device offers a good user experience and directs the user if the patient needs intervention or not. The

user needs to check the patient frequently in case of an emergency and this distinguishes other wearable thermometer over this model.

Figure 24. *Braun Thermoscan 7*

This device is easy to use but still missing the social connections and emotional values. The bond between a parent and child is intimate. The device interacts with the user via the traditional screen and presents all the relevant information to take care of the patient.[61]

Braun VitalScan Plus

The Braun VitalScan Plus is a sphygmomanometer for home environment. It measures the blood pressure of the user and stores up to ninety readings in its memory. These blood pressure monitors reads the heartbeat of the user as

[61] Thermoscan 7. 2014. "New Braun ThermoScan 7 with Age Precision" Braun GmbH. Available online on: http://www.brauntherms.com/our-products/thermoscan-7/

well. The professional measurement of the device makes it reliable and easy to use compared to traditional devices.

Figure 25. *Braun VitalScan Plus*

The device is designed for ease of use with large buttons and one button to start the task. The screen indicates all of the relevant information for the user to monitor his health. It takes the blood pressure from the wrist of the user. [62]

Microlife Infrared Thermometer

The Microlife Infrared Thermometer is a contactless skin thermometer. It takes the temperature in a few seconds and can show up to thirty readings in its memory. Contactless thermometers are taking away the emotion behind taking care of someone but is fast and efficient. It forms a barrier between the infant and the parents. Clinical research shows that skin to skin interaction is very important on the development and treatment of an infant.[63]

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[62] Braun VitalScan Plus. 2007. "Braun VitalScan Plus: wrist blood pressure monitor" Braun GmbH. Available online on: http://www.braunbloodpressuremonitors.com/heart-health/braun-vitalscan-wrist-blood-pressure-monitor/

[63] Harmon, Kate. May 6, 2010. "How Important Is Physical Contact with Your Infant?" Available online on: http://www.scientificamerican.com/article/infant-touch/

Figure 26. *Microlife Infrared Thermometer*

Communication and interaction between people are necessary to form bonds and stimulate emotion. The technological advancement should bring people closer rather than taking them apart from their loved ones. The human-machine cooperation is improving the healing process by presenting continuous input to keep track what went wrong and when and fix it the next time. It leads to the improvement and transformation of the human life for the better.[64]

MightySat Fingertip Pulse Oximeter

The MightySat is a fingertip pulse oximeter that measure oxygen saturation, pulse rate and perfusion index of the user. It has a colour screen that presents the user with relevant information. The user can send the data to his phone

[64] Microlife NC 100. 2014. "Microlife Non Contact Thermometer NC 100." Microlife USA, Inc. Available online on: http://www.microlife.com/WebTools/ProductDB/pdf/IB%20NC%20100%20V13-1%202014.pdf

through the Bluetooth LE feature of the device to the free app on the user's smart phone.

Figure 27. *MightySat Fingertip Pulse Oximeter*

The user clips the pulse oximeter on their fingertip to start and measure the biological data. The device portable and can be carried around in different environments and places.[65]

5.2 WT-Glove project

In this part of the study, the developing and promising field of embedded wearable technologies is examined and studied on a practical wearable glove application. Development in wearable devices have erased the logic behind

[65] MightySat. 2015. "MightySat: fingertip pulse oximeter" Masimo Co. Available online on: http://masimopersonalhealth.com

the idea that there is only one certain place, use or function of an object. For example, when the function of a glove is asked the immediate response would be to keep the hands warm but it may embrace different roles in different parts of life.

Wearable thermometer examples that have been analysed in the previous part are varied. There are patches, ankle bracelets, hand and arm bands, suckables, etc. Also home used medical devices have been investigated. The missing entity with these devices is the existing emotional values, cultural communication and physical contact. There are several places on the body where the pulse can be read and temperature can be taken truly with physical contact. The carotid artery on the neck and radial artery on the wrist are places that medical experts take the pulse of the patient. Don Norman asserts "Natural mapping, by which I mean taking advantage physical analogies and cultural standards, leads to immediate understanding."[66] To feel if a loved one is feverish the most common motion for a person is pressing on their forehead with palm of the hand.

[66] Norman, Donald A. 1988. T*he Psychology of Everyday Things (1st ed.).* Pocatello, Idaho*:* Basic Books

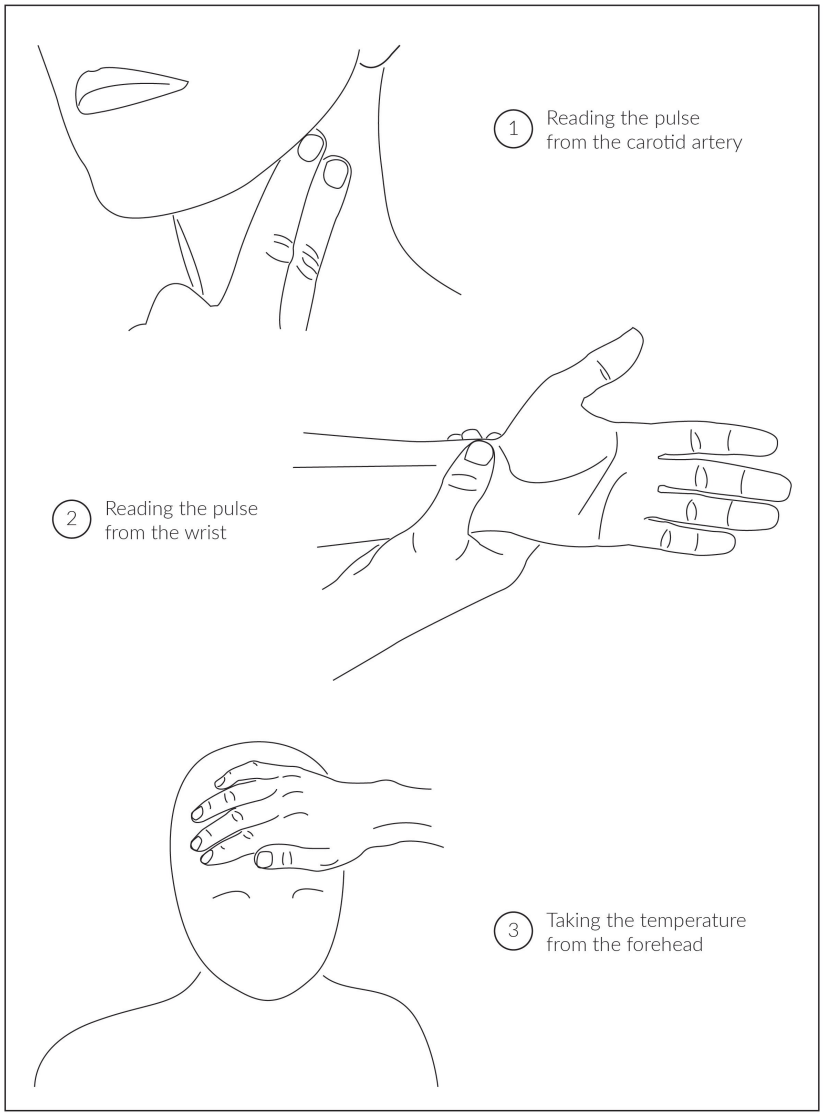

Figure 28. *Hand gestures for checking the pulse or taking the temperature*

The traditional thermometer that is taking the temperature of the infant from the rectum is causing discomfort and distress. Digital thermometers are taking the temperature from the axillary cavity and the perineum. To get a more accurate reading, prominent thermometers that are preferred by hospitals are taking the temperature from inside the ear. These devices interpose the machine between the user and the patient and severs the

emotional bond. For this reason, the extant human gestures have been analysed in order to present the user with a familiar and habitual experience while taking the temperature of a patient or a near of kin.

