Student name: ***Lala Rukh***

Student number: ***w16042081***

Programme of study title: ***Masters in Computing and Information Technology***

Supervisors: ***Nauman Aslam, David Kirk***

Viva Date: ***N/A till further correspondence (Told by Supervisor to be start of April, but no date was given)***

Word Count: **2998**

Android Application for Healthcare Monitoring Using Shimmer Technology

Lala Rukh KF7028LD7028

Contents

Aim 4
Literature Review – (Background, Motivation and Relevance) 4
Introduction: 4
Related Work: 5
Motivation: 6
Sources and use of Knowledge 7
Scope, Objectives and Risk 8
Scope: 8
SMART Objectives 9
Task List: 11
Risk Log 13
Professional, ethical, social, legal and security issues: 14
Schedule of Activities 15
Gantt chart 15
REFERENCES: 18

Aim

Aim of this project is to develop a mobile healthcare system for patients with coronary heart disease using wireless body area networks.

Literature Review – (Background, Motivation and Relevance)

Introduction:

Healthcare sector in UK faces daunting challenges considering the imbalanced proportion between healthcare practitioners, patients and financial requirements. The world population is fast aging resulting in increased rate of heart disorders. Providing healthcare for cardiovascular diseases is one of the challenges that, according to a report of British heart foundation, cause about 26% of all deaths in UK. Among the cardiovascular diseases, coronary heart disease is the most common type in which coronary arties in the heart narrow down due to buildup of fatty material within their walls. The discomfort felt from this kind of narrowing is called angina and complete blockage results in a heart attack. This disease is responsible for 70,000 deaths in UK and is also the leading cause of death worldwide. Most of the deaths in the patients with coronary heart disease are caused by heart attacks (Townsend, 2014). Thus cardiovascular patients require continuous monitoring and care.

With the advancement in technology, various applications have emerged to improve the quality of healthcare worldwide. Devices with the capabilities of sensing through embedded sensors, actuating, logical computation through tiny computers and communication through ID technology, short-range radio or local Wi-Fi network are termed as ‘smart things’ (Naik and Jenkins, 2016).One of the examples of smart things is wireless body area sensor networks.

WSNs carry the promise of drastically improving the quality of care across a wide variety of settings and for different segments of the population by offering large-scale and cost-effective solutions to the problem (Ko et al., 2010). For instance, WBSNs are extensively being used practically for health and wellness monitoring, safety monitoring, home rehabilitation, assessment of treatment efficacy and early detection of disorders (Patel et al., 2012). The sensor networks scope to outfitting patients with intelligent sensor nodes that can be put inside or around human body and are can detect motion,

heartbeat, body temperature, blood glucose levels, blood pressure, gait, position and ECG etc. With the capability to connect to computing or mobile devices using Bluetooth or WI-FI, sensors aid in remote monitoring of a patient's health status. As the devices consume very less power and are small in size, they are high in demand (Sangwan and Bhattacharya, 2015). Shimmer technology is one of the examples of wireless sensor devices that allow simple and effective biophysical and kinematic data capture in real time for a wide range of applications especially for electronic and mobile health solutions.

Electronic health generally refers to healthcare practices that are assisted by communication systems and electronic processes. Mobile health is defined as "medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices. According to world health organization, the use of mobile and wireless technologies for healthcare has the potential to transform face of health service delivery across the globe (Ryu, 2012). Therefore a healthcare system is proposed in the document that provides continuous monitoring, care and support to cardiovascular patients using mobile health solution.

Related Work:

Extensive amount of research has been going on in the respective field and many mhealthcare systems have been developed. As normal heartbeat detection in an ECG signal requires expert algorithms, many researchers have been working on improving the efficiency of already developed algorithms**.** Pandit et. al., (2016) for instance in their paper work on abnormal beat detection algorithms with improvements on feature extraction. Diverse classifiers are used for abnormality detection and an intelligent approach has been applied towards achieving high success rate. Chin-Teng Lin et al., (2010) and Oresko et al., (2010) on the other hand work towards providing the complete system to monitor patients having cardiac arrhythmia in which heart beats are three times faster than a healthy person. Intelligent algorithms are applied by both researchers to distinguish between different types of beats from the data collected with the help of wireless sensor networks. Although mobile applications to receive and transmit data have been developed in both systems, these are very simple lacking any impressive features that can be in practical use for the patient himself. Key focus is on extracting good results from algorithm testing. Watanabe et al., (2013) however work more towards the application and add certain features to make it user friendly by displaying results in GUI and alerting people around the patient and emergency services in case of emergency. He also notices that since his sensor also includes accelerometer, the data collected may have disturbance if the patient moves constantly. His work however doesn't include any experiments to validate the working of his system. Mamaghanian et al., (2011) contribute towards the research by using

