USING THE INTERNET OF THINGS IN PERSONAL HEALTH

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Abstract: With the increase in development of technology and with the evolution of the Internet, a wide network was created, which is composed of devices with different sizes and multiple functions, known as Internet of Things (IoT). Internet of Things has found high usability in different industry sectors, like:military sector, aerial, educational, medical and in many other sectors. It had a great influence in the medical sector, by making the process of monitoring medical data easier, medication management, diagnosis of diseases, saving and better analysis of the data, and reducing patients expenses. These monitoring devices like smartphones, smartwatches, glucose and oxygen monitors, have applications that collect patient data in real time, afterwards the data is shown to the users. They use different sensors to monitor metrics like heartbeats, quality and longevity of sleep, burned calories and many more. The potential for future development of Internet of Things in the personal health aspect is really high, also including here mental health which will be discussed in this thesis.

Keywords: Internet of Things, Electronic Health, Electrocardiogram, Internet of Body, etc.

1. INTRODUCTION

The head of the DARPA agency, J.C.R. Licklider envisioned a global network in which all computers are interconnected. With the development of this concept, ARPANET was created as a result in 1969. Then, from 1980 it began to be used by the public. In the early 1980s, David Nichols, a student from Carnegie Mellon University, created what is considered to be the first IoT device. He, together with some of his colleagues, worked in a Coca-Cola machine, where the inventory and temperature of the drinks were constantly displayed. [1] While in 1991, John Romkey and Simon Hackett created the Internet Toaster. This toaster was connected to the Internet through TCP/IP protocols. It only had the turn on functionality and the darkness of the toast depended on how long the toaster was on. [2] Until recently, the Internet of Things was not considered a single technology, but rather as a collection of experiments. However, this changed in 1999, when Kevin Ashton coined the term "Internet of Things". [3]

2. LITERATURE REVIEW

2.1 Internet of Medical Things

Medical devices and equipment that are connected to each other through computer networks represent the Internet of Medical Things. IoMT has many use cases, some of them are: hospital monitoring of patients with chronic diseases, tracking the location of patients admitted to the hospital, collecting personal data from smartwatches and many other uses. The devices are then connected to the cloud platform where the extracted data will be stored. Through IoMT, the amount of data that can be monitored by users has increased. [4]

2.2 The impact of the Internet of Medical Things

With the development of the Internet of Things, there was also a revolution in healthcare. Some of the changes that flow as a result of this development are:the increase in the accuracy of data, patient care, development of the work environment and the facilitation of the work for medical personnel. This is how many categories were created, such as:

2.2.1 Internet of Things for Patients - The amount of information needed by patients for follow-up of the disease by doctors depends on the disease. For example, patients who have chronic diseases such as diabetes, hypertension, cardiopathy, these diseases need for more information to be monitored so the management or prevention of deterioration of the condition can happen. Therefore, monitoring devices such as smartphones and smartwatches were created to wirelessly monitor their health.

2.2.2 Internet of Things for Medical Staff - Authorized medical personnel have access to where their patient data is stored. In this way, they can monitor the health of the patients, analyze the data and then give the correct diagnosis based on the analysis done.

2.2.3 Internet of Things for Healthcare Providers - In order to make asset management more effective, various medical devices such as oxygen pumps, defibrillators, and other devices are equipped with sensors.

2.2.4 Internet of Things for Health Insurance Providers - Medical insurance companies make it possible for patients to recover by paying for their expenses at health facilities. However, there are many people who want to trick these companies. The implementation of the Internet of Things has made the work of the companies easier, as there is now continuous monitoring of data, which reduces the opportunities for fraud. [5]

2.3 IoMT Advantages

The Internet of Medical Things opened many doors for significant changes in patient care. Globally renowned company Goldman Sachs has reported that medical organizations save $300 billion a year by implementing remote patient monitoring. Another benefit that came from the integration of monitoring devices and applications is the reduction of human error that can be created by medical personnel. [6]

I. Improving patient care

More sources of information - With the creation of numerous technologies, medical personnel are now provided with a wealth of patient data. One of the examples of these technologies that are worth mentioning are smart tablets. These tablets contain nanosensors, through which it can be known whether or not the patient has consumed the necessary medications.

Early intervention - Using wearable monitoring devices such as fitness bands and smart watches by patients, doctors will be informed about changes in patients' condition and the appearance of worsening symptoms of the disease. This allows doctors to quickly notice diseases and allows them to intervene early before the disease progresses to more difficult stages.