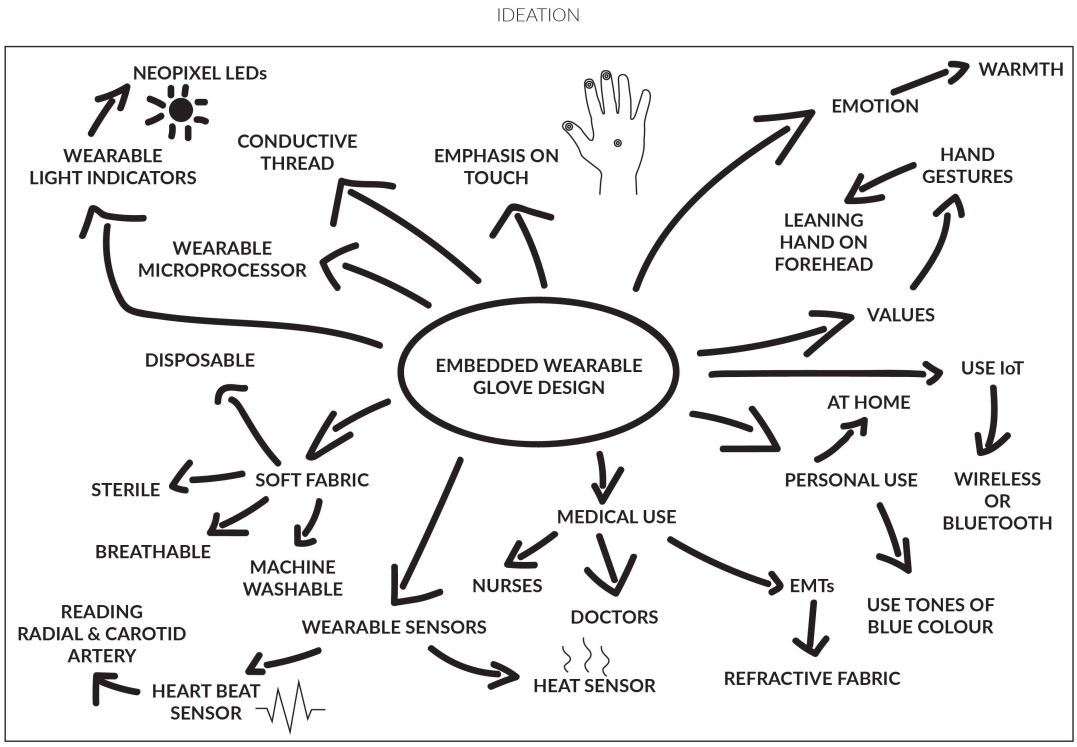

Figure 29. *Ideation Process for the Wearable Thermometer Glove*

From here, a wearable thermometer glove application is designed. WT-Glove is an embedded wearable clothing accessory that embodies a lilypad arduino board, a pulse and heat sensor and LED indicators which will be uncoupled later on. The visual and systematic design of this application was very challenging. The tangible interface of the device is using sensors to get a biological input from the body and convey the output information to the user via neopixel light emitting diots(LEDs) and a notification to their phones.

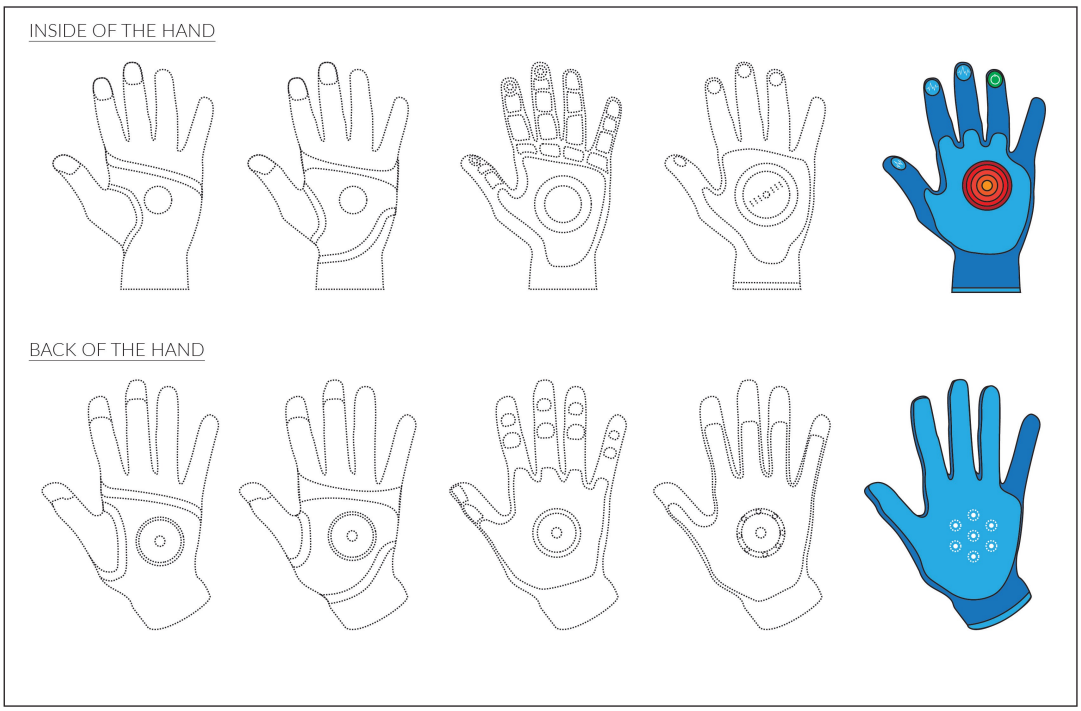

Figure 30. *Concept Generation for the Wearable Thermometer Glove*

This way, the user is able to record the relevant information and is getting a useful feedback from the device that the task is completed. To relay the information, the glove is using the available health applications on the smartphones connecting via bluetooth. Right after the temperature reading is done, LEDs that are on the back of the glove are changing colours depending on the degree celsius or fahrenheit of the temperature. The colours are identified between the intervals that are normal, mild, fervent and critical fevered patients. Green, orange, red and purple colours were selected for this output. This immediate reading is important to take precautions in case of an emergency.

