Health Care 360°

Real time vital human medical activities monitoring, activity status, prediction, anomaly detection, diagnose/decision support & value added features via wearable health devices using the techniques of artificial intelligence, cloud computing, IoT & aligned technologies.

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Certificate of Approval

We approve the project proposal of Raja Ahmed Sajjad, Syeda Fatima Ashoor and Ashley Alex Jacob titled "Health Care 360°" submitted to Department of Computer Systems Engineering, UET Peshawar in partial fulfillment of requirement for the degree of B.Sc. (CSE).

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Introduction

In our project, we are going to develop a minimal viable health care product which can be used as per patient's feasibility. We will be using wearable sensors to grab data of vital human organ activities more inclined towards the complete blood picture details. Blood being a vital entity of human body tells about all the nuances of human body health status. So, by taregting blood as a bio marker we will be going to aim for a number of diseases. The data from wearable sesnors gets stored in real time on cloud, from where we will be implementing the techniques of artificial intelligence including machine learning, deep learning & computer vision to assess the biomarker values as per standards. Once we get the results we are good to show them in our end-nodes a mobile application & a web app. We will be going to make this a complete reliable product by implementing other aligned features right into it's core inorder to leverage it's productivity.

Abstract

Wearable Health Devices (WHDs) are increasingly helping people to better monitor their health status both at an activity/fitness level for self-health tracking and at a medical level providing more data to clinicians with a potential for earlier diagnostic and guidance of treatment. The technology revolution in the miniaturization of electronic devices is enabling to design more reliable and adaptable wearables, contributing for a world-wide change in the health monitoring approach. In this paper we review important aspects in the WHDs area, listing the state-of-the-art of wearable vital signs sensing technologies plus their system architectures and specifications. A focus on vital signs acquired by WHDs is made: first a discussion about the most important vital signs for health assessment using WHDs is presented and then for each vital sign a description is made concerning its origin and effect on heath, monitoring needs, acquisition methods and WHDs and recent scientific developments on the area (electrocardiogram, heart rate, blood pressure, respiration rate, blood oxygen saturation, blood glucose, skin perspiration, capnography, body temperature, motion evaluation, cardiac implantable devices and ambient parameters). A general WHDs system architecture is presented based on the state-of-the-art. After a global review of WHDs, we zoom in into cardiovascular WHDs, analysing commercial devices and their applicability versus quality, extending this subject to smart t-shirts for medical purposes.

Keywords:

Healthcare, Biomarker, Cloud, AI, Wearable health devices, Vital signs, Wearable systems, Health, Clinical, Medicine

Problem Statement:

We all know that medical and health services are at the pinnacle of success. But even though health is the foremost concern, having an enormous stream of funding resources, digitization and modernization in practice but still there’s a room for improvement in this regard because medical and health services are the basic needs as well as the medical sector includes a wide aspect of departments due to which it is not as easy to overcome the problems related to health care.

1- Inclincation towards less invasive techinques in health care
2- Portability & feasibility in health care
3- Economical solution targeting the under-previliged
4- Distance between patient and medical expert/physician/Doctors
5- Lack of proper digital apparatus and services
6- Lack of Proper health care check-ups & monitoring of vital organ activities

Vital Signs—Most Important to be Monitored

1- Body Temperature
2- Blood Pressure
3- Blood Glucose Levels
4- Heart Rate
5- Respiration Rate
6- Oxygen saturation
7- Electrocardiogram
8- Skin Perspiration

Other Physiological Parameters

Motion Evaluation

Ambiance Parameters

WHDs Survey topics and restrictions.

Main Topic	Years Gaps	Purpose *	Vital Signs Words *
Wearable Device	2010–2013; 2014–2017	"Medical", "Activity"	"Body Temperature", "Blood Pressure", "Respiration", "Glucose", "Heart Rate", "oxygen saturation", "Electrocardiogram"

The human body has multiple different physiological signs that can be measured: from electrical signs to biochemical, human biosignals are possible to be extracted and be used to better understand the bodily health status and reaction to external factors. Before understanding how the signs are produced and how they can be acquired using wearable sensors and devices, it is of major importance to understand the main biosignals that contributes for a better human body health analysis. Nowadays technology and wearable scenarios let us to classify WHDs according to three aspects scenario of use (home/remote or clinical environment); the type of monitoring (offline or online); and the type of user (healthy or patient).