compression techniques on two efficient algorithms, CS and DWT to observe which one works best in case of compressed data. Results in terms of energy consumption measurements and reconstructed data quality were compared. Gradl and Kugler, (2012) proposes a system with the goal of avoiding expert supervision for examining ECG patterns and achieves it with a simple system using pan-Tompkins algorithm. Wang et al., (2010) however develops a system that collects the ECG signals and sends them directly to the physician's office PC from where they get transmitted later on to the hospital database. Although being mature, the approach doesn't seem practical as the doctor would not want every patient's extensive ECG data getting collected into his PC. Key focus in the paper was on security and privacy of data that was achieved using several encryption techniques.

Despite there being extensive research going on in the respective field, not a lot of successful systems have been developed in terms of practical use. A research conducted in US shows that more than half of its consumers who have owned a wearable sensor device do not continue to use it. Thus it may seem that the wearable sensor technology is not only about the sensor itself but about the data and what is done with the data (Justin, 2015). The system proposed here therefore puts emphasis towards the implementation of a system.

The research done for this project aims at evaluating the use of sensors particularly for coronary heart disease patients while examining the ECG graphs and heart beat patterns and making sure they are as useful as the graphs obtained during ECG done in hospitals. As the ECG done in hospitals is obtained for limited time intervals, the graphs obtained through the sensors can be of much more importance in anticipating the happening of an angina attack or judging if it already has happened before patient reached hospital and needs treatment.

The research also intends to evaluate different abnormal beat detection algorithms and use the apparently best ones in experiments done for the project to evaluate its effectiveness towards practical use.

Motivation:

The personal motivation behind my interest in undertaking this work is the emotional factor as my father has got the coronary heart disease. I witnessed his constant struggle in fighting the pain while he was having continuous angina attacks without being aware of that. When he was taken to the hospital, a lot of time was spent taking the ECG readings and comparing them against each other to judge his heart condition while he struggled through the discomfort and pain. He finally got treatment based on the ECG

and other results but his life now follows upon a healthy lifestyle while the risk of heart attack is always there.

In addition to that I have always been fascinated by the idea of working towards the betterment of humanity despite having a computing background, as the work can be rewarding alongside. Also, having worked with android application development using Eclipse and Android SDK during my bachelor's, I feel like I have got the required skillset to point my research towards the development of a working product at the end.

Sources and use of Knowledge

The work proposed in the proposal document is relevant for publication in the journal '***E Health telecommunication systems and networks***'. The journal is international refereed and publishes articles that are based on research in the topics of electronic or mobile health and telecommunication systems and networks, specifically on systems, algorithms, and applications of e-health and medical telecommunications. As the project involves application of wireless sensor networks for the purpose of providing healthcare and involves communication between the mobile and the sensor network, thus the journal seems to be exactly relevant to the work proposed.

The 'E Health telecommunication systems and networks' journal accepts articles on a wide variety of topics although the topics should be relevant to healthcare and telecommunication networks integrated together. The journal expects manuscripts prepared as a single PDF or MS word document and should include title page followed by abstract and three to five keywords. 'Times new roman' font with a 10 font size is required. The journal doesn't mention the name of referencing style it accepts but shows a format to incorporate references from journals, books, conference proceedings, internet and other.

Several articles on the subject of mobile health and wireless body sensor networks have been published in the above mentioned journal. For instance, the article '*Patient Centered Real-Time Mobile Health Monitoring System*' by Yi and Saniie, (2016) describes the development of a healthcare system incorporating different sensors for monitoring ECG and fall detection in case of unanticipated happenings.

Another journal named as '*International Journal of Distributed Sensor Networks'* also publishes articles related to applications of WBSNs for healthcare systems. One of the articles published in this journal '*Wireless Body Area Networks for Healthcare Applications: Protocol Stack Review*' by Filipe et al., (2015) explains the same topic although with respect to protocols, technologies, bandwidth and security mechanisms and issues during the implementation of wireless sensor networks for healthcare. The

article discusses architecture of communication and transmission from sensors to mobile systems and the protocols involved in the layers embedded in the architecture.