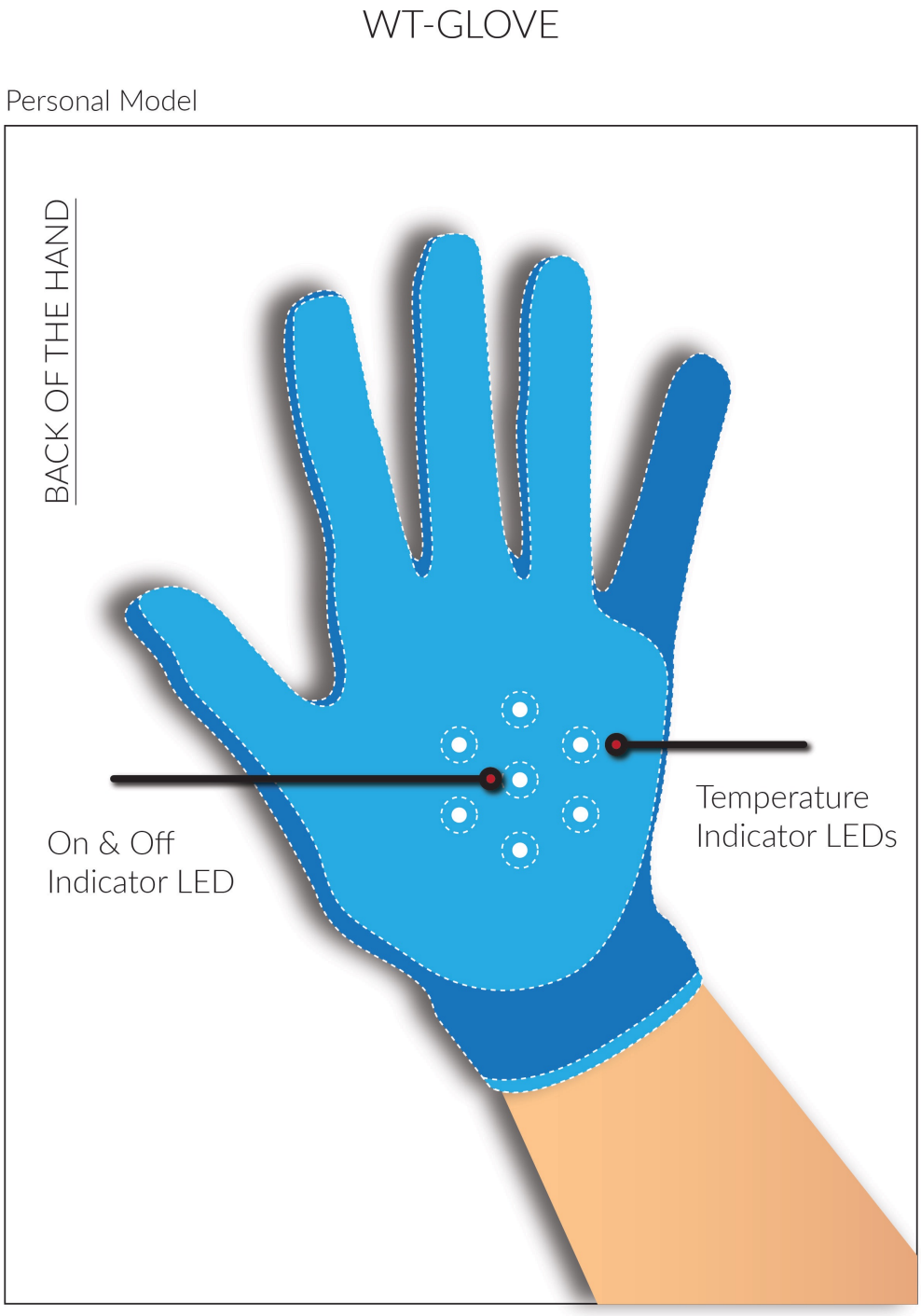

Figure 31. *Personal and medical model of WT-Glove(Front)*

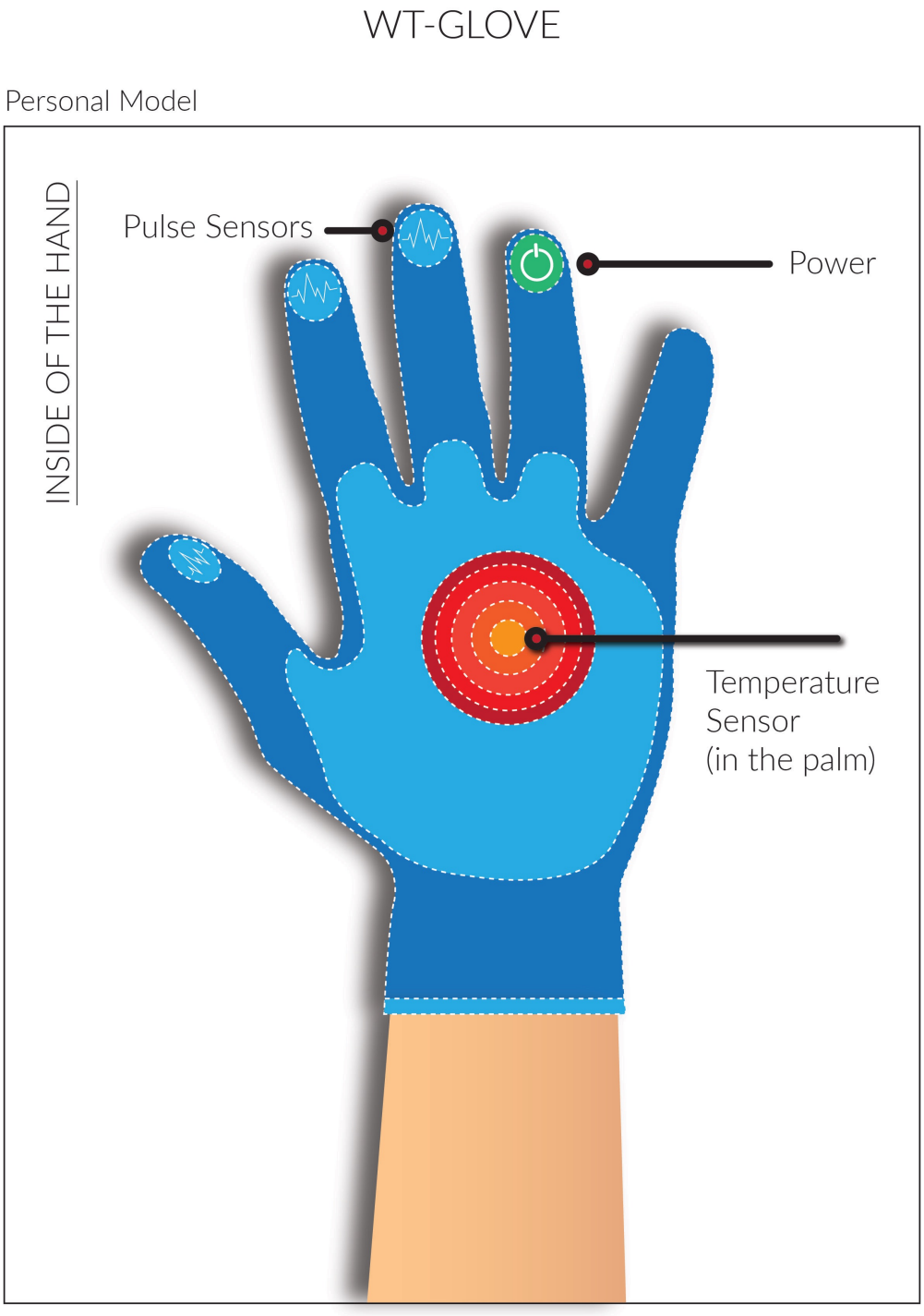

Figure 32. *Personal and medical model of WT-Glove(Back)*

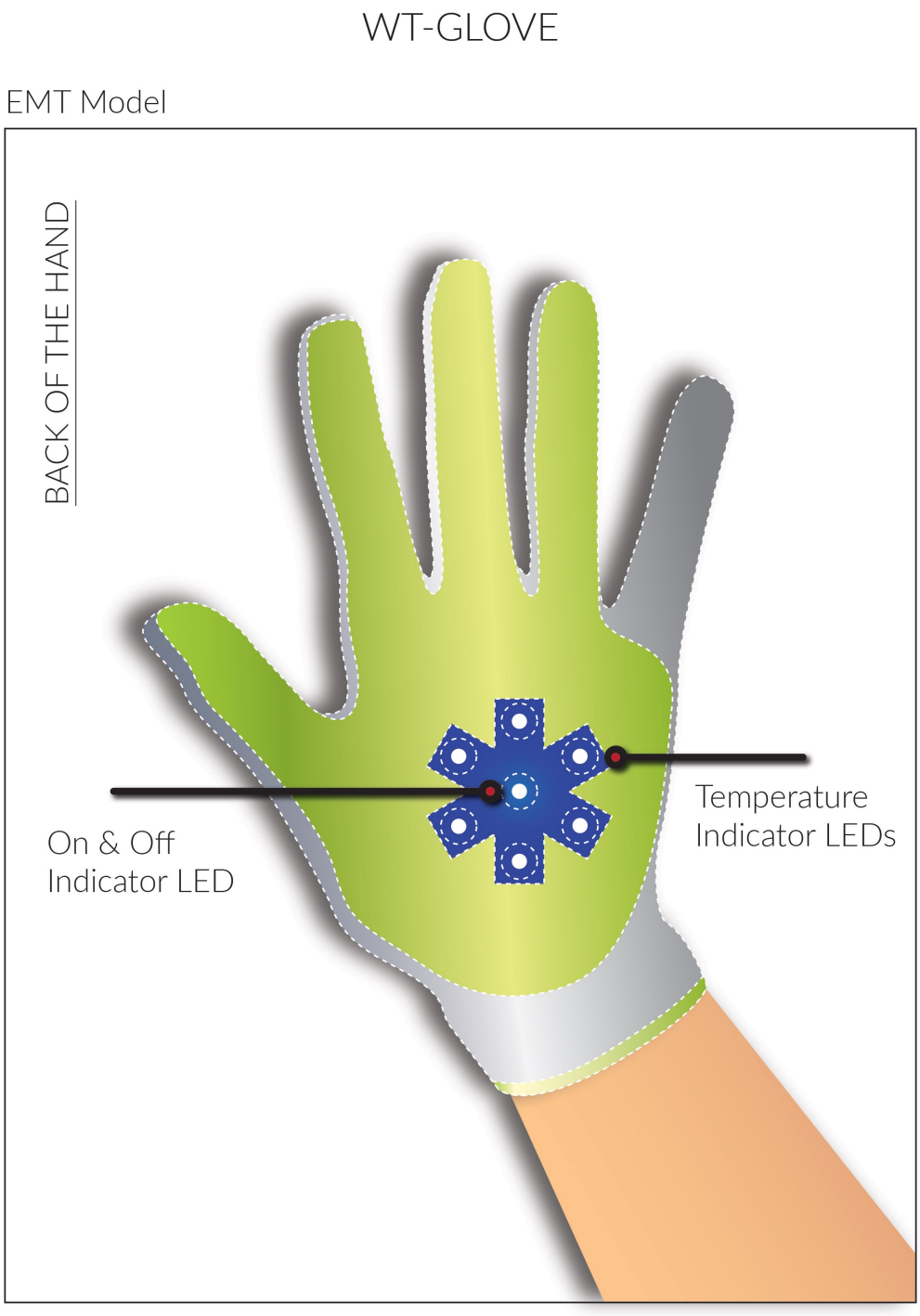

Figure 33. *EMT model of WT-Glove(Front)*

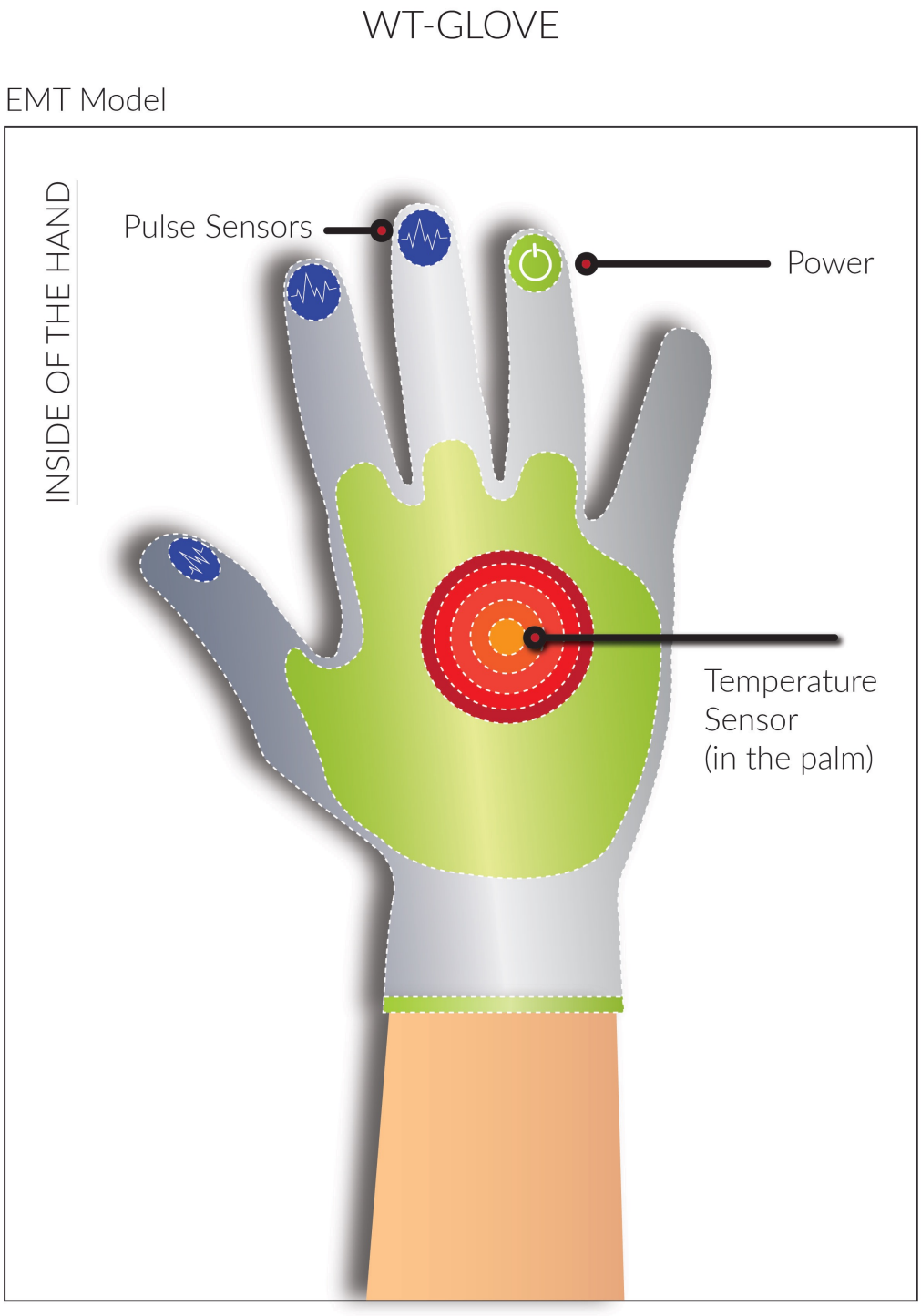

Figure 34. *EMT model of WT-Glove(Back)*

The emergency medical technicians(EMT's) are facing difficult events, for instance accidents and sudden heart attacks and the intervention time is critical for the well being of the patient. The wearable thermometer glove is also a solution in these occasions.

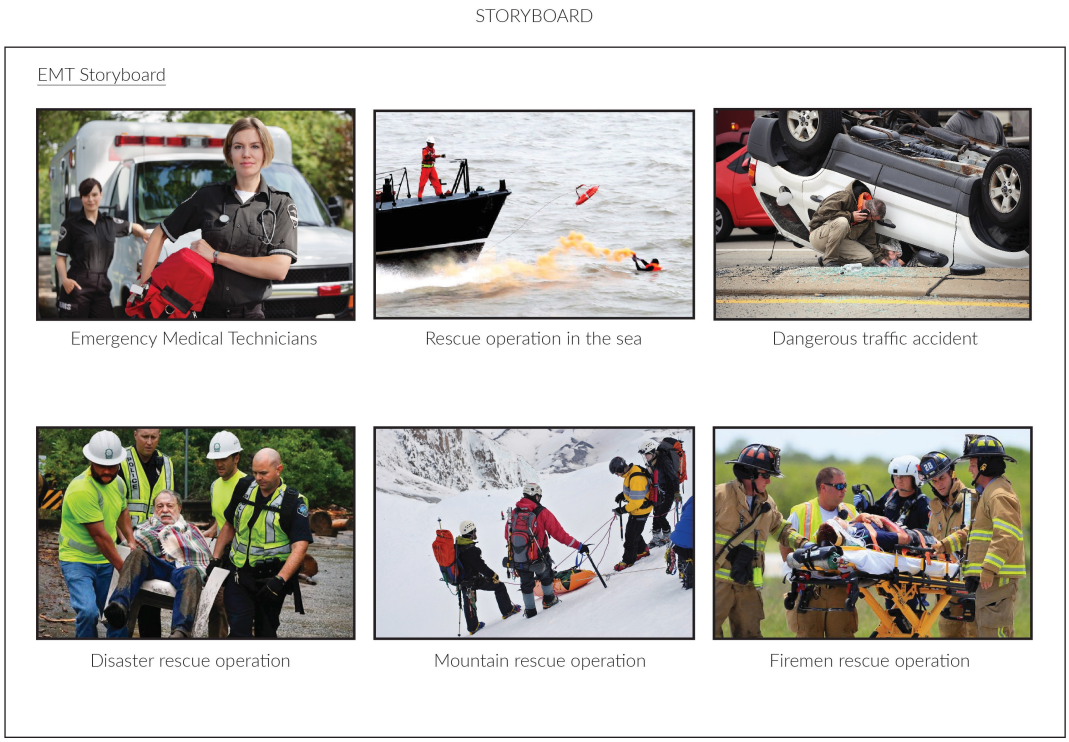

Figure 35. *EMT Storyboard*

High temperature can be critical. It can leave a bad trace after the sickness, can result in paralyses or even death in the earlier days of the infant. Considering the skin to skin interaction and the time spent with the infant, the loved one or the patient is important for the recovery, other wearable devices fail to display compassion in this field. The cooperation and collaboration between the men and the machine is significant in this case and the glove as an extension of the user by becoming a part of the user removing

the barriers that has been built. The natural interaction of the user is preserved with the extant gestures.

Figure 36. *Medical & Personal Use Storyboard*

The glove has three heart sensors; on the tip of the thumb, index finger and the middle finger. The heat sensor that takes the temperature is placed at the centre of the palm. The user pushes on the tip of the ring finger with his thumb to activate the WT-Glove. An LED light starts to glove in the centre of opisthenar(back of the hand) to indicate the glove is on. The reason behind using the ring finger as a switch is because the other three main fingers have different tasks assigned and the user can push them involuntarily and close the glove during an emergency situation. The WT-Glove has a two models for personal care and medical care, and for emergency unit use.

Tones of blue is preferred in the visual design in order to give the feeling that this is a product for medical use. The technological features are embedded inside the glove and are not visible for the outside eye and physical intervention. The areas around the sensors are emphasised with icons and colours. The digital representation of a heart beat on a screen is represented here on the point of the finger. The place of the heat sensor is represented with tones of red colours of the flame. The on and off button is represented with an I/O("1" and "0" from the binary system) symbol that is widely used on many lighting and electrical products. In this way the user's perception is guided with familiar graphical elements. The gloves interaction with the patient is also very important. The circular design and tranquil colours is opted to establish trust and lenience.