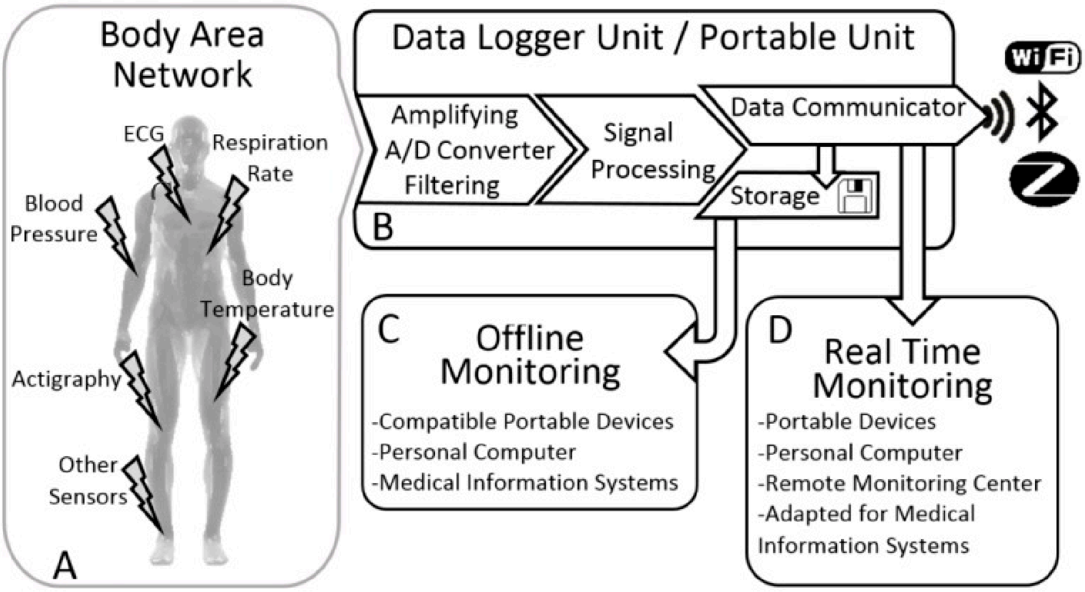
Regarding this classification, it is possible to divide WHDs in two main areas, activity monitoring area (1) and the medical area (2) that is divided in three main sub-categories.

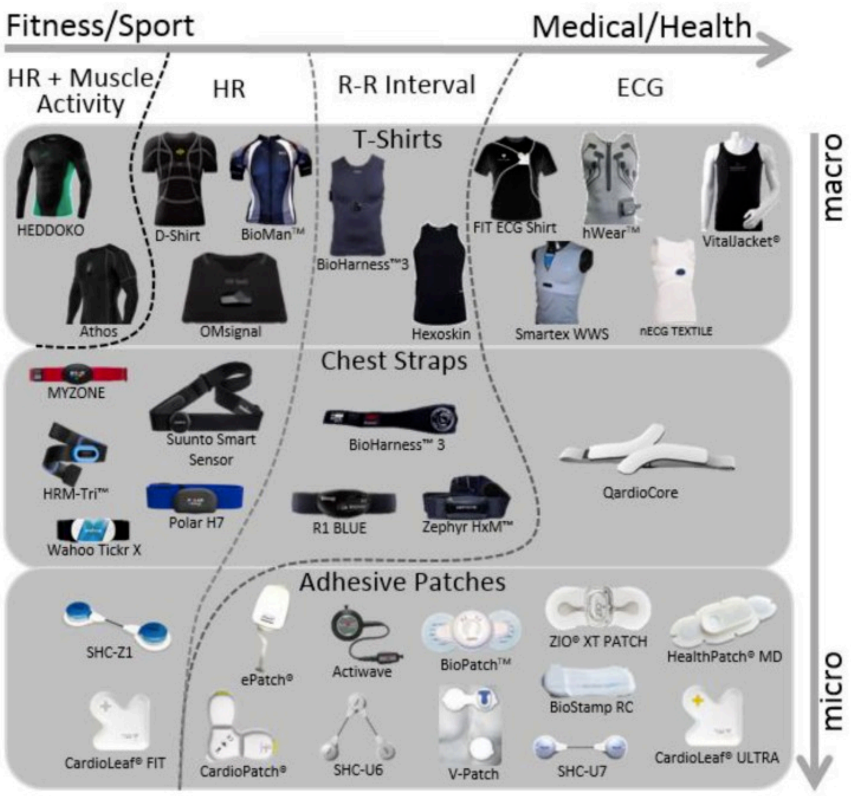
(1) **Activity area**—where fitness/wellness and non-medical applications, self-monitoring and rehabilitation procedures are included.