Scope, Objectives and Risk

Scope:

The work intends to give a complete practical system to the cardiac patients where Shimmer sensor will be attached to the body of the patient that collects heart rate and ECG data from the patient continuously. The data is then transmitted to a smart phone with the help of Bluetooth present in the sensor. The android application running on the phone collects all the data and generates user friendly reports out of the ECG graphs to show what the heart rate and heart condition of the patient is at that time. The application will have an expert system based on algorithms running in the background that will check the real time ECG data for any abnormal behavior of heartbeats. When abnormal beats are identified, two things happen simultaneously: a) alert messages are sent to the patient's phone as well as to the other people around him, and ECG data is sent to the patient's GP for him to examine and respond back, b) the voice recognition software in the patient's phone turns on automatically. If the patient says coded words as 'help' or 'emergency', that would imply his pain in event of angina or a heart attack about to happen or already happened. Thus the voice recognition system gets connected to the android application and the application automatically calls emergency services providing them with the GPS coordinates and address of the patient. This way the delay in calling emergency services in case of patient being alone or other circumstances can be avoided, as every second during a heart attack is crucially precious. The mobile application will be synchronized with a cloud platform so that all the data gets collected there. The GP can access that ECG data anytime to checkup on the patient's present condition any give him advice without actually seeing him.

The system implements the use of one ECG sensor for the purpose. However, several sensors can be combined later on for the next projects to improve the monitoring experience and to make it more effective for practical use. For example blood glucose monitoring sensors can be used alongside ECG sensor to monitor diabetes in coronary heart disease patients as very high or low sugar levels can prove to be critical for the patients. Also, sensors to check blood pressure of patients after specific intervals will also help reducing the risk of anticipated heart attack.

SMART Objectives

I. Read about work done on communication strategies between wireless sensor networks and mobile system in healthcare and their applications.

Deliverable: Literature review.

The literature review obtained after the thorough research would cover the work that is done already in the field and is exactly applicable to the proposed project. Thus it would be precise and relevant. Qualitative research method will be used for this objective and it will aid in gathering requirements for the experiment design.

II. Understand detailed structure and working of intelligent ECG data collection and abnormal behavior detection algorithms

Deliverable: Requirements for experiments.

The requirements obtained will determine the exact procedure needed to be adapted during the experiments. Requirements will help in experiment design.

III. Select two algorithm approaches to use for testing the system

Deliverable: Selected algorithms for experiments.

The objective determines the choice of algorithms to implement in the experiments that will aid in understanding the in depth techniques for beat detection and differentiation.

IV. Draw system diagrams using Unified modeling language.

Deliverable: Logical view of system

The diagrams give a clear view of the undergoing process and working of the whole system and establish a base for the design of expert system. Quality of this deliverable will be validated after the actual design and testing.

V. Convert and code algorithms into an expert system

Deliverable: Android application with an expert system

The application design and built at this stage will consist of the backend working to check if the sensor data gets synchronized with the coded application. Programming languages will be learnt and applied. The deliverable will aid in carrying out the experiments.

VI. Analyze requirements gathered for carrying out experiments

Deliverable: Definition of experimental variables

Study of experimental requirements will help in deciding dependent and independent variables that will in turn help in experiment design process.

VII. Formulate the experiment process

Deliverable: Experiments design

Already recorded ECG data will be used at this stage and experiment objects will be setup.

VIII. Carry out experiments

Deliverable: Experiments implementation

Data will be transmitted to the expert system to check its working in differing circumstances. The results obtained will help in comparison and determination of the better algorithm to implement. Qualitative method of observation is adapted.

IX. Analyze, contrast and compare the outcomes

Deliverable: Results

The results will determine the success rate of one of the algorithms that will be used in the final design and implementation of the application.

X. Design the Graphical user interface of application.

Deliverable: Application GUI

Application will be coded in Eclipse IDE with JAVA programming using android SDK. Relevant skills will be learnt and practiced. Rest of the features will be integrated in the GUI.

XI. Code all the interactive features in the application.

Deliverable: Build of product

Features and permissions to access GPS and voice recognition software etc. will be integrated in the coding. The resulting application will be complete along with the expert system running behind it.