The first thing that attracts the attention on this glove is the EMT's logo. The indicator LEDs is placed inside the logo to bring a function to it. The outer material is a refractive fabric that are used on EMT's, construction workers, police officers and etcettera to attract attention and caution. The EMT's use plastic gloves the entire time they are on duty for a medical emergency to protect themselves. This embedded technology replaces the primitive plastic glove with a functional and efficient one. Location of sensors and indicators are preserved on the same place as the previous model. The hardware that is used on the professional and personal models is identical. This represents the

quality, importance and consideration that has been put on the personal device for the user.

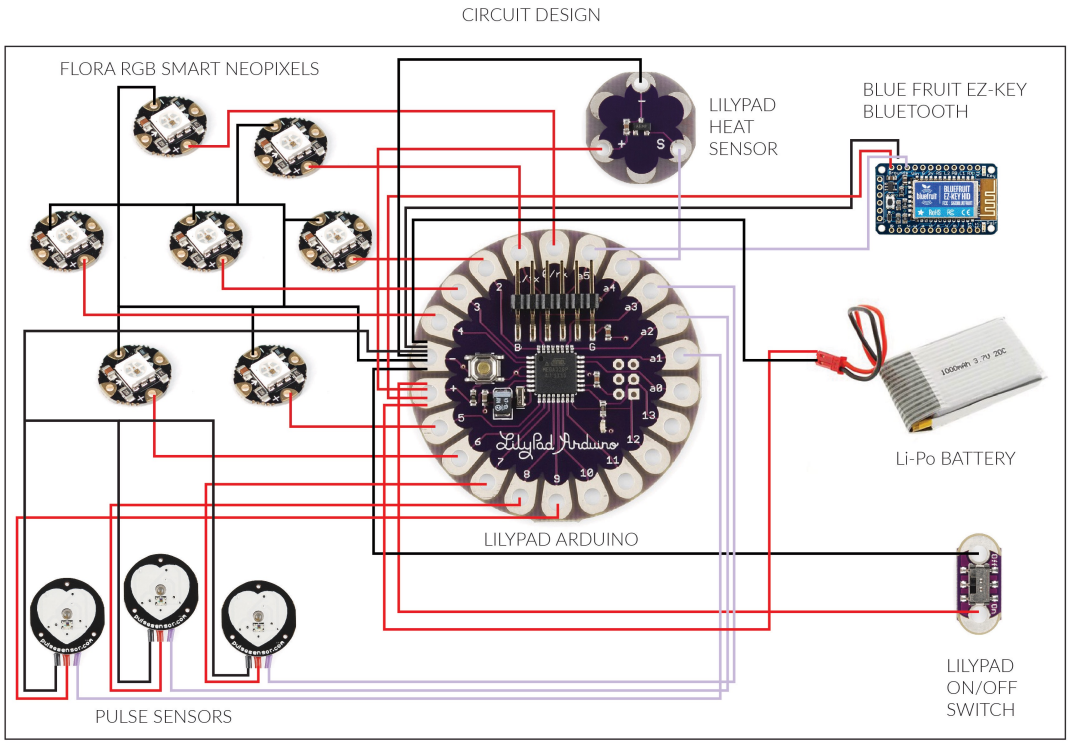

Figure 37. *Circuit design of the WT-Glove*

The circuit design presented below is showing the inner schematics of the glove. Lilypad Arduino is opted for the easy programming and application. The main board is connected to every sensor, LEDs and the blue fruit to transmit the data wirelessly to iOS or Android phone. The Lilypad heat sensor take the temperature by touching the patients skin. Our aim was using extant sensors but the user of the glove can take the temperature of the patient by touching any part of the body with their palm. The system is powered by a small lithium polymer battery that does not take much space. Parts that will thicken the glove and disturb the user is avoided. The flora

neopixel LEDs are grouped to indicate the information at the same time. Only one is separated to indicate if the device is working or not.

The prototype development of the WT-Glove has been recorded and photographed through different stages. The materials for the WT-Glove has been gathered and connected to a computer for programming the sensors with the wearable lilypad arduino microchip.[67]

Figure 38. *Materials used for the WT-Glove*

[67] Sparkfun. 2003. *Wearables.* Sparkfun Electronics. Available on: https://www.sparkfun.com/categories/204