(2) **Prediction**—consists in the identification of events that have not occurred yet, providing medical information to help in the prevention of further chronic problems, and sometimes, can support a diagnosis decision [11];

(3) **Anomaly Detection**—responsible for the identification of unusual patterns that are not conformed to the expected behaviour, based on classification

methods to distinguish normal data from outlier data. Alarm is a subtask mainly used in anomalies detection, raising an alarm as soon as an anomaly is detected. (4) **Diagnosis Support**—is one of the most important tasks of clinical monitoring, resulting in a clinical decision according to retrieved knowledge of vital signs, health records and anomaly detection data.





Industry Standardized measuring tools:

Table 7

Summary table for all reviewed fitness wristband monitors

Product name	Type	Heart rate (Vital signs)	ECG	O_2 saturation	Blood pressure	Respiration rate	Temperature	White papers (Evidence)	Registry (Trials in progress)	Protocols (Peer reviewed publications)	Validation/reliability	Patient perspectives
Helo Lx	Wristband: fitness tracker	✓		✓	✓	✓						
FitBit	Wristband: fitness tracker	✓							✓ 27 28 31–41 56–64		✓ 65–76	
Apple Watch	Wristband: fitness tracker	✓							✓ 82 83		✓ 65 73 74 84–88	
Garmin Vivofit	Wristband: fitness tracker	✓							✓ 29			
Garmin	Wristband:	✓							✓			

You can check a complete list of all the devices & sensors here:

https://innovations.bmj.com/content/6/2/55

Literature Review:

Most wearable technologies are still in their prototype stages. Issues such as user acceptance, security, ethics, and big data concerns in wearable technology still need to be addressed to enhance the usability and functions of these devices for practical use.

Motivation of the Project

“If you have life, you have the world”. So, under the light of this great saying, the most valuable and primary thing in this world is life. Medical and health services have always been a top priority of science and technology. The advent of technology has leveraged the medical sector. A few centuries ago, obsolete criteria of diagnosing were in practice and herbal plants were prescribed as medicinal doses. In the past few decades, the advancements and digitization in health care services have brought a drastic change in the lives of patients and medical experts. The evolution of mobile technologies and smart devices in the arena of health care has greatly impacted the obsolete ways of diagnosis and treatment. Health experts are taking advantage of the wonders of these cutting edge technologies, thus flourishing digitization in clinical, hospital and pharmaceutical industries. Likewise, millions of people use M-Health (Mobile Health) applications and E-Health (health care supported by ICT) daily for routine medical check-ups and to keep a track of their health. Internet of Things (IoT) has enabled almost every digital device to be able to get connected to the internet, which in terms of health care is being used to send real-time data across the internet, hence making it easier for the medical advisors to diagnose and prescribe on a real-time basis. Chronic diseases such as diabetes, cardiac diseases and blood pressure among others, are considered as an economic and social threat to the world. Telemonitoring uses information technology (IT) principles which have been deployed to remotely monitor the health of patients that are located in remote areas or homes in very crucial circumstances so that due to several reasons they are not able to have an appointment at the hospital or medical centres. For that, wearable medical sensors, such as pulse sensor, temperature sensor etc. have been employed to acquire the real-time information from the remotely located patients via the Internet.