XII. Synchronize the built application with a cloud platform.

Deliverable: Implementation

Android application will communicate with the cloud platform to send extensive amount of data to store and retrieve for later use.

XIII. Test the working of the whole system.

Deliverable: Results

Whole system with all the working processes will be tested and results will be noted. Smooth communication between all the processes and data collection and detection will determine the quality of product developed.

Task List:

Task Title	Deliverable	Resources	skills	Time	Risk	Costs
Literature Review	Chapter in Project report	Library, Internet	Reading, Understanding High level Writing, Critical Analysis skills.	2 weeks	Procrastination, Unplanned circumstances, Copyright protection, Referencing check	Printing paper
Requirement Gathering	Requirement specification	Literature review outcomes, Data collected, Internet	Reading, understanding, judgment, High level writing.	1 week	Data not enough, irrelevance of lit review, management	Travelling - bus pass
Requirement Analysis	Base for design, selected algorithms	Gathered requirements, vision and scope of project	Analysis skills, understanding, intelligence, prioritizing.	1 week	Requirements irrelevant or incomprehensive, algorithms not understood	Travelling - bus pass
Logical Design	Diagrams for detailed overview of algorithm working	PC, Visio 2016 software, other design tools	UML Diagraming concepts, logic development, process identificatio	2 weeks	Wrong design, can't form logic, repetitive iterations	Software purchase

			n			
Coding	Expert system based on logical view	Eclipse software, Android development toolkit	JAVA programming, Eclipse, Android SDK	1 month	Errors in code, wrong logics, debugging	Software purchase
Experimental Requirements	Experiment variables	Data collected, algorithms	Sensor handling information	1 week	Not enough requirements, non-identifiable variables	Travelling
Experiments Design	Experiment setup	PC, Conceptual design software, wireless connection, communication	Logical thinking, conceptual design, establishing communication	1 week	Unable to understand requirements, factors for designing	Environment setup costs
Implementation	Results	Experimental environment, ECG sensor, heartbeat database, expert system	Monitoring, analyzing, observation	1 week	Environment not available, sensor not available, database not available, unable to synchronize, no communication established, errors	Sensor costs
Results Collection	Result records	Computer software (MATLAB)	Graph reading, analogue to digital data conversion	1 week	Disturbance in graphs, noise in recording, low percentage results	Software

Results Analysis	Evaluation	Scope of project, aim, results collected	Data analysis techniques, Observation, justification	1 week	Unable to compare and contrast	Nil
Product Design	GUI	Android tools	JAVA programming,	2 weeks	Errors in codes, debugging	Software
Product Build	Programmed application	Eclipse software, Android tools	JAVA programming, Eclipse IDE, Android SDK	1 month	Software crash, errors in codes, debugging	Software
Product Implementation	Cloud synchronized application	Cloud platform, Database software	Database design and querying	1 week	Not able to sync cloud, cloud platform not available	Cloud platform costs
Testing	Overall results	System developed	Operating developed system	1 week	System stops working, un expected results, data lost	Nil

Risk Log

Risk Type	Risk Event	Likelihood (1-10)	Impact (1-10)	Risk Value (1-100)	Risk Monitoring Flag	Risk Management Strategy
E	Unplanned Circumstances	8	5	49	Maybe Acceptable	Flexible time frames.
T	Errors while coding in programming language	9	8	70	Risk High	Continuous Debugging, Research

T	Software Failure	4	5	49	Maybe Acceptable	New Software
P,E,F	Sensor unavailable	5	9	80	Risk very high	Not decided
T	Expert system doesn't work	6	8	70	Risk High	Debugging
T,S	Data lost	2	8	50	Risk High	Backup data
T	System Crash	2	9	50	Risk High	Online Backup

Professional, ethical, social, legal and security issues:

Medical advances integrated with technological elevation are contributing a valuable share towards human lifestyle improvement and convenience. With the unlimited advantages comes the ultimate need to address professional, legal, ethical and social issues that could possibly disturb the flow of prosperity towards mankind.

The proposed project includes m-health product integrated with wireless monitoring devices that interact directly with the patient to collect sensitive medical and health data about the patient. These calls for the data protection and confidentiality law to be considered which also include privacy and security issues in turn. The communications and networks thus need to be secured properly after the implementation of system in order to cater for patient's privacy protection (Kelly, 2011) that if not looked after can give rise to identity theft, blackmail and cybercrime (Jamshed et al., 2015) etc. Security of the system being developed is a crucial element given that unauthorized access of patient's medical and personal data could give rise to serious legal issues. Therefore, the patient's medical health records, ECG and heart beat data and graphs and other health information sent electronically through phone over the internet therefore requires following proper rules and regulations.

