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An intelligent m-Health Platform for Chronic Diseases: Design and Conception

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Abstract:*Chronic diseases are one of the principal causes of mortality in the globe. This dramatic health status conducts many researchers to investigate and explore new solutions using the advantages of mobile health technology. For that reason, we propose an adaptive, context-aware and low-cost intelligent solution, providing a real-time alert system and an efficient management of critical cases. This paper stands for a state of art of mobile health proposed solutions managing this kind of diseases. It leads to a new approach in medical mobile application's design based on patient's needs, health professional's concerns, and other solution's lacks. Our new platform's design can be considered as a novel intelligent mobile assistant for chronic diseases.*

Index Terms:*Adaptive, chronic diseases, context-aware, intelligent, m-health platform, real-time.*

INTRODUCTION

Health status over the world is dramatically evolving. The numbers of cardiovascular diseases (CVDs), cancers, diabetes, mental disorders, dementia, asthma and chronic diseases in general is increasing over years. More than 17 million deaths were caused by chronic diseases in 2015 [1].this critical situation need immediate, rapid and efficient solutions, to provide long term health care strategies. For that purpose, and in order to improve health careefficiency, patient's Quality of Life (QoL), and patient/doctor relationship, many studies and advanced researches are working to offer new solutions; using the remarkable technology revolution.Mobile Health (m-health) is one of the most recent health care fields. Based on mobile phones (Smartphone or connected devices) use [2], m-health represents a new field, emerging new possibilities, opportunities and even new challenges. It takes patients and their environment into account, to develop various types of medical applications, and provide new techniques in: signal processing, image processing, symptoms detection, primary diagnosis, data analysis, and data transferring, etc.

Our study represents a technical report of the most efficient solutions, compares their accuracies, and tries to figure out the most common issues. In order to develop at the end our main contribution and present a primary design of our new medical platform.

The paper is structured as follows. Section II is dedicated to related works. Section III explains the research methodology. In Section IV, results are offered, discussed and illustrated by means of the proposed platform's architecture. Finally, conclusions and perspectives are presented in Section V.

RELATED WORKS

M-health is a new challenging medical trend. It combines sensors and wearable technology for detection, Internet of Things (IoT) for interconnection and storage and artificial intelligence (AI) for classification and decisions [3]. It includes technology advancements and applies these later to enrich the health care system.

In the literature, several studies are developed to report the state of art of this new field and examine the quality of the existed solutions. Boulos *et al*. [4] elaborated a detailed study about common needs, and concerns required in mobile medical applications. A certification program is also proposed in the same study to evaluate the quality of a m-health application. In 2015, Silva *et al*. [5] proposed a state of art of m-health services and applications. They illustrated a chronological overview of m-health evolution, and discussed the future challenges.

In terms of managing chronic diseases, Wilhide III *et al*. [6] described a procedure in designing a mobile application framework; supporting several chronic diseases, derived from clinical recommendations and standardization.

Used technologies are also treated in several works; Riazul Islam *et al*. [7] detailed the use of IoT technologies in the health care field. They surveyed several solutions, analyzed the most relevant features and suggested a new model to enhance the security part. In the same context, Shah *et al*. [8] reported the Quality of Services (QoS) issues using the Cloud of Things (CoT) technologies in designing a health remote application. They presented a brief state of art and discussed challenges in applying this category of technologies.

This paper combines firstly a summarized state of art of present m-health solutions and an investigational survey of most common patient's needs and health expert's recommendations. In the second part, it describes an adaptive design of a chronic m-health platform responding to all exigencies discussed before. The pragmatic side is illustrated by an initial electrocadiogram (ECG) monitoring system.

METHODOLOGY

Chronic diseases represent one of the most serious health problems in the globe [1]. The main purpose of our study is to present a concise state of art of the most relevant health care solutions.

First of all, it seems important to portray patient's needs, in order to describe primary goals responding to their concerns, and covering their journeys. Patients are the center of our study. They are the most important actor, for who we must offer the best experiences. Our research methodology is composed of several steps, as shown in Fig.1.