Employing of pervasive medical devices and their connectivity with the advanced networks or the Internet created the new horizons for medical treatment. One such example is the use of wireless body area networks (WBANs), in which the dedicated sensors retrieve information such as temperature, heart/pulse rates, and other medical signals, via the connectivity of wireless media including cellular networks. The use of automated health analytics tools like ECG (electrocardiogram) analyzers have enhanced the analysis and track record of the disease. Emerging technologies like Cloud computing has taken telemonitoring and health care systems to the next level. Cloud computing has been playing tremendous roles in the medical field in terms of real-time information monitoring, processing, analysis and storage. Cloud computing is an efficient and scalable solution. Deployment of public cloud services at a hospital or medical centre can enhance the productivity in terms of better diagnosis, treatment, medical records history, analysis and can lead to an improved administration and technology-enabled organization. Using Cloud services information such as health care records etc. can be retrieved from any place 24/7. Peripheral devices like wearable sensor devices, sensor networks, Bluetooth devices, and Wi-Fi module based sensor devices have enabled the treatment of remotely home-resident critical patients. Usually, these dedicated sensors are embedded or attached to specific parts (like chest, finger etc.) of the human body and transmit the data through wired or wireless connections. Telemedicine is an amazing tool which is best suited for remote health care delivery and home care. In last decades, several kinds of research have been conducted for the development of advanced context-aware medical applications, by a combination of computer networks, cellular networks (e.g., 2G, GRPS, and 3G), and wearable sensor networks. Indeed technology has revolutionized medical science with accuracy, efficiency and pace.

Objectives:

a) Eradicate the obsolete ways of diagnosis & monitoring

b) Portable & Feasible solution to health care industry

c) Disruption by being the economical and minimal viable product

Applications/Features:

1- Monitoring of Vital human organs
2- Activity Status
3- Diagnosing
4- Predictions
5- Value Added features like Health Bot

6- Tele-Health
7- Diet Recommendations

Conclusion and future work

Wearable health devices are a recent reality in healthcare and still under development with the aim to be integrate in medical health systems. There are some personal monitoring devices on the market capable to provide instantaneous single-parameter assessment and transmission. But the main value potential of WHDs is to integrate several biosensors, intelligent processing and alerts, to support medical applications, while interacting with health providers, using some of the technology that is not yet available on the market, only in research. The existing devices are highly expensive and work wireless based, technology that is not available everywhere in many countries, such as France where many consumers do not have access to broadband internet as reported in the literature in 2012. This type of data communication leads to another problem: privacy—a problem that concern healthcare, in the prevention of information, leading people to have lower confidence in these devices, resulting in ethical problems. This is one of the main barriers and the suggested solution is to create clear guidelines to providing privacy, confidentiality and proper use of electronic medical information. A way to increase security of these data can pass by the use of personal non-clonable ID biometric technology to secure data, such as fingerprint, iris and ECG waveform. All this effort will allow sharing secure data with a direct impact on societies, such as in China where WHDs may contribute to lower healthcare cost by introducing preventive healthcare strategies, cutting equipment and labour costs, eliminating unnecessary health services.