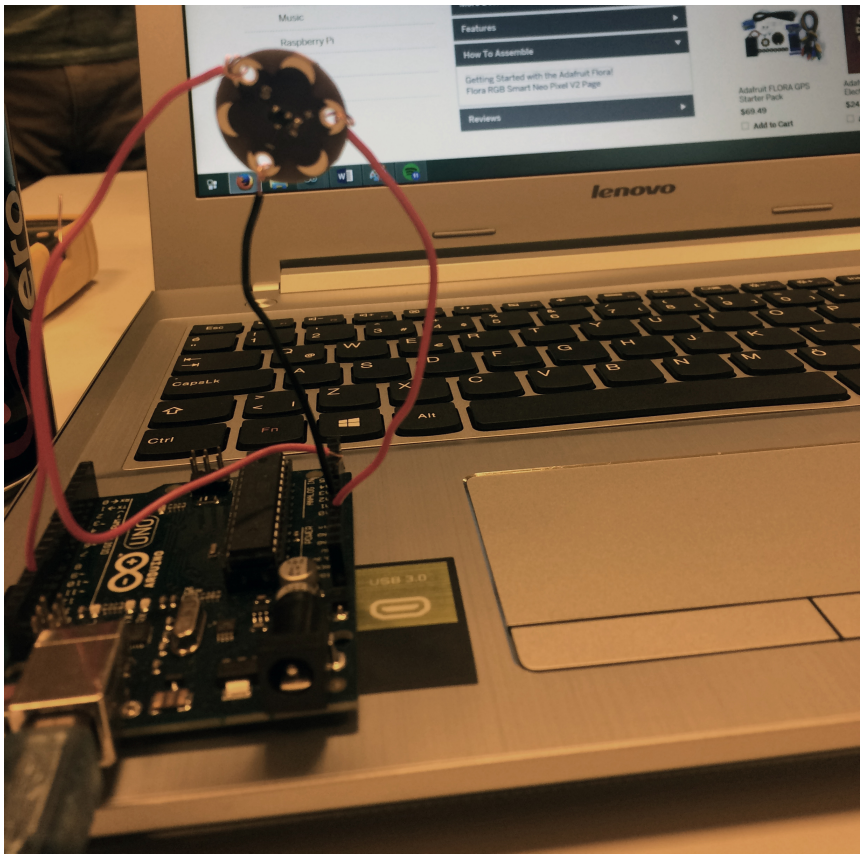

Figure 39. *Programming the lilypad heat sensor with arduino board*

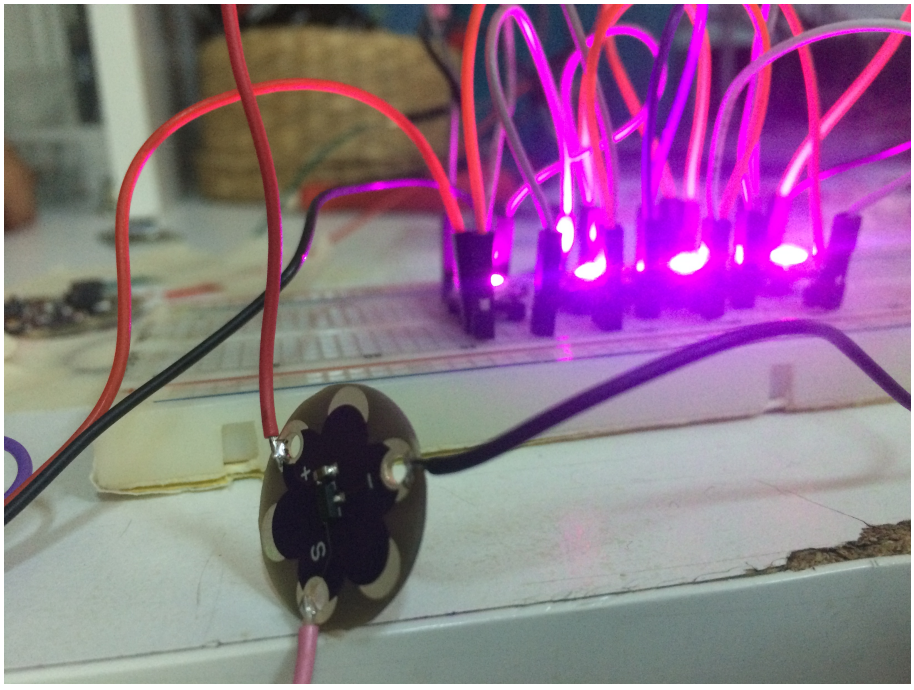

Figure 40. *Programming the neopixels to work with the heat sensor*

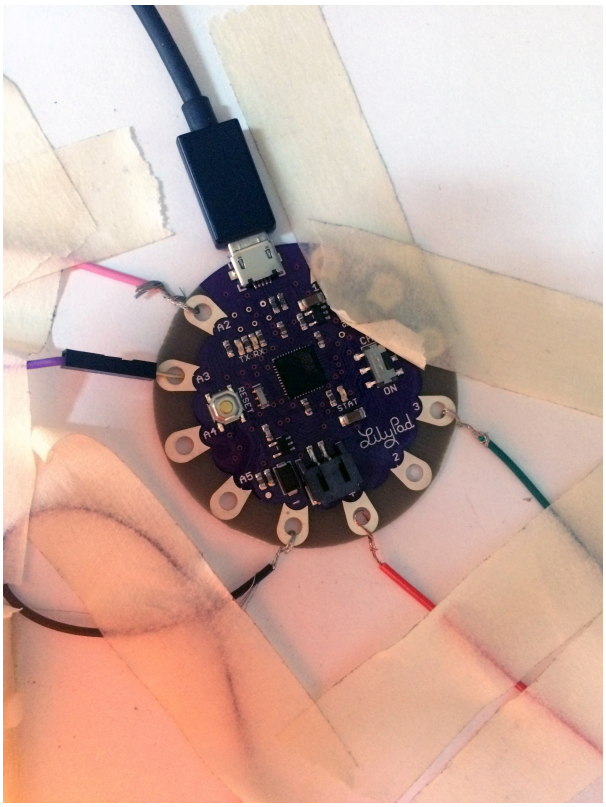

Figure 41. *Programming the lilypad arduino board*

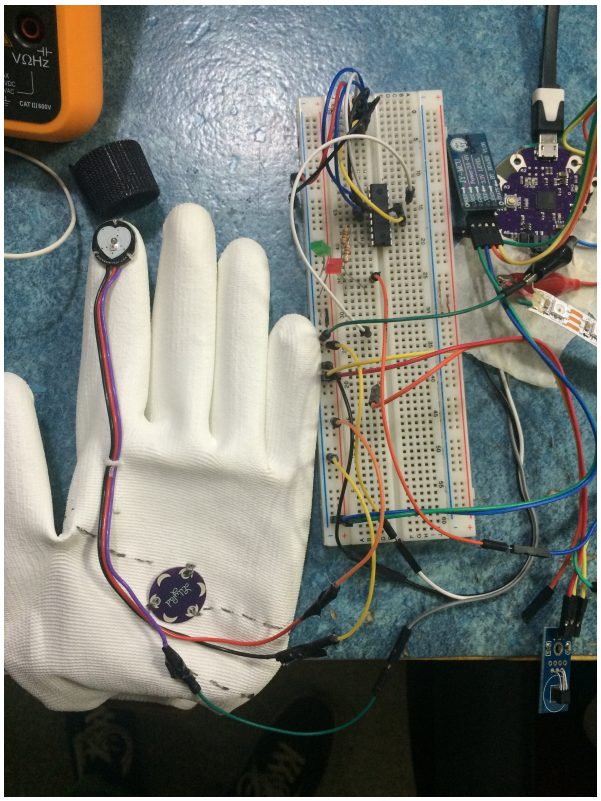

Figure 42. *Programming the WT-Glove*

```
 #include <Adafruit_NeoPixel.h>

int tempPin = 2;        // the analog pin is connected to temp sensor
//the resolution is 10 mV / degree centigrade with a
//500 mV offset to allow for negative temperatures
float temp1=0;        // the analog reading from the sensor
float temp=0;        // the analog reading from the sensor
float temp2=0;        // the analog reading from the sensor
float temperatureC=0;

#define PIN            3
#define NUMPIXELS      4

Adafruit_NeoPixel pixels = Adafruit_NeoPixel(NUMPIXELS, PIN, NEO_GRB + NEO_KHZ800);

void setup(void)
{
  // To send debugging information via the Serial monitor
Serial.begin(115200);
    pixels.begin(); // This initializes the NeoPixel library.
}
void loop(void)
{
     temp2=0;
     for(int i=0;i<10;i++)
     {
       temp1 = analogRead(2)*0.00322265625;
       temp2=temp2+temp1;
      delay(20);
     }
     temp1=temp2/10;
     Serial.println(temp1);
     temperatureC = (temp1 - 0.5) * 100 ;
     Serial.println(temperatureC); //

               if(temperatureC>=35&&temperatureC<=36.5)
               {
               pixels.setPixelColor(0, pixels.Color(0,255,0)); // green color.
     pixels.setPixelColor(1, pixels.Color(0,255,0)); // green color.
     pixels.setPixelColor(2, pixels.Color(0,255,0)); // green color.
     pixels.show(); // This sends the updated pixel color to the hardware.
               }
     else if(temperatureC>=36.5&&temperatureC<=38)
               {
               pixels.setPixelColor(0, pixels.Color(255,120,0)); // orange color.
     pixels.setPixelColor(1, pixels.Color(255,120,0)); // orange color.
     pixels.setPixelColor(2, pixels.Color(255,120,0)); // orange color.
     pixels.show(); // This sends the updated pixel color to the hardware.
               }
              else if(temperatureC>=38&&temperatureC<=40)
               {
               pixels.setPixelColor(0, pixels.Color(255,0,0)); // red color.
     pixels.setPixelColor(1, pixels.Color(255,0,0)); // red color.
     pixels.setPixelColor(2, pixels.Color(255,0,0)); // red color.
     pixels.show(); // This sends the updated pixel color to the hardware.
               }
               else if(temperatureC>=40)
               {
               pixels.setPixelColor(0, pixels.Color(170,0,170)); // purple color.
     pixels.setPixelColor(1, pixels.Color(170,0,170)); // purple color.
     pixels.setPixelColor(2, pixels.Color(170,0,170)); // purple color.
     pixels.show(); // This sends the updated pixel color to the hardware.
               }
               else if(temperatureC<36)
                         {
                                   pixels.setPixelColor(0,pixels.Color(0,0,0));
                                   pixels.setPixelColor(1,pixels.Color(0,0,0));
                                   pixels.setPixelColor(2,pixels.Color(0,0,0));
                                   pixels.show();
                         }
     delay(200);
}
```

