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PAPER

Current Knowledge and Future Possibilities of Medical Digital Technologies based on Mobile Health

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ABSTRACT

Medical digital technologies have the potential to improve public access to healthcare by enhancing its flexibility. The availability of complementary details about health, ailments, complications, and the most recent advancements in biomedical research are all included. Diagnostic and medical services are now becoming more available and accessible, especially in low-income countries. Regarding digital health technology, there are still a lot of challenges that need to be overcome, such as dependability, safety, testing, and ethical concerns. We propose that mobile technology should enhance rather than replace the psychiatrist-patient connection in the existing environment of inadequate regulatory oversight and scientific research to lessen possible clinical and moral harm to patients at risk. We identify potential areas of moral conflict between consumer-driven mobile businesses and healthcare practice and create a decision tree model for putting ethical safeguards in place. Informed consent, confidentiality, and shared treatment expectations are the main areas of attention for this paradigm when it comes to risk management in the therapeutic partnership. To comprehend the utility, capacity, and limitations, this study covers recent breakthroughs in mobile technologies, their applications, and a comparative analysis of their performance metrics. Understanding the weaknesses of current technologies can facilitate the creation of new frameworks with increased performance capabilities and superior service quality.

KEYWORDS

mhealth, medical digital technologies, therapies, portable health clinic, decision-tree model, medical apps (MAs)

1 INTRODUCTION

Apple's iPhone, the first smartphone, was released in 2007, just 13 years ago. Since then, a lot has changed in terms of daily life and consumer behavior as a result of the growing popularity of smartphones and other digital inventions like tablets, gadgets, watches, and other devices [1]. One of the most revolutionary technical developments in recent decades has been the advent of contemporary information

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and communication technologies (ICT). The way people engage with technology has significantly changed as a result of the pervasive availability of mobile devices, smartwatches, and laptops, as well as broad internet connectivity. The exponential growth in computing power and storage, the popularity of cloud computing, and the implementation and advancement of AI techniques have all created new opportunities for ICT architecture.

Medical apps and mobile health apps are gaining popularity as digital solutions for a variation of medical uses across practically every aspect of healthcare. This is true for gastrointestinal clinical practice as well, which has lately undergone a digital transition that will have a significant impact on patients and healthcare workers shortly. The purposes for which MHAs and MAs are used in endoscopy are very varied. They range from workflow management systems and electronic health records (EHR) to specialized mobile apps for the treatment of certain diseases in particular contexts or the handling of either acute or chronic pain.

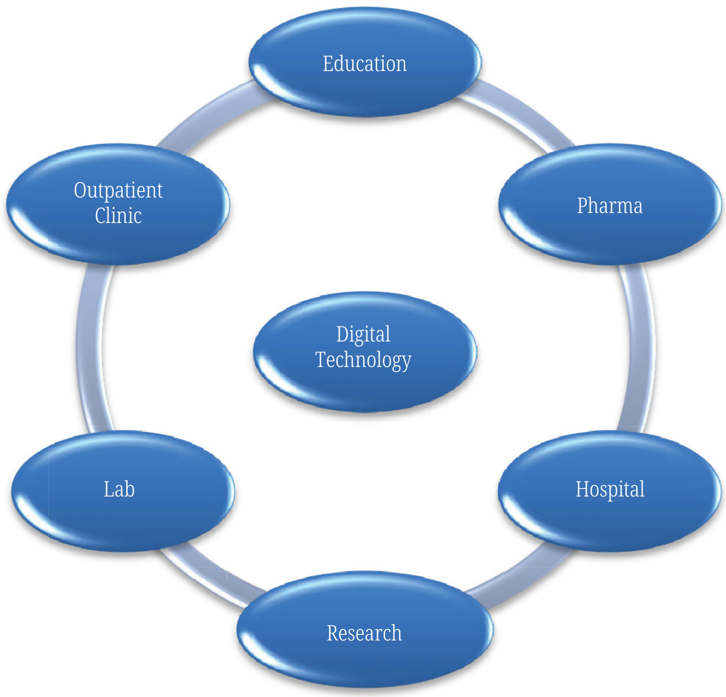

Fig. 1. An illustration of the key uses of digital technology in healthcare

This review discusses the developments and advances in the field of digital medical technologies. It discusses using telemedicine, the blockchain system, "big data", machine learning, and other technologies to address actual problems in healthcare and medical training (Figure 1).

AI applications in biomedicine, healthcare, and medical education are a promising and rapidly growing subject. The functionality and performance of diagnostic tools could be considerably improved by AI [2]. In addition, it might aid in the optimization of the therapy process, leading to greater therapeutic efficacy, happier clients, and fewer expenses. AI can also facilitate clinical trials and biomedical studies. AI will be essential in fields that demand extensive manual labor and automation. Despite recent developments, artificial intelligence cannot yet fully replace people in the realms of healthcare and biological research.