Gantt Chart:

Work/Schedule Plan	**Month** **Year**	**Month** **Year**	**Month** **Year**	**Month** **Year**	**Month** **Year**	**Month** **Year**
Literature Survey	**Nov 2021**					
Experimental work		**January 2021**				
Sample Testing			**March 2021**			

Observation and calculation of Results				**April 2021**		
Thesis writing					**July 2021**	

References:

1.Wearable Health Devices—Vital Sign Monitoring, Systems and Technologies Duarte Dias 1,* ID and João Paulo Silva Cunha 1,2 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6111409/)

2. Lymberis A.G.L. Wearable health systems: From smart technologies to real applications; Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society; New York, NY, USA. 30 August–3 September 2006; pp. 6789–6792. [PubMed] [Google Scholar]

3. Rita Paradiso G.L., Taccini N. A Wearable Health Care System Based on Knitted Integrated Sensors. *IEEE Trans. Inf. Technol. Biomed.* 2005;**9**:337–344. doi: 10.1109/TITB.2005.854512. [PubMed] [CrossRef] [Google Scholar]

4. Seoane F., Mohino-Herranz I., Ferreira J., Alvarez L., Buendia R., Ayllon D., Llerena C., Gil-Pita R. Wearable biomedical measurement systems for assessment of mental stress of combatants in real time. *Sensors.* 2014;**14**:7120–7141. doi: 10.3390/s140407120. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

5. Yilmaz T., Foster R., Hao Y. Detecting vital signs with wearable wireless sensors. *Sensors.* 2010;**10**:10837–10862. doi: 10.3390/s101210837. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

6. Statista B.I. *Wearable Device Sales Revenue Worldwide from 2016 to 2022 (in Billion U.S.Dollars)* Statista Inc.; New York, NY, USA: 2017. [Google Scholar]

7. Yussuff V., Sanderson R. *The World Market for Wireless Charging in Wearable Technology.* IHS; Englewood, CO, USA: 2014. [Google Scholar]

8. Khan Y., Ostfeld A.E., Lochner C.M., Pierre A., Arias A.C. Monitoring of vital signs with flexible and wearable medical devices. *Adv. Mater.* 2016;**28**:4373–4395. doi: 10.1002/adma.201504366. [PubMed] [CrossRef] [Google Scholar]

9. Majumder S., Mondal T., Deen M.J. Wearable sensors for remote health monitoring. *Sensors.* 2017;**17**:130. doi: 10.3390/s17010130. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

10. Pantelopoulos A., Bourbakis N.G. A Survey on Wearable Sensor-Based Systems for Health Monitoring and Prognosis. *IEEE Trans. Syst. Man Cybern. Part C Appl. Rev.* 2010;**40**:1–12. doi: 10.1109/TSMCC.2009.2032660. [CrossRef] [Google Scholar]

11. Banaee H., Ahmed M.U., Loutfi A. Data mining for wearable sensors in health monitoring systems: A review of recent trends and challenges. *Sensors.* 2013;**13**:17472–17500. doi: 10.3390/s131217472. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

12. Ahrens T. The most important vital signs are not being measured. *Aust. Crit Care.* 2008;**21**:3–5. doi: 10.1016/j.aucc.2007.12.061. [PubMed] [CrossRef] [Google Scholar]

13. Elliott M.C.A. Critical care: The eight vital signs of patient monitoring. *Br. J. Nurs.* 2012;**21**:621–625. doi: 10.12968/bjon.2012.21.10.621. [PubMed] [CrossRef] [Google Scholar]

14. Xu P.J., Zhang H., Tao X.M. Textile-structured electrodes for electrocardiogram. *Text. Prog.* 2008;**40**:183–213. doi: 10.1080/00405160802597479. [CrossRef] [Google Scholar]

15. Chan M., Esteve D., Fourniols J.Y., Escriba C., Campo E. Smart wearable systems: Current status and future challenges. *Artif. Intell. Med.* 2012;**56**:137–156. doi: 10.1016/j.artmed.2012.09.003. [PubMed] [CrossRef] [Google Scholar]

16. Appelboom G., Camacho E., Abraham M.E., Bruce S.S., Dumont E.L., Zacharia B.E., D'Amico R., Slomian J., Reginster J.Y., Bruyere O., et al. Smart wearable body sensors for patient self-assessment and monitoring. *Arch. Public Health.* 2014;**72**:28. doi: 10.1186/2049-3258-72-28. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