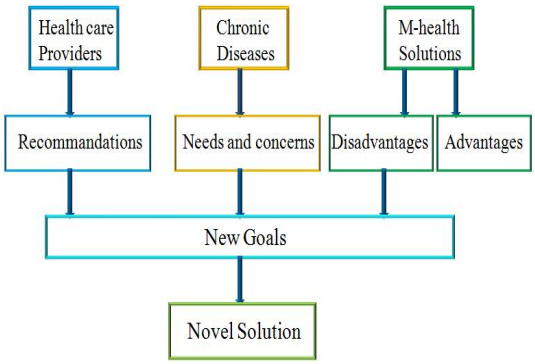

Fig1: Research strategy

To take a general overview, the first step is about studying the physiology of different chronic diseases, especially cognitive diseases that affect the brain, like: Alzheimer's disease (AD), Parkinson's disease, Lowy body dementia, etc. This first step is essential to find out difficult conditions patients are obliged to live with and to have more details about suffering from a chronic disease. It is an excellent opportunity to describe patient's needs and most common concerns.

The second step is to analyze recent research and proposed solutions, made for helping persons living with thistype of chronic conditions. The analyze method is separated into two groups. The first includes latest examples of academic solutions cited in Table I. It describes the solutions, identifies their advantages, and discerns their lacks which are the keys to define new objectives. The second contains some popular

commercial works cited in Table II. It regroups recent m-health applications and products. It also collects the disadvantages of each solution. The resulted collection represents the second base of our final architecture.

The third step is to enhance the research plan with health provider's opinions. Several discussions with health professionals have been organized. These strategies contribute to the design of new goals to be reached at the end by our new solution. These goals are presented in the next section.

TABLE 1:EXAMPLES OF M-HEALTH SOLUTIONS

M-health solution	Date of publication	Description	Advantages	Disadvantages
Roshan Fekr*et al*. [9]	2015	A respiration disorders Classification using motion sensors.	-Cloud-based platform. - Integration of motion sensors for diagnosis. -Efficient classification method.	-No security enrichment.
Hommersom*et al*. [10]	2013	A development process of a m-health assistant for chronic diseases.	-Reinforce the exchanges between patients and doctors. -A general review of the most key points to succeed a m-health solution.	-Lack of solutions for reel-time, security, and adaptation.
Hanen *et al*. [11]	2016	A mobile medical web service based on Mobile Cloud Computing (MCC) technology.	-Remote consultation. -Patient registration.	-Lack offeatures for User Experience (UX).
Cancela*et al*. [12]	2016	A m-health platform for motor and non motor symptoms detection of Parkinson's disease.	-Health professionals collaboration.	-Just for Parkinson's disease.
Chang *et al*. [13]	May/June 2016	An interactive m-health solution for diabetes based on IoT.	-Real-time warning. -Cloud storage.	-External storage only. -No solutions in case of interruption.

TABLE 2:EXAMPLES OF M-HEALTH APPLICATIONS

Mobile Application	Description	Advantages	Disadvantages
Embrace [14]	Nervous system monitoring solution.	-Activity tracking. -Stress management. -Several integrated sensors (temperature, accelerometer, gyroscope...).	-Detect only TicTonic movements in epilepsy.
iHealth my Vitals[15]	Detect changes of various vital parameters.	-Good accuracy. -Graphical representation. -A wide range of parameters.	-Sharing data manually by the patient. -Security side is not treated.
Meyko[16]	Assistant for asthmatic children.	-Alert drug system for parents. -Prevent children from complications. -Good UX.	-Just for medicine routine.
Siren Care[17]	Smart socks to detect inflammations for diabetics.	-Early detection. -Close to skin. -Comfortable. -Cloud storage.	-Health providers are not involved.
SmartSole [18]	Smart wearable	-Cellular integrated	-Not intelligent

for feet with location alerts for persons with dementia.	technology -Location alerts every 10 minutes. -Mobility.	alerts (when patient is really in need). -Privacy and security of patients.