Figure 43. *Code for Temperature Sensor*

PULSE SENSOR CODE

```
/*
>> Pulse Sensor Amped 1.2 <<
This code is for Pulse Sensor Amped by Joel Murphy and Yury Gitman
   www.pulsesensor.com
   >>> Pulse Sensor purple wire goes to Analog Pin 0 <<<
Pulse Sensor sample aquisition and processing happens in the background via Timer 2 interrupt. 2mS sample rate.
PWM on pins 3 and 11 will not work when using this code, because we are using Timer 2!
The following variables are automatically updated:
Signal :        int that holds the analog signal data straight from the sensor. updated every 2mS.
IBI  :          int that holds the time interval between beats. 2mS resolution.
BPM  :          int that holds the heart rate value, derived every beat, from averaging previous 10 IBI values.
QS  :           boolean that is made true whenever Pulse is found and BPM is updated. User must reset.
Pulse :         boolean that is true when a heartbeat is sensed then false in time with pin13 LED going out.

Code Version 1.2 by Joel Murphy & Yury Gitman  Spring 2013
This update fixes the firstBeat and secondBeat flag usage so that realistic BPM is reported.

*/
volatile int rate[10];                    // array to hold last ten IBI values
volatile unsigned long sampleCounter = 0;          // used to determine pulse timing
volatile unsigned long lastBeatTime = 0;           // used to find IBI
volatile int P =512;                      // used to find peak in pulse wave, seeded
volatile int T = 512;                     // used to find trough in pulse wave, seeded
volatile int thresh = 512;                // used to find instant moment of heart beat, seeded
volatile int amp = 100;                   // used to hold amplitude of pulse waveform, seeded
volatile boolean firstBeat = true;        // used to seed rate array so we startup with reasonable BPM
volatile boolean secondBeat = false;      // used to seed rate array so we startup with reasonable BPM

//  VARIABLES
int pulsePin = 5;                 // Pulse Sensor purple wire connected to analog pin 5
int blinkPin = 13;                //
int fadePin = 2;                  //
int fadeRate = 0;                 //

// these variables are volatile because they are used during the interrupt service routine!
volatile int BPM;                   // used to hold the pulse rate
volatile int Signal;                // holds the incoming raw data
volatile int IBI = 600;             // holds the time between beats, must be seeded!
volatile boolean Pulse = false;     // true when pulse wave is high, false when it's low
volatile boolean QS = false;        // becomes true when Arduoino finds a beat.

void setup(){
  pinMode(blinkPin,OUTPUT);         //
  pinMode(fadePin,OUTPUT);          //
  Serial.begin(9600);               //
  interruptSetup();                 //
   //analogReference(EXTERNAL);
}

void loop(){
  //sendDataToProcessing('S', Signal);     // send Processing the raw Pulse Sensor data
  if (QS == true){                       // Quantified Self flag is true when arduino finds a heartbeat
        fadeRate = 255;                  // Set 'fadeRate' Variable to 255 to fade LED with pulse
        sendDataToProcessing('B',BPM);   // send heart rate with a 'B' prefix
        //sendDataToProcessing('Q',IBI);   // send time between beats with a 'Q' prefix
        QS = false;                      // reset the Quantified Self flag for next time
     }
  ledFadeToBeat();

  delay(20);                             //  take a break
}
void ledFadeToBeat(){
    fadeRate -= 15;                         //  set LED fade value
    fadeRate = constrain(fadeRate,0,255);   //  keep LED fade value from going into negative numbers!
    analogWrite(fadePin,fadeRate);          //  fade LED
  }
void sendDataToProcessing(char symbol, int data ){
    Serial.print(symbol);                // symbol prefix tells Processing what type of data is coming
    Serial.println(data);                // the data to send culminating in a carriage return
  }
void interruptSetup(){
  // Initializes Timer2 to throw an interrupt every 2mS.
  TCCR0A = 0x02;     // DISABLE PWM ON DIGITAL PINS 3 AND 11, AND GO INTO CTC MODE
  TCCR0B = 0x03;     // DON'T FORCE COMPARE, 256 PRESCALER
  OCR0A = 0XF9;      // SET THE TOP OF THE COUNT TO 124 FOR 500Hz SAMPLE RATE
  TIMSK0 = 0x02;     // ENABLE INTERRUPT ON MATCH BETWEEN TIMER2 AND OCR2A
  sei();             // MAKE SURE GLOBAL INTERRUPTS ARE ENABLED
}
ISR(TIMER0_COMPA_vect){                         // triggered when Timer2 counts to 124
  cli();                                // disable interrupts while we do this
  Signal = analogRead(pulsePin);              // read the Pulse Sensor
  sampleCounter += 2;                         // keep track of the time in mS with this variable
  int N = sampleCounter - lastBeatTime;       // monitor the time since the last beat to avoid noise

    //  find the peak and trough of the pulse wave
  if(Signal < thresh && N > (IBI/5)*3){       // avoid dichrotic noise by waiting 3/5 of last IBI
    if (Signal < T){                        // T is the trough
      T = Signal;                         // keep track of lowest point in pulse wave
    }
  }

  if(Signal > thresh && Signal > P){          // thresh condition helps avoid noise
    P = Signal;                             // P is the peak
  }                                         // keep track of highest point in pulse wave

  //  NOW IT'S TIME TO LOOK FOR THE HEART BEAT
  // signal surges up in value every time there is a pulse
  if (N > 250){                             // avoid high frequency noise
    if ( (Signal > thresh) && (Pulse == false) && (N > (IBI/5)*3) ){
      Pulse = true;                         // set the Pulse flag when we think there is a pulse
      digitalWrite(blinkPin,HIGH);          // turn on pin 13 LED
      IBI = sampleCounter - lastBeatTime;         // measure time between beats in mS
      lastBeatTime = sampleCounter;               // keep track of time for next pulse
      if(secondBeat){                       // if this is the second beat, if secondBeat == TRUE
        secondBeat = false;                 // clear secondBeat flag
        for(int i=0; i<=9; i++){            // seed the running total to get a realisitic BPM at startup
          rate[i] = IBI;
        }
      }
      if(firstBeat){                        // if it's the first time we found a beat, if firstBeat == TRUE
        firstBeat = false;                  // clear firstBeat flag
        secondBeat = true;                  // set the second beat flag
        sei();                              // enable interrupts again
        return;                             // IBI value is unreliable so discard it
      }
      // keep a running total of the last 10 IBI values
      word runningTotal = 0;                // clear the runningTotal variable

      for(int i=0; i<=8; i++){              // shift data in the rate array
        rate[i] = rate[i+1];                // and drop the oldest IBI value
        runningTotal += rate[i];            // add up the 9 oldest IBI values
      }
      rate[9] = IBI;                        // add the latest IBI to the rate array
      runningTotal += rate[9];              // add the latest IBI to runningTotal
      runningTotal /= 10;                   // average the last 10 IBI values
      BPM = 60000/runningTotal;             // how many beats can fit into a minute? that's BPM!
      QS = true;                            // set Quantified Self flag
      // QS FLAG IS NOT CLEARED INSIDE THIS ISR
    }
  }
  if (Signal < thresh && Pulse == true){   // when the values are going down, the beat is over
    digitalWrite(blinkPin,LOW);            // turn off pin 13 LED
    Pulse = false;                         // reset the Pulse flag so we can do it again
    amp = P - T;                           // get amplitude of the pulse wave
    thresh = amp/2 + T;                    // set thresh at 50% of the amplitude
    P = thresh;                            // reset these for next time
    T = thresh;
  }
  if (N > 2500){                           // if 2.5 seconds go by without a beat
    thresh = 512;                          // set thresh default
    P = 512;                               // set P default
    T = 512;                               // set T default
    lastBeatTime = sampleCounter;          // bring the lastBeatTime up to date
    firstBeat = true;                      // set these to avoid noise
    secondBeat = false;                    // when we get the heartbeat back
  }
  sei();                                   // enable interrupts when youre done!
}// end isr
```