II. Cost reduction for patients

Remote monitoring and eHealth - The medical staff has access to the patients' medical data, which are continuously obtained from the monitoring devices in real time. When there are negative changes in these data, there is a worsening of the patient's condition, then the appropriate doctors are immediately notified. However, if there is no significant difference, the patient does not need to travel and spend unnecessarily.

High operational efficiency - In addition to monitoring and storing patients' medical data, the Internet of Medical Things also offers the storing of other information. It can be used to present the medical personnel found in a health institution, the medical equipment that the institution possesses as well as its infrastructure, i.e. where the wards are located and how they are divided. The presentation of this information increases the efficiency of the work and the allocation of medical resources according to the place where they are needed the most.

III. Improving patient experience

Flexible treatment plan - By using apps and monitoring devices to send monitored information to doctors, patients are given access to the right healthcare regardless of their location.

Easy to implement and use - The Internet of Medical Things devices and monitoring applications are designed to be very easy to use, so they can be used by people of all ages, but there are exceptions. Transmitting data to the right sources is also not complicated. Using artificial intelligence, monitored information is presented to patients in ways that are most understandable to them.

IV. Reduction of work for medical staff

Rarer visists - Due to continuous data monitoring, doctors are aware of their patients' condition by accessing their data. This eliminated unnecessary visits, which saved medical staff time as well as reduced patient costs.

Easier access to data - Authorized doctors have access to all patient data using electronic devices, such as tablets, after they have been stored in the right place by nurses or medical devices. [7]

2.4 IoMT Disadvantages

2.4.1 Data Security - Protecting user data from unauthorized access is one of the biggest concerns presented. Collected information such as name, location, gender, blood pressure, pulse goes through computer networks. This causes worry from patients, as they are not sure what will happen with this data. Their data is stored in the cloud, which is constantly under attack by people who want unauthorized access to steal information.

2.4.2 Battery lifetime - In order for electronic devices to work, they need electricity. Portable devices such as phones and watches rely on their batteries to function. The most commonly used batteries are lithium-ion batteries, which found use in laptops and other portable devices. The longer the battery lasts, so will the device. As technology develops, the battery can now operate under a safe circuit. This enables the battery to continuously output stable current.

2.4.3 Processing power - Previously, medical records were stored in paper form, so they accumulated a lot over time and caused a mess. Whereas, nowadays the data is stored in digital form in the cloud. In order to predict the disease, in addition to the general data collected, the physical indicators as well as the present symptoms should also be recorded. However, there are cases when not all symptoms will appear and this makes the doctor's work difficult for the proper diagnosis of the patient. Ali cloud software company has provided medical assistance, offering the classification of diseases using images stored in the cloud. They did this by analyzing the images in the cloud, and see if there is any shadow in the cloud which symbolizes the disease. This method is 92% accurate. 92% is a pretty high number in terms of health, but not enough. Diagnostic accuracy should be higher, where 100% accuracy is preferred.

2.4.5 Monitoring responsibility - As medical practices develop, sometimes disagreements can arise between patients and medical staff. Before the digital system was developed, in the traditional system, when an error occurred or a dispute arose, all medical personnel including doctors and nurses who were involved in the case would be contacted by the patient's health insurance company and the relevant attorney. However, now with the integration of IoMT, the procedure has changed. If a patient is using a monitoring device prescribed by his/her doctor, the data obtained from the device will be stored in the platform 1. Then, the collected data will be analyzed by the appropriate group 2, which are members of a certain medical company 3. If a disease has appeared in the patient, but the data collected by the monitoring equipment does not present the proper signs that the disease has appeared, then the doctor cannot notice it and thus problems appear. When it comes to compensating the patient for the risk created to his health, it is not known from whom to ask for it.

2.4.6 Difficulty of use for older people - The use of technology has created a love-hate relationship among the elderly. They like the portability that these devices offer, but they don't like when their functions are complicated. Devices like phones and smart watches are very important for data collection. However, due to the complexity of activating some applications, they decide not to monitor their health at all. Therefore, when designing monitoring devices and applications, it is preferable that they be as simple as possible for use by all ages. Some devices are very difficult to operate, such as ECG monitors which have a large number of buttons. Thus, they are forced to seek the help of other people. [8]

2.5 The application of IoMT

Internet of Body - Using the human body, health or physical data is collected. The devices receive the data and transmit it between IoT networks to the places where it will be stored. The collected data is analyzed, and then the results are sent to the users. IoB has found multiple implementations in the human body. Examples of implementation are: biometric verifications, artificial organs, smart capsules and various implants. This concept includes almost any technology that can be implemented on the body or worn.