A. Patient's needs

From a medical view point, patients are the first and the most important actor ever. They symbolize the center of any clinical operation. Many studies confirm that persons suffering from livelong diseases do not like to be seen nor treated as patients [19]. They also prefer to get access to medical services easily [20]. Especially for elderly persons with low level of knowledge; they need an easy way to get involved to their health care journey.

In the other hand, persons living with cognitive diseases like ADs, are usually dependent and need a closer help; because of their memory loss [21]. They may suffer from behavioral disorders, frequent falls, and difficulties in managing simple daily activities. For that an alert system is very useful with real time notifications of the current location address, the medication routine, etc.

Also sometimes and for a single type of chronic diseases such like diabetes, there may exist many different cases; according to the disease's type or stage, the patient's age, or the clinical journey phase [13]. That is why the factor of time can play a major role in creating a health care platform, especially when it can engender complications and changes on the patient's health and in consequence require different actions.

Emotions are also an important factor in every design procedure [19], especially when it is about motivating patients, managing their emotional conditions and encouraging them such as persons suffering from cancers.

Dangerous cases or emergencies must also be carried by the m-health solution. For example, the most mortal disease in the world, which is the CVDs [1], must be handled immediately and in real-time.

In conclusion, patients need easy tools; that can improve their autonomy, and offer immediate, efficient, and adequate help, corresponding to their conditions, preserving their rights and enhancing high level of QoL.

B. Lacks in present solutions

The recent m-health solutions prove their efficacy in the majority of time, although, this efficiency is attained in general for a specific type of disease or specific category of patients.

Handling critical cases (such as the battery level of the medical devices or Smartphone, the connection status, and the storage capacity) is also missing in several designs. For that, it seems important to improve the adaptation notion in the proposed architecture; which represents the different modifications that are made to a system to guarantee its performances under a new context of use [22].

In the security side, several advancements in research are maintained [7], but still rarely used to accomplish existing frameworks. That is why simple to use applications are usually less secure and vice versa.

Lastly, from a technical overview, the key method to succeed m-health solutions is to add specific concepts, think about different cases, insert several techniques of adaptation, and reinforce the security andthe privacy side without increasing the complexityof the product.

C. Healthprofessional'srecommendations

Health care providers represent a relevant actor in the health care system [23]. It includes: doctors, physicians, nurses, hospitals, health care centers, emergency services, etc. They are responsible for making decisions, providing adequate operations and offering appropriate services.

According to health professionals, standalone m-health applications can cause problems. Even most intelligent and efficient algorithms can engender sometimes and in some cases errors in generating a diagnosis or making a medical decision [8]. For that purpose, it is necessary to provide second judgment by contacting a health expert. The contact should be as fast as possible to provide immediate interactions

and functional actions. So the m-health platform should offer a proficient service, in which the reel-time notion is preserved and the quality is guaranteed.

In the other hand, the use of notifications must be clever; by differentiating between languages used to notify patients about their conditions, and messages sent to the health providers. These messages should contain more details than the notifications for patients. In some cases, informing patients about their dangerous status can be itself a dangerous act, and cause risky complications [24].

For professionals, m-health technology should also help them in organizing their work [23]. So, it is important that the health care solution provides a proficient support for experts.

D. The proposed solution

Responding to the majority of requirements explained above, the proposed global architecture contains two sides:

- A mobile application made for patients; in charge of reading data (receivedfrom a healthdevice via Bluetooth, such as a blood pressure monitor, a glucose monitor, etc.), connecting the application to the cloud for immediateexternalstorage, treating data (algorithms of data analysisaccording to the type of disease),making real-time decisions, generatingnotifications to guide patients, and transferringrapid and automaticalerts in critical cases (withoutany action from patients) by sending Short Messages Service (SMSs) to the healthprofessional and the familycaregiver in the same time. For more details, Fig. 2illustrates the application'sdiagram.
- Another mobile application made for the healthprofessionals and especiallydoctors. This sideis in charge of generating a text to speech in case of receiving an alertfrom the patient side. The text to speech alarmiscreated to read the name of the patient;consideringthat the doctormaybeoccupiedenough to not have the time to check hisincoming messages. Whenhearing the patient'sname, the doctor can consulthis data by a login to access the databases of his patient as shown in Fig.3. When the doctorconfirmsthat the patient needsimmediate help, thenhe can use hislist of prewritten messages to send an alert to the familycaregiver or the emergencies. The use of a list of prewritten messages is indispensable to not waste the time in writingtexts. This listiscreatedbasing on the doctor's and expert's suggestions. This quick interaction can beconsidered as a first aide to the patient.

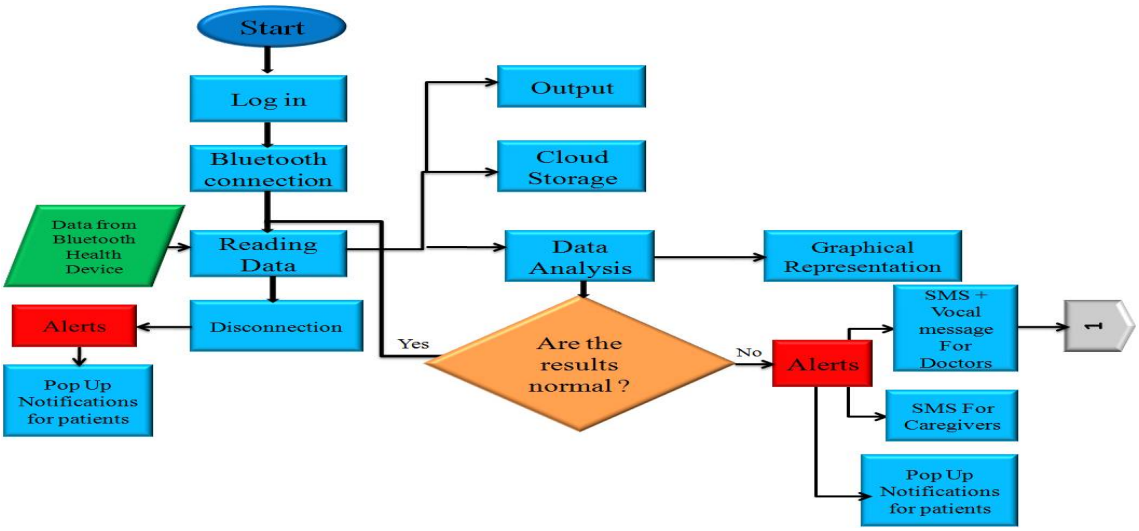

Fig. 2: The flow diagram of the patient's mobile application.

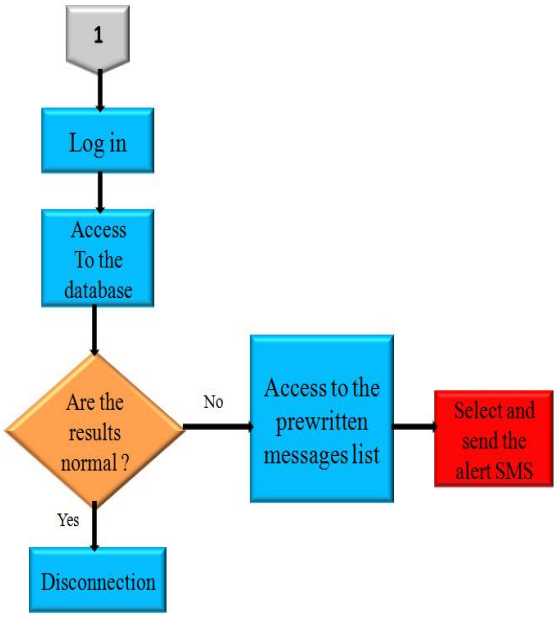

Fig3: The flow diagram of the health professional's mobile application.