The stakeholders involved in the project will have the right to access any information involved in the project (Kelly, 2011). If qualitative methods of surveys etc. are adapted at the testing stage to get reviews, the data protection and disclosure of necessary information beforehand becomes applicable. The real names of the participants will need not to be disclosed.

Ethical and legal issues require the work of other authors and researchers used while doing the research on wireless communications and algorithms developed by respective researchers will need to be properly referenced under the copyright law. In some cases,

permission will need to be requested (e.g from the owners of the algorithms) that in turn ensures a professional behavior (Luo, 2016). Serious professional issues may arise if the researcher fails to follow the above mentioned laws as there can be legal implications. Professional behavior from the researcher would require honesty, politeness and good communication skills while interacting with the stakeholders involved (BCS - The Chartered Institute for IT, 2015).

Social issues do not seem to be arising as long as the proposed system does not go into the actual commercial phase as it does not involve big human factor during the development phase.

Schedule of Activities

Gantt chart

Task name	Start date	Duration hour	Progress
Total estimate	*02/04/2018*	*3097.00*	
Android Application	02/04/2018	3097.00	0%
Analysis	02/04/2018	505.00	0%
Literature Review	02/04/2018	97.00	0%
Requirement Gatheri	16/04/2018	1.00	0%
Requirements Analys	23/04/2018	1.00	0%
+ Add a task + Add a milestone			
Design	30/04/2018	2257.00	0%
Logical Design	30/04/2018	1.00	0%
Coding	14/05/2018	1.00	0%
Experimental Require	14/06/2018	1.00	0%
Experiments Design	21/06/2018	1.00	0%
Implementation	28/06/2018	1.00	0%
Results Collection	05/07/2018	1.00	0%
Results Analysis	12/07/2018	1.00	0%
Product Design	19/07/2018	1.00	0%

Fig 1

Implementation	02/08/2018	169.00	0%
Product Implementati	02/08/2018	1.00	0%
Testing	09/08/2018	1.00	0%
+ Add a task + Add a milestone			
+ Add a task + Add a milestone			
+ Add a new project			

Fig 2

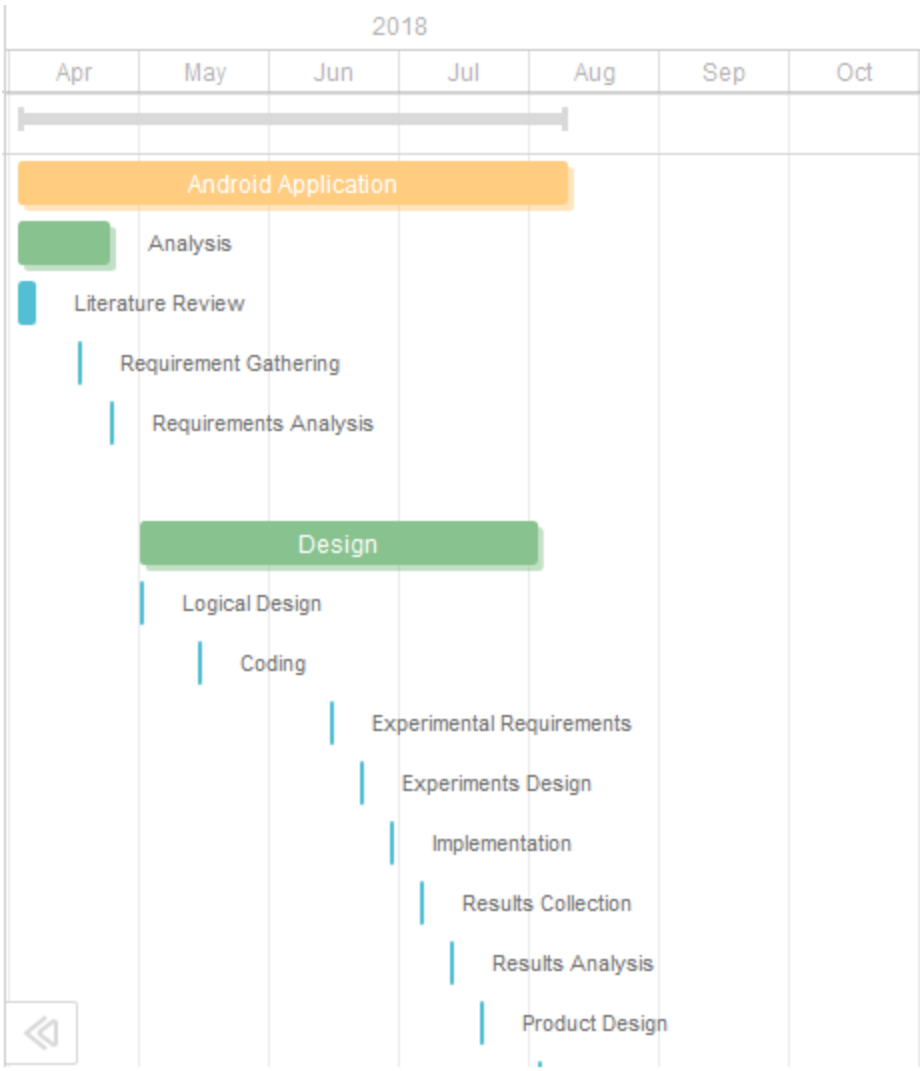
2018
Apr
May
Jun
Jul
Aug
Sep
Oct
Android Application
Analysis
Literature Review
Requirement Gathering
Requirements Analysis
Design
Logical Design
Coding
Experimental Requirements
Experiments Design
Implementation
Results Collection
Results Analysis
Product Design