Wristbands - They include the most advanced medical Internet of Things technology group, ranging from smartwatches to fitness trackers. In addition to the many medical uses, these devices can also be used for other functions to check the time, weather, messages, etc. The bands monitor various metrics such as heart rate, breathing, oxygen content, body temperature, but can also be used for monitoring the user's emotional state.

Hearing aids – To make life easier for people with hearing problems, hearing aids have integrated the latest technology. Various systems were created, such as the Whisper system, which is one of the most popular systems in the IoMT. This system combined artificial intelligence along with the latest developments in IoT to improve the listening experience for their customers. The system is constantly improving by learning from the situations and problems it has solved before.

Glucose Monitoring – Over 11% of the US population has been diagnosed with diabetes and this number is expected to grow exponentially. Thus arose the need to provide a solution against this disease. Abbott Laboratories created the glucose monitoring system as a solution to this. Using the sensors, the glucose level is constantly monitored. If any changes occur, the user will be notified on the phone device to which they have connected the glucose monitor.

Emotional State - Apart from improving physical condition by using IoT, people nowadays can also improve their emotional state. To stimulate peace and increase productivity, the company FeelZing created bandages that produce electrical waves that affect the human nervous system. This method was proven to be effective and safe, by over 30 thousand studies.

Robotic surgeries – Engineers from around the world, along with surgeons, worked together to create robots that will perform complex surgical procedures. Now, the created robots can perform these procedures better than the surgeons themselves. Robots have found use in numerous medical operations. These include:back, heart, urological and gynecological surgeries. These robots are used in many institutes, but the most well-known is the Da Vinci Surgical Systems Institute. Surgical operations performed by robots are faster, safer and reduce the chances of patient infections. [9]

2.6 IoT data security techniques

Internet of Things device manufacturers in addition to creating devices with multiple functions to improve the work experience for users, they must also focus on the security of these devices. As the number of IoT devices increases, so does the number of security challenges. An example of these challenges is the Mirai software, which spread in 2016. This software creates what is known as a botnet. A botnet is a network of computers and devices infected with bot malware that are controlled by hackers remotely. Thus, a large number of online sites had problems because of it. [10] In September 2016, Mirai attacked various services such as Krebs on Security and OVH through DDOS attacks. All the attacks spread from small IoT devices like cameras, routers, air controllers etc. The number of compromised devices reached 600,000 thousand devices. [11]

2.6.1 User Authentication

Authentication based on shared keys - The server and the user have the same username and password. The user sets the name and password, then if these two are similar to the name and password stored on the server, the user is logged in. Accessing websites, emails, depositing and withdrawing money from ATMs all come under shared key authentication.

Authentication based on biological characteristics - It refers to physical characteristics such as voice, fingerprints and the iris of the eye. In IoT, the cloud and the devices must be authenticated so that the cloud believes the device is trustworthy. If the device is not trusted, data can be stolen or manipulated. This form of authentication requires authentication devices to work based on real time, this removes the risk of using static images or data manipulation.

2.6.2 OTA Security

OTA (Over the air) - has an important role in the development of the Internet of Things. It is used to update the firmware of IoT devices. It provides better services to users after the update as well as repairs system vulnerabilities. Device firmware through updates implements security algorithms with the help of OTA, which protects the device from Trojan attacks.

Risk Modeling - is the process of optimizing the security of a system by identifying security risks and creating methods to prevent or reduce them. It can identify problems in a very short time. It tries to understand the ways in which attackers will compromise the system and whether the corresponding protection functions are in place. Through risk modeling, security strategies are created during system design rather than after the system is introduced to the market.If the system is placed on the market, security methods cannot be implemented because it is very difficult to implement them on a large number of devices, which can cause numerous problems. [12]

2.7 Security challenges and solutions

Lack of standardization - It is one of the biggest security challenges in the Internet of Things. Since there are a very large number of devices and protocols, it is difficult to ensure that they are compatible with each other.

Solution: Creating and applying standards for IoT devices and protocols. This includes standards for data security, device security, and communication protocols.

Lack of authentication - Many IoT devices are designed with minimal security, making them highly vulnerable to attack.

Solution: Implementing more secure security methods, such as two-factor authentication. This authentication allows only the right people to access the device.

Insufficient software security - Internet of Things devices are placed in integrated systems that have limited resources, making it difficult to secure them. Also, these systems have specialized hardware and software, which creates new security challenges.

Solution: Using secured firmware verifies that the device has a reliable software. Through secure firmware update processes, it is ensured that the device has the latest firmware version and the updates are authentic and it’s not tampered with.