The present research suggests a symmetrical exemplar to calculate the effect of mobile health submissions in different medical facility marketplaces [3]. The framework can show prospective outcomes for both patients and physicians in the demand for health care, whether or not m-Health applications are present, and may reconcile the supply of doctors and demand from patients. The m-Health app is completely up to the discretion of both physicians and patients, who are also able to accept or reject each other. The patients' goal is to reduce their overall healthcare expenses, which include consultation fees, waiting room prices, and medical treatment costs.

By downplaying their own futility, doctors can earn the most money possible.

The following are the primary contributions of this paper:

- A thorough analysis of m-Health's state of the technology;
- The futility function is redesigned. The key factors considered by the paper's pointless function are the doctor's waiting time, consulting fees, and the doctor's interest in learning about the patient's illness.
- A discussion of the most recent and unresolved problems regarding m-Health services and technologies.
- In the trial, which is based on a fictitious distributing platform, we build a market system for mobile health medical services. The findings demonstrate that the model was capable of balancing the supply of physicians with demand from patients.

This paper's summary is structured as follows. Section 2 goes into more detail about the current state of m-health systems and how medical organisations and personnel are utilising information and communication technology. The utilisation of m-Health services and applications is the main topic of Section 3. In Section 4, there is a discussion of existing and unresolved problems with m-Health technology. The paper finishes with Section 5.

2 RELATED WORKS

Sweileh, W. M., et al. [4] In this study, information on m-Health was obtained from Scopus, a collection of books that contains information on approximately 21,000 titles in the social, practical, medicinal, and scientific fields. Unlike Pubmed or Web of Science, Scopus has the largest database, which is why it was chosen. Numerous reports that were published suggested that m-health had a favorable effect on both personal and governmental medical care. Mobile health has been utilized in a number of health services, including promoting medication compliance, reducing weight, preventing behaviors connected to certain diseases, offering psychological support to people with persistent illnesses, helping smokers quit, and many more.

Liu, C., Zhu, Q., Holroyd, K. A. et al. [5] The authors created a prototype mobile BMM application for the iPhone in 2009 to assist adolescent migraine patients with controlling their migraines and communicating with their counsellors. The writers made the decision to create an iPad edition of this BMM app in 2010 when Apple introduced the iPad, taking advantage of the device's larger screen. In this study, analysis of the state of m-health apps and pertinent research was undertaken, including: (1) network or security issues for m-health apps (2) m-health app architectures and (3) exact m-health programmers.

Saleem, K. et al. [6] In terms of medical technology and healthcare, health telematics has developed into a fascinating subject. To increase the superiority, security, and efficiency of healthcare services, healthcare facilities are currently turning to information and communication technology (ICT). E-Health links business, public health, and medical informatics via related technologies like the Internet. But because hospitals and health systems gave ICT little attention in the 1990s, it got off to a poor start. However, it was essential to create an established framework for information systems at hospitals.

Miah, S. J., Gammack, J., et al. [7] Even though the development of the smart phone marked the official start of today's m-health studies, AT&T created the "Mobile Telephone Service" programme in 1949 to offer health services to 5,000 consumers and 100 US communities. However, the service encountered significant technological problems because they could only serve three users at once using three radio frequencies. Due to the widespread adoption of mobile methods, as well as new capabilities in software and hardware as potent cellular machineries, mobile health apps may be widely distributed because to features that companies like Samsung and iPhone have built for their mobile devices.

Boukerche, A., & Ren, Y. et al. [8] High standards for wireless and mobile networks are needed for use in widespread healthcare services, providing safe data transmission, dependable control from afar, secure data storage, effective mobility administration, prompt emergency response, and ongoing monitoring of a patient's health problems. The usefulness of mobile computing and the benefits of implementing wireless technology as portable and mobile hand-held or wearable gadgets for medical use make it easier for patients to swiftly access central healthcare services. The author then outlines a thorough wireless health monitoring idea that offers omnipresent, context-aware, mobile healthcare.

Aschbrenner, K. A., Naslund, et al. [9] On flyers and brochures provided by clinical personnel at each CMHC, the Teen Internet and Social Media Use Survey was promoted. Before responding to survey questions, the youth and a parent or legal guardian were required to read a consent form, which was available online or on paper. This form asked for the parent or legal representative's permission and the teenager's consent to finish the survey. By ticking a box via the internet or on the printed form, teenagers were asked to confirm that they were willing to participate in the poll with their parental or legal guardian's consent.

Khan, Z. F., & Alotaibi, S. R. et al. [10] AI is the method through which machines exhibit intelligence in contrast to the natural intelligence portrayed by humans. The process of machine learning, which equips systems with the capacity to learn on their own and get better with experience without being explicitly programmed, is one use of artificial intelligence. Additionally, it emphasizes the development of algorithms and how they can acquire data and use it to teach themselves. AI has been used in many industries, including the Internet of Things, computer vision, automated driving, and processing natural languages, as a result of its rapid advancement.