Fig 3

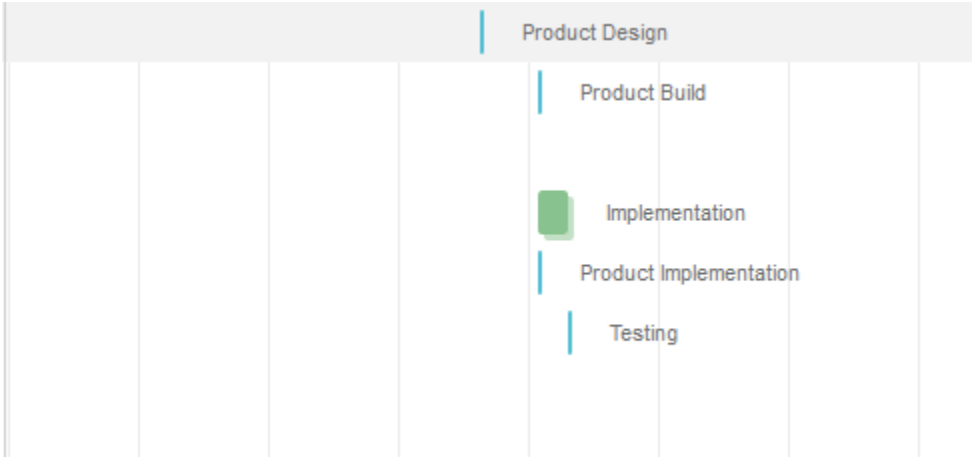
Product Design
Product Build
Implementation
Product Implementation
Testing

Fig 4

REFERENCES:

BCS - The Chartered Institute for IT (2015) *Bcs.org*. Available at: http://www.bcs.org/BCS/AboutBCS/codes/conduct (Accessed: 24 March 2017).

Chin-Teng Lin, Kuan-Cheng Chang, Chun-Ling Lin, Chia-Cheng Chiang, Shao-Wei Lu, Shih-Sheng Chang, Bor-Shyh Lin, Hsin-Yueh Liang, Ray-Jade Chen, Yuan-Teh Lee, and Li-Wei Ko, (2010) "An Intelligent Telecardiology System Using a Wearable and Wireless ECG to Detect Atrial Fibrillation", *IEEE Transactions on Information Technology in Biomedicine*, 14(3), pp. 726-733. doi: 10.1109/titb.2010.2047401.

Filipe, L., Fdez-Riverola, F., Costa, N. and Pereira, A. (2015) "Wireless Body Area Networks for Healthcare Applications: Protocol Stack Review", *International Journal of Distributed Sensor Networks*, 2015, pp. 1-23. doi: 10.1155/2015/213705.