Insufficient network security - IoT devices are sometimes connected to the Internet using unsecured networks. An attacker can disrupt communication between the device and the Internet, accessing sensitive data.

Solution: Implementation of secure network protocols, such as HTTPS and VPN, which enable data to be transferred securely. VPN is used to encrypt communication between IoT devices and the Internet, to make it difficult for attackers to access data.

Difficulty in detecting and responding to risks - Internet of Things devices such as thermostats, security cameras and other smart devices often work in the background constantly collecting and transferring data. Since these devices have minimal user usage, it can be difficult to identify and manage security risks. An attacker can gain access to the device without the user's knowledge.

Solution: Implementation of security monitoring and incident response processes. For example, security software may be installed on the device. This software monitors network traffic and alerts administrators to any potential threats. [13]

3. METHODOLOGY

3.1 Data gathering

To solve the problems identified above, I have developed a methodology which contains several steps. Initially, a literature review was done which was used to provide information related to IoT and its impact on the healthcare sector. The literature review was done by analyzing online articles, books and previous research papers on platforms such as ResearchGate. The primary purpose of this analysis is to understand the essence of this topic by me as well as by its readers.

After reviewing the literature in the results section, I presented the questions posed in the created questionnaire. Through these questions, statistics were collected regarding the Internet of Things as well as its use for health monitoring by the respondents. The questionnaire was designed in such a way that the presented questions yield results of high importance. After completing the questionnaire, all responses were collected from the Google Form and then analyzed. The data extracted from the questionnaire were analyzed using the SPSS statistical program. After the analysis, the data were interpreted in different visual forms, in the form of tables as well as in the form of graphs (pie-chart). Tables were created using descriptive statistics.

The questions posed are:

1. Are you a smartphone or smartwatch user?

2. Do you use apps on your smartphone or smartwatch to monitor your personal health?

3. What type of information do you monitor the most through these personal health apps?

4. How often do you use your smartwatch or personal health monitoring apps on your smartphone in a week?

5. How do you think the use of health monitoring apps has affected the way you take care of your health?

6. Which of these opportunities do you think is most important to develop in health monitoring applications in the future?

7. What health-related information you read on the Internet interests you the most?

3.2 Results

The following chapter will present the data collected from the questionnaire, which was created as a form of research related to the paper. The questions presented in the questionnaire were asked in order to obtain opinions from the respondents regarding the Internet of Things as well as its impact on their health. The questions are focused on the use of smart devices such as smartphones and smartwatches for monitoring the respondents' health. Questions are presented regarding the number of users of IoT devices, the number of users of monitoring applications, the most monitored data, the impact of the use of these devices and applications on their lives, as well as the interests they have in the medical aspect.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Smartphone	94	79.0	79.0	79.0
	Smartwatch	2	1.7	1.7	80.7
	Te dyja	23	19.3	19.3	100.0
	Total	119	100.0	100.0	

Table 1.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Po	91	76.5	76.5	76.5
	Jo	28	23.5	23.5	100.0
	Total	119	100.0	100.0	

Table 2.

1=Rrahjet e zemrës,2=Kaloritë e djegura,3=Hapat e bërë,4=Gjatësia dhe cilësia e gjumit,5=Nuk monitorojë asnjë lloj informacioni

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rrahjet e zemrës	3	2.5	2.5	2.5
	1, 2	1	.8	.8	3.4
	1, 2, 3	13	10.9	10.9	14.3
	1, 2, 3, 4	13	10.9	10.9	25.2
	1, 3	5	4.2	4.2	29.4
	1, 3, 4	4	3.4	3.4	32.8
	1, 4	1	.8	.8	33.6
	2, 3	18	15.1	15.1	48.7
	2, 3, 4	4	3.4	3.4	52.1
	2, 4	1	.8	.8	52.9
	Hapat e bërë	23	19.3	19.3	72.3
	3, 4	8	6.7	6.7	79.0
	Nuk monitorojë asnjë lloj informacioni	25	21.0	21.0	100.0
	Total	119	100.0	100.0	

Table 3.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Rrallë	22	18.5	18.5	18.5
	Disa herë	36	30.3	30.3	48.7
	Çdo ditë	33	27.7	27.7	76.5
	Shumë herë në ditë	5	4.2	4.2	80.7
	Asnjëherë	23	19.3	19.3	100.0
	Total	119	100.0	100.0	

Table 4.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Shumë pozitivisht	33	27.7	28.0	28.0
	Pak pozitivisht	42	35.3	35.6	63.6
	Nuk ka ndryshuar	43	36.1	36.4	100.0
	Total	118	99.2	100.0	
Missing	System	1	.8		
Total		119	100.0		

Table 5.