RESULTS AND DISCUSSIONS

A. Global Architecture

The final architecture of our m-health solution collects extracted outcomes from the research procedure described in the methodology section. The design combines the two applications; for patients and health professionals. It also integrates the family caregivers as a third actor. Fig. 4 resumes the global proposed architecture. The two mobile applications are on the amelioration stage.

B. Discussions on the patient's side

Patient side is the main base of our design. Several solutions for problems discussed before are proposed, offering numerous features, like:

- User authentication: by a login and a password to preserve the confidentiality of patient's data;
- Adaptive features and preferences management: only for the first time, the patient need to select his age, the type of his chronic disease, the number phone of his doctor and his preferable caregiver from the contact list. All these parameters will be used automatically after that;
- Automatic data extraction: searching for the Bluetooth health device, connecting, and reading data will be done automatically;
- Data analysis: analyzing data, classifying the values and making decisions will be established via cloud. The mobile phone is just in charge of reading data from the health device, sending them to the cloud and interpreting data sent to or received from the cloud. This can reduce the consumption of energy, decrease the used memory space in the mobile phone and increase the performances of the mobile application.
- Data backup and storage capacity reinforcing: a second automatic storage using the cloudcomputing opportunities at the same time of the analyzing phase. This can engender rapidity, flexibility, scalability, accessibility, convenience and prompt recuperation;
- Critical cases handling: automatic alerts to inform the users about the health device connection's status, the battery levels, and the cloud connection's status;
- Location alert system: based on the cellular network algorithm [25] for automatic alerts. In case of emergencies, patients can simply press the alert button and the mobile phone will automatically send an SMS to the family caregiver. The SMS will contain his current location address(road, city).

C. Discussions on the health care provider's side

The second application is dedicated to the health professionals. At this level, the offered options are:

- Vocal alerts: in case of receiving an SMS alert from the patient's side, the application will read the message containing the name of the patient, and a brief description of his dangerous state;
- User authentication: the health professional can consult the patient's data immediately via cloud and securely by a login and a password;
- Rapid interactions: in dangerous cases, the health professional can send a quick alert to the emergencies or the health care centers by choosing a convenient SMS from the prewritten messages list. He can also send directives to the caregivers for the first aide, or advices to the patients in other cases.

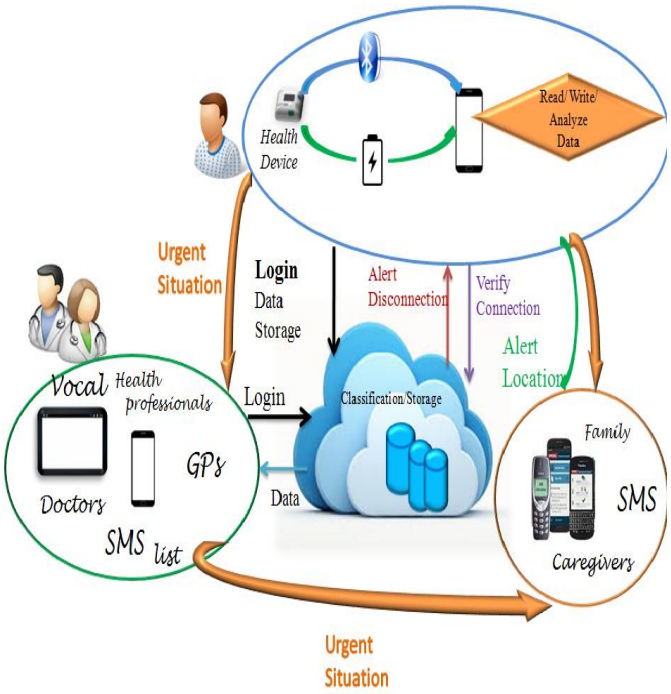

Fig 4: Global Design of our m-health platform.

D. Tests

The two mobile applications are on the amelioration stage using the Android Studio Software Development Kit (SDK). This work stands for the design phase of our m-health platform, while testing phase was done primarily in interpreting ECG signals. The data were correctlyand continually interpreted in real-time with an accuracy of 90% compared with real ECG signals recorded by a health device ('Holter Supplies QuickReader Version 2.01') as shown in Fig. 5. The mobile application's performances were excellent either using a real device ('Samsung J7 Pro') or several versions of Android Virtual Device (AVD).