Figure 44. *Code for Pulse Sensor*

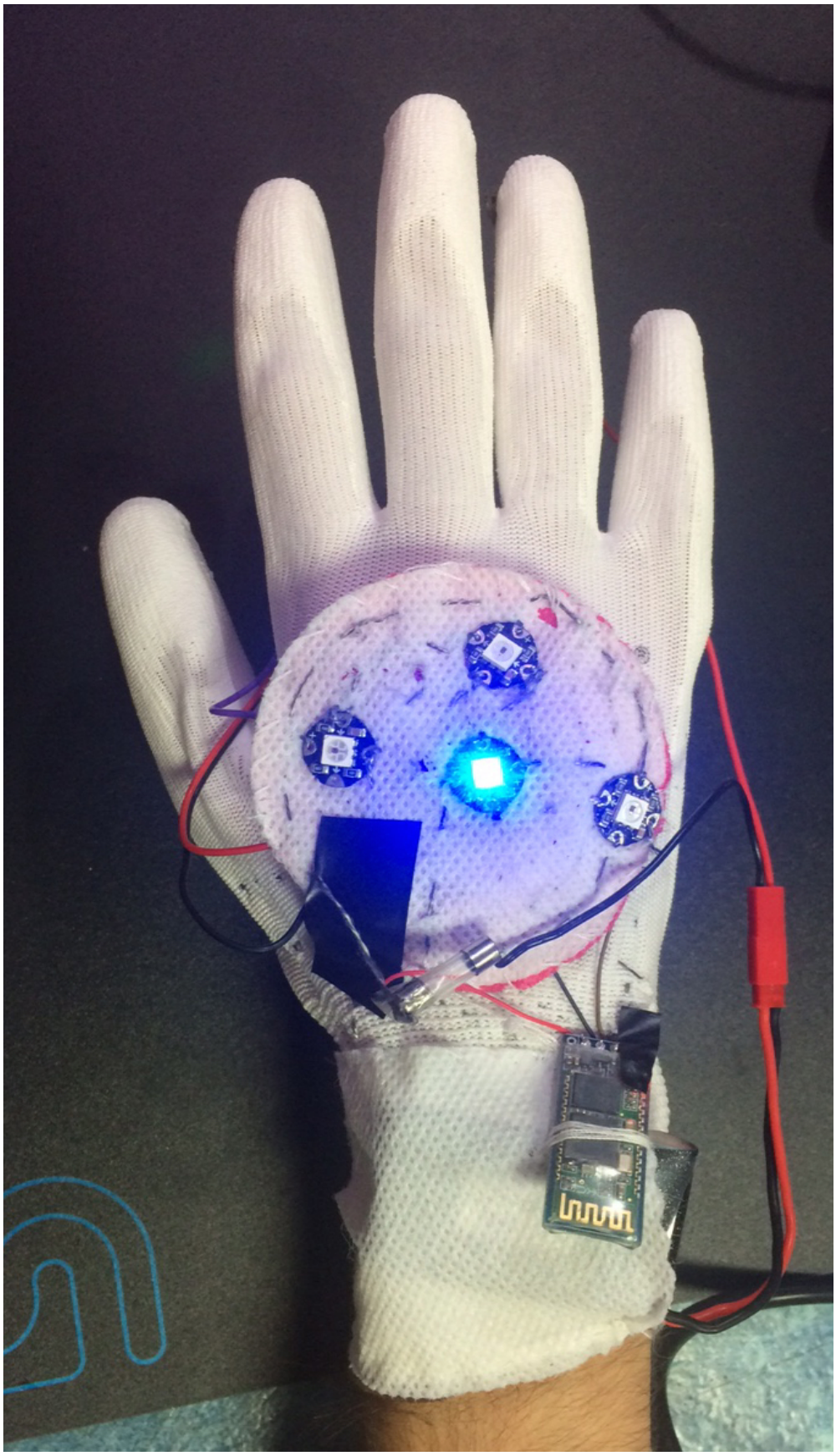

Figure 45. *Final version of WT-Glove*

The human and machine cooperation is emphasised in every part of this embedded wearable device and it is necessary for people and experts to improve themselves with technological devices. This integration will excel people at their work, social life and home. It will increase efficiency and control over their life. Donna Haraway mentions "Late twentieth-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines."[68] Even if she talks about another issue, the distinction between the real and artificial is disappearing with technological advancements and become ordinary. The expectation is after using this device frequently for a while, the user will perform the tasks unwittingly. As in the example of Professor Kevin Warwick, Neil Harbisson or Steve Mann, the human and machine will eventually merge and work in unison for the better of humanity.

5.3 WT-Glove 2.0: Post-human concept

Wearable Thermometer Glove 2.0 is a concept, that aims to be a contribution and wishes to start another discussion on post-human discourse. The embedded wearable technology glove will find its place under the skin of its

[68] Haraway, Donna. 1991. "A Cyborg Manifesto: science, technology and socialist-feminism in the late twentieth century." In David Bell and Barbara M. Kennedy, eds., *The Cybercultures Reader.* London: Routledge, 291-324

user in the future. Katherine Hayles asserts "In this model, it is not a question of leaving the body behind but rather of extending embodied awareness in highly specific, local, and material ways that would be impossible without electronic prosthesis."[69]

It is hard to compete with the machine for people in production industry. Manufacturing costs increase everyday and companies either lay off their workers, replaces them with machines or moving their base of operation to a cheaper location with lower labor costs. On the other hand, some companies prefer to integrate machines on their production process to keep their employees. People are reconciled using technological devices, services and systems that enhance their capabilities. These devices make their jobs easier, help them work faster and help to achieve other tasks that they are not capable on their own. When humans combine their intelligence with the machine, they achieve better results. Neither one is capable of doing everything the other can. Wearable technologies assist people to do things they are not able to without them. By embedding technology on the body, the user can attain a certain power that puts himself forward in life over others. For example, there are various type of job titles. All of these jobs have specific requirements from the person to do the job well. When a company posts a job online or from a traditional media outlet they compile a list of qualifications

[69] Hayles, N. Katherine. 1999. *How we became posthuman: virtual bodies in cybernetics, literature, and informatics.* Chicago, Illinois-The University of Chicago Press

for the job. Imagine that a person can attain a qualification on that post by operating on his body to get the job or another scenario is, that the job post is looking for a candidate who is willing to make a technological alteration on parts of his body. People are comfortable with wearing things on themselves or implanting things in their bodies by choice but will they willing to make changes by the request of others? People perform different operations to change their appearance e.g. have a hair transplant, have a tattoo done or have a cosmetic surgery that are all painful. There are also very dangerous jobs that contain a lot of risk for the employee. Being a lumberjack, deep sea fisherman, firefighter, miner or an emergency medical technician is just few examples of these job titles and all of these jobs requires extra attention and care from the employee.[70] In the post-human concept people are not just aiming to improve themselves in the physical sense but intellectually, socially, culturally and ethically. Humanity is in the ocean of change with no other way than to move forward.

The idea behind the wearable technology glove 2.0 is embracing the advance that technology bring about and while examining and questioning the situation we should not stand against it. For an emergency medical technician having a sterile hand is important to protect from diseases that can be transmitted from the patient.

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[70] Pegg, David. November 28, 2013. "25 Most Dangerous Jobs In The World" Available online on: http://list25.com/25-most-dangerous-jobs-in-the-world/4/

Figure 46. *Embedded temperature and pulse sensor, and light indicators(Front)*

Figure 47. *Embedded temperature and pulse sensor, and light indicators(Back)*

With the aid of technology this technician can work with their bare hands while having advanced features embedded in their skin to expedite the treatment procedure. This two features are just simple examples to give an idea of the possibilities in the near future. The process can transform into people with abilities to sense the emotion, heartbeat, temperature of the person in front of them by getting closer to them and focusing on their bodies in the distant future.

Marvin Minsky supports "…we have to make computers more self conscious, just in order to make them smarter!"[71] but we can achieve an emotional, rational thinking, self conscious machine through the symbiosis of men and the machine. Cyborgs or enhanced generations are coming to bring a new experience for the world. The responsibility and statement they are carrying on their shoulders is important for shaping of the future. They will establish new structures, and establish new cultural forms of communication. The mobile media will find itself incorporated in the body of the human, mediating with another medium.

[71] Minsky, Marvin. 1982. "Why People Think Computer Can't?," The AI Magazine. Cambridge, Massachusetts: 3-15

CHAPTER VI

CONLUSION

This study, elaborated today and the future of embedded wearable technologies impact on the post-human concept by presenting an embedded functional apparel design. The symbiosis between men and the machine has been investigated using human-computer interaction and interface design on tangible and intangible objects. The social, cultural, intellectual and ethical concerns were leaned on to quote on potential scenarios that may occur and come up with possible implications. The emotion behind the symbiotic application is emphasised over the existing models that have been examined and studied. The efficiency of the embedded wearable application can raise questions in terms of sufficiency on medical implementation but also opens discussion for other variations.

Mobility of the mobile media was the foundation that entailed the proliferation and rise of wearable computing. The issues with mobile media and consequences for the user were discussed in historical context and in the post modern society. Mediation came up as an important variable in the transfer of information and technology into a new form from the traditional medium. It appears that wearable technology will be mediated by becoming a part of the body, constituting the cyborg that embodies new technological features. The biggest organ of the body the skin became an irreplaceable form of interaction, communication and function for the cyborg with the sense of touch. The study encouraged to increase the skin to skin interaction to protect and preserve the strong emotional bond that makes us human. Most of the time function and appearance get ahead in importance by the designer and the engineer but the experience and emotion are also the most important and crucial part of the design.

A number of wearable technology applications of today, that present an immersive experience has been reviewed to uncouple the changes they bring to the person's lifestyle. The quantifiable data of the self was the prominent input that shaped the future of the user. It incites the user to know more about his body by tracking biological data, habits, places of resort and time of activities. The suggestions that the applications present plays a defining role in shaping the quality of life and altering the lifestyle. The rich output

and smart guidance has immersed the user into the digital world of these devices. Immersive technologies transport the user on a journey with digital representations or computer generated spaces through virtual reality applications. This personal experience can only be achieved with wearable computers that are unique in their own field.

The personal experience of different pioneers in wearable computing field have been probed to found out the pros and cons of this lifestyle. All of the individuals who preferred incorporating wearable technology on 24 hours of their lives are unique and faces with different challenges. A few of the challenges are social acceptance, unwilling monitoring and documenting of the surrounding information(surveillance), financial deficiency on procuring potential desires(appetite) and so on. The return on the contrary was much more than they have imagined. These individuals are substantial roots of the post-human, not only in the sense of technological improvement but on intellectual, ethical, social, and just level. The challenges they face today are not in any importance because new technologies that are unfamiliar to people takes time to adjust. After the people acknowledge the facts, they adopt technology faster than anticipated.

Technology plays a defining role for the future of humanity and in shaping of the post-human concept. Embedded wearable technology that is implanted in the body cannot be removed unless a surgical intervention. Implanting

one's self with technology requires permanency rather than carrying around technology that you can detach anytime you want. The enhancement of human kind will be a reality faster by establishing more familiar experiences and interaction for the user. The future existence of humans depends on the choices that will be made by all of humanity and without having a metamorphosis, a symbiosis with the machine looks indistinguishable.

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