1=Përmirësimi i saktësisë të të dhënave të monitoruara,2=Ndërfaqe më intuitive dhe tërheqëse,3=Më shumë informacion dhe këshilla shëndetësore të personalizuara

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	1.7	1.7	1.7
	Përmirësimi i saktësisë të të dhënave të monitoruara	28	23.5	23.5	25.2
	1, 2	4	3.4	3.4	28.6
	1, 2, 3	22	18.5	18.5	47.1
	1, 3	22	18.5	18.5	65.5
	Ndërfaqe më intuitive dhe tërheqëse	5	4.2	4.2	69.7
	2, 3	5	4.2	4.2	73.9
	Më shumë informacion dhe këshilla shëndetësore të personalizuara	31	26.1	26.1	100.0
	Total	119	100.0	100.0	

Table 6.

1=Të ushqyerit e shëndetshëm,2=Ushtrimet gjimnastikore dhe sporti, 3=Kujdesi, si të ruhemi nga virusët,4=Mjekimi alternativ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid		2	1.7	1.7	1.7
	Të ushqyerit e shëndetshëm	29	24.4	24.4	26.1
	1, 2	38	31.9	31.9	58.0
	1, 2, 3	5	4.2	4.2	62.2
	1, 2, 3, 4	10	8.4	8.4	70.6
	1, 2, 4	7	5.9	5.9	76.5
	1, 3	4	3.4	3.4	79.8
	1, 3, 4	1	.8	.8	80.7
	1, 4	1	.8	.8	81.5
	Ushtrimet gjimnastikore dhe sporti	12	10.1	10.1	91.6
	2, 3	3	2.5	2.5	94.1
	2, 4	2	1.7	1.7	95.8
	Kujdesi, si të ruhemi nga virusët	2	1.7	1.7	97.5
	3, 4	2	1.7	1.7	99.2
	Mjekimi alternativ	1	.8	.8	100.0
	Total	119	100.0	100.0	

Table 7.

4. CONCLUSION

4.1 Discussions

First, I will begin by presenting the key findings that have emerged through this paper. The enormous impact that the Internet of Things has had on the health sector has been revealed. It was revealed how extensive the integration of this technology is, by examining the various devices where it has been applied. By using various sensors, smart devices such as phones, watches and many other devices monitor various information. Thus, with the help of these devices, the number of diseases was significantly reduced. Also, with the help of the questionnaire, some conclusions were drawn regarding the use of the Internet of Things in personal health. They are: the number of users of health monitoring applications is significantly high, the most monitored data are steps taken and calories burned which are considered generic data. Next, we will talk about the high potential that the Internet of Things has for future development, starting with its use for the treatment of mental health problems.

4.1.1 Using the Internet of Things in mental health treatment

Mental health care systems using Internet of Things devices provide real-time data on the mental state of patients. These systems collect data such as sleep patterns, heart rate and activity level. Then the data is used to monitor the patient's condition, identify changes in the condition and create special treatments. For example, if the patient's heart rate increases, the relevant doctor will be notified who will then take appropriate steps for the patient's recovery. Another advantage of the Internet of Things in mental health is the diagnosis of patients, which is much more accurate. By means of the collected data, a model of the patients' behaviors is created and thus the decisions made are based on a lot of evidence. Wearable devices such as smart watches and fitness bands send alerts to their wearers if their mental health is deteriorating. This prevents the creation of any more serious situations. These devices also offer cognitive behavioral therapy (CBT) among other apps and tools. This form of therapy has been very effective in managing mental health symptoms. [14]

4.1.2 The first non-invasive cortisol detector

A very important goal of technology for treating mental health is the reduction of the stress hormone, cortisol. Cortisol levels should be monitored 24/7. Now, its level can be monitored without the need to draw blood, not spending unnecessary time sending samples to laboratories. Taking blood is a stressful situation for many people who are afraid, while in order for cortisol to be reduced they need to be relaxed. Thus, the first non-invasive device for detecting cortisol from skin sweat was created. The system consists of a carbon layer, which has a large number of holes on the back.

Cortisol antibodies are located here. Drops of sweat released from the skin enter these holes and create a chemical reaction that is detected by the device and measured by it. Thus, real-time stress monitoring is done. Cortisol levels are constantly monitored and observed if there are major changes and to react immediately before the situation worsens. [15]

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