From the patient's mobile application, Fig. 6. demonstrates the SMS alert sent to the caregiver containing the current location address of the patient in need. Tests were done using two mobile phones ('Samsung J7 Pro' for the patient and Simple 'Starlight' phone for the caregiver). Results were perfectly in real-time (calculating, sending and receiving the SMS alert were done exactly at the same time which was: '12:47'). The road is mentioned as unknown just because of lack in nomination of some roads in our country.

More details about other implementations, will be reported in the future works.

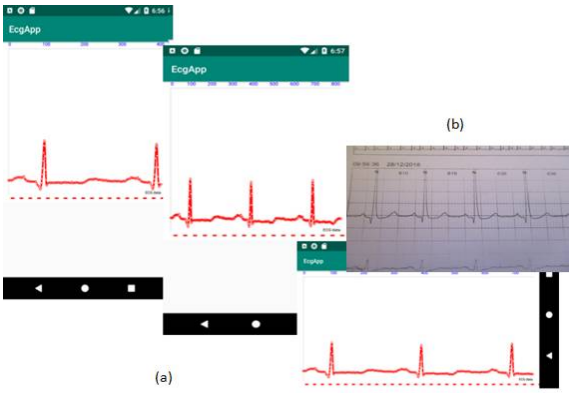

Fig5: ECG signal.(a) ECG data recorded by our m-health application.
(b) ECG data recorded by the health device named: Holter Supplies QuickReader Version 2.01.

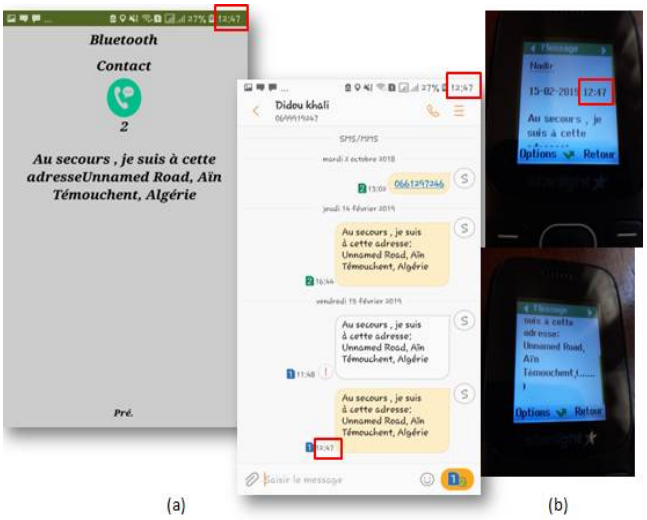

Fig 6: Location SMS alerts. (a) The execution of the location alert from the patient side and the generation of the alert SMS by the Smartphone. (b) The location alert SMS received by the caregiver's simple mobile phone.

CONCLUSION

Mobile health is a good opportunity to improve the QoL of patients. In the other hand, living with a chronic disease requests a permanent monitoring and tracking system, by means of the advancements in the m-health technology. Our proposed solution is a new advance in this field. Basing on patient's needs all along their journeys (events, dates, environments and emotions), collaborating with health professionals and getting inspired by lacks in other solutions, our design provides a general approach to manage a wide range of chronic diseases. As an initial application, we integrate an ECG monitoring system where data are received from a medical sensor via Bluetooth. The analyze method supports all different ages, detects several critical cases, and takes advantage of cloud's opportunities (capacity, backup, and security). The solution is not only a standalone application; the decisions made by the mobile application are confirmed by a second judgment of a health expert. The UX is also enriched by an easy to use interface with automatic and intelligent interactions. The present work is just an initiation. We are going to include more vital parameters. The security side is also one of the most challenges of our public solution. For that we are looking to enhance the level of security by adding new features.

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