17. Saritha C., Sukanya V., Murthy Y.N. ECG Signal Analysis Using Wavelet Transforms. *Bulg. J. Phys.* 2008;**35**:68–77. [Google Scholar]

18. Luo N., Ding J., Zhao N., Leung B.H.K., Poon C.C.Y. Mobile Health: Design of Flexible and Stretchable Electrophysiological Sensors for Wearable Healthcare Systems; Proceedings of the 2014 11th International Conference on Wearable and Implantable Body Sensor Networks; Zurich, Switzerland. 16–19 June 2014; pp. 87–91. [CrossRef] [Google Scholar]

19. Giovangrandi L., Inan O.T., Banerjee D., Kovacs G.T. Preliminary results from BCG and ECG measurements in the heart failure clinic; Proceedings of the 2012 Annual International Conference of the IEEE Engineering in Medicine and Biology Society; San Diego, CA, USA. 28 August–1 September 2012; pp. 3780–3783. [PubMed] [Google Scholar]

20. Syduzzaman M., Patwary S.U., Farhana K., Ahmed S. Smart textiles and nano-technology: A general overview. *J. Text. Sci. Eng.* 2015;**5**:1000181. [Google Scholar]

21. Aleksandrowicz A., Leonhardt S. Wireless and non-contact ECG measurement system—The "Aachen SmartChair" *Acta Polytech.* 2007;**47**:4–5. [Google Scholar]

22. Aarts V., Dellimore K.H., Wijshoff R., Derkx R., Laar J.V.D., Muehlsteff J. Performance of an accelerometer-based pulse presence detection approach compared to a reference sensor; Proceedings of the 14th Annual Body Sensor Networks Conference; Eindhoven, The Netherlands. 9–12 May 2017; pp. 165–168. [Google Scholar]

23. Xiao-Fei T., Yuan-Ting Z., Poon C.C.Y., Bonato P. Wearable Medical Systems for p-Health. *IEEE Rev. Biomed. Eng.* 2008;**1**:62–74. doi: 10.1109/RBME.2008.2008248. [PubMed] [CrossRef] [Google Scholar]

24. Turner J.R., Viera A.J., Shimbo D. Ambulatory blood pressure monitoring in clinical practice: A review. *Am. J. Med.* 2015;**128**:14–20. doi: 10.1016/j.amjmed.2014.07.021. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

25. Puke S., Suzuki T., Nakayama K., Tanaka H., Minami S. Blood pressure estimation from pulse wave velocity measured on the chest; Proceedings of the 2013 35th Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC); Osaka, Japan. 3–7 July 2013; pp. 6107–6110. [PubMed] [Google Scholar]

26. Yu-Pin H., Young D.J. Skin-Coupled Personal Wearable Ambulatory Pulse Wave Velocity Monitoring System Using Microelectromechanical Sensors. *IEEE Sens. J.* 2014;**14**:3490–3497. [Google Scholar]

27. Woo S.H., Choi Y.Y., Kim D.J., Bien F., Kim J.J. Tissue-informative mechanism for wearable non-invasive continuous blood pressure monitoring. *Sci. Rep.* 2014;**4**:6618. doi: 10.1038/srep06618. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

28. Guo L., Berglin L., Wiklund U., Mattila H. Design of a garment-based sensing system for breathing monitoring. *Text. Res. J.* 2012;**83**:499–509. doi: 10.1177/0040517512444336. [CrossRef] [Google Scholar]

29. Gandis G., Mazeika M., Rick Swanson R. CRTT. Respiratory Inductance Plethysmography an Introduction. [(accessed on 5 June 2017)]; Available online: http://www.pro-tech.com/

30. Anmin J., Bin Y., Morren G., Duric H., Aarts R.M. Performance evaluation of a tri-axial accelerometry-based respiration monitoring for ambient assisted living; Proceedings of the Engineering in Medicine and Biology Society; Minneapolis, MN, USA. 3–6 September 2009; pp. 5677–5680. [PubMed] [Google Scholar]