FirstAppWhy not use wearable tech in clinical trials? - FirstApp (2015) *Firstapp.com*. Available at: http://www.firstapp.com/blog/why-not-use-wearable-tech-in-clinical-trials/ (Accessed: 24 March 2017).

Jamshed, N., Ozair, F., Sharma, A. and Aggarwal, P. (2015) "Ethical issues in electronic health records: A general overview", *Perspectives in Clinical Research*, 6(2), p. 73. doi: 10.4103/2229-3485.153997.

Kelly, B. (2011) *E-health: ethical and data privacy challenges in the Eu*. 1st ed. Informa UK Ltd, pp. 27-28. Available at: https://www.cov.com/~/media/files/corporate/publications/2011/04/e-health---ethical-and-data-privacy-challenges-in-the-eu.pdf (Accessed: 24 March 2017).

Ko, J., Lu, C., Srivastava, M., Stankovic, J., Terzis, A. and Welsh, M. (2010) "Wireless Sensor Networks for Healthcare", *Proceedings of the IEEE*, 98(11).

Luo, L. (2016) "For Your Enrichment: Ethical Issues in Reference: An In-Depth View from the Librarians' Perspective", *Reference & User Services Quarterly*, 55(3), p. 188. doi: 10.5860/rusq.55n3.188.

Mamaghanian, H., Khaled, N., Atienza, D. and Vandergheynst, P. (2011) "Compressed Sensing for Real-Time Energy-Efficient ECG Compression on Wireless Body Sensor Nodes", *IEEE Transactions on Biomedical Engineering*, 58(9), pp. 2456-2466. doi: 10.1109/tbme.2011.2156795.

Naik, N. and Jenkins, P. (2016) "Web Protocols and Challenges of Web Latency in the Web of Things", *IEEE Conference Publications*, pp. 845-850.

Oresko, J., Zhanpeng Jin, Jun Cheng, Shimeng Huang, Yuwen Sun, Duschl, H. and Cheng, A. (2010) "A Wearable Smartphone-Based Platform for Real-Time Cardiovascular Disease Detection Via Electrocardiogram Processing", *IEEE Transactions on Information Technology in Biomedicine*, 14(3), pp. 734-740. doi: 10.1109/titb.2010.2047865.

Patel, S., Park, H., Bonato, P., Chan, L. and Rodgers, M. (2012) "A review of wearable sensors and systems with application in rehabilitation", *Journal of NeuroEngineering and Rehabilitation*, 9(1), p. 21. doi: 10.1186/1743-0003-9-21.

Pandit, D., Zhang, L., Aslam, N., Liu, C. and Chattopadhyay, S., 2016, August. Improved abnormality detection from raw ECG signals using feature enhancement. In *Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD), 2016 12th International Conference on* (pp. 1402-1406). IEEE.

Ryu, S. (2012) "Book Review: mHealth: New Horizons for Health through Mobile Technologies: Based on the Findings of the Second Global Survey on eHealth (Global Observatory for eHealth Series, Volume 3)", *Healthcare Informatics Research*, 18(3), p. 231. doi: 10.4258/hir.2012.18.3.231.

Sangwan, A. and Bhattacharya, P. (2015) "Wireless Body Sensor Networks: A Review", *International Journal of Hybrid Information Technology*, 8(9), pp. 105-120.

Gradl, S. and Kugler, P. (2012) "Real-time ECG monitoring and arrhythmia detection using Android-based mobile devices", in 34th Annual International Conference of the IEEE EMBS.

Townsend, N. (2014) *Cardiovascular disease statistics, 2014*. 1st ed. London: British Heart Foundation.

Wang, H., Peng, D., Wang, W., Sharif, H., Chen, H. and Khoynezhad, A. (2010) "Resource-aware secure ECG healthcare monitoring through body sensor networks", *IEEE Wireless Communications*, 17(1), pp. 12-19. doi: 10.1109/mwc.2010.5416345.

Watanabe, H., Kawarasaki, M., Sato, A. and Yoshida, K. (2013) "Wearable ECG Monitoring and Alerting System Associated with Smartphone:", *International Journal of E-Health and Medical Communications*, 4(4), pp. 1-15. doi: 10.4018/ijehmc.2013100101.

Yi, W. and Saniie, J. (2016) "Patient Centered Real-Time Mobile Health Monitoring System", *E-Health Telecommunication Systems and Networks*, 05(04), pp. 75-94. doi: 10.4236/etsn.2016.54007.