Secundo, G., Shams, S. R., et al. [11] New demands arose as a result of this emergency, solving the problems that were already placing great strain and uncertainty on the whole healthcare industry. It was almost impossible to track infections until a decade ago. It is now simpler and more effective to locate viruses so that a quicker response can be made using AI, machine learning, big data analytics, Global Information System, information mining, and insight extraction. Such electronic tools are enhancing the healthcare ecosystem's effectiveness quickly. The advent of fresh digital technology theories has prompted academics to go deeper into their research on how to use digital tools to address the worldwide healthcare leadership dilemma.

3 METHODS AND MATERIALS

3.1 Future obstacles for mobile health systems

The following categories can be used to group the anticipated developments in apps for mobile health.

i. Internet access in the administrative health-care sector. All other kinds of transactions will be handled here [12], including m-prescriptions, electronic medical records, processes, and other electronic engagements that will lead to more effective and improved care for patients.
ii. Financial ties between patients and the healthcare system. These will handle the dispensation of all upcoming small payments and decisions, promoting, and other banking facilities that will fall within the purview of the m-Health facilities offered by medical facilities and healthcare points of entry.
iii. Connectivity in the medical sector. The most significant area is this one. All m-diagnostic programmers, tracking, and other on-the-go applications between the various healthcare professionals and their patients will be included.

Consider some of the fundamental and possible advantages of such systems in order to better understand future difficulties in m-Health platforms. The summaries of these are as follows.

- Despite geographic limitations, the provision of immediate response to emergency medical care. For instance, patients with severe injuries can be addressed locally, and wireless networking can provide access to a trauma expert.
- Better handling of healthcare assets and flexible, prompt access to expert advice and judgement at the point of service. Linking medical photos and videos for interactive consulting and communications.
- Greater control of medical knowledge and autonomy, particularly in underserved and remote regions.
- Providing prompt medical attention in dire situations and managing medical information during catastrophes or emergencies where regular communication channels could be broken.
- Promoting healthy lives through ongoing health surveillance.
- Combining data from several sensors allows for a more comprehensive understanding of one's health as well as the kind and intensity of exercise.

To facilitate information sharing between sensors and the intelligent Shirt controller, customizable data buses built into the fabric are provided by Smart Shirt. However, this system configuration is inappropriate for prolonged continuous monitoring if other sensors, such as those that monitor physical activity, electromyograms (EMG) of the extremities, electroencephalograms (EEG), and other nonlocal messages, could not be connected via the data buses of the Smart Shirts.

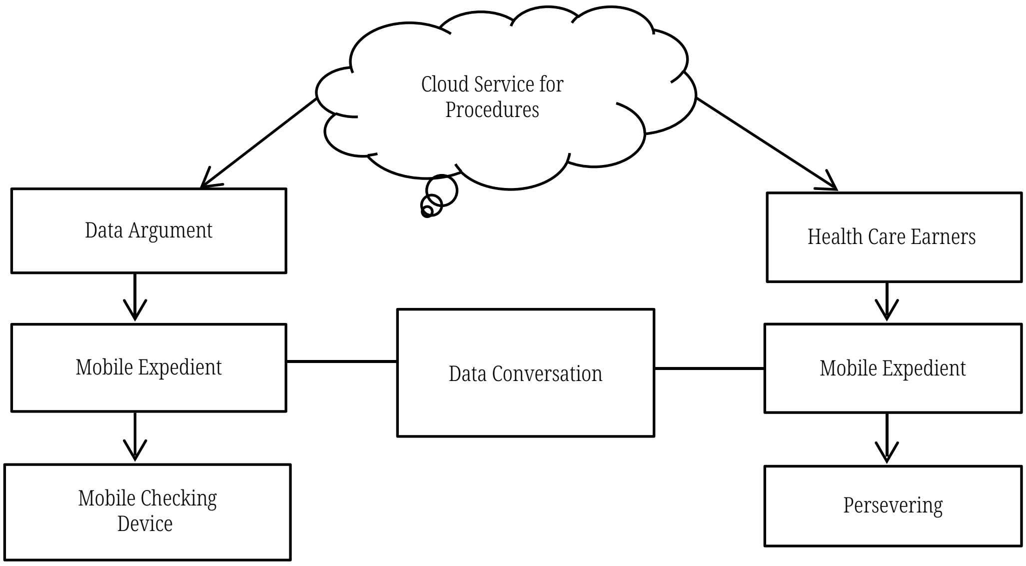

Fig. 2. A general system organization for m-Health systems

The patient, medical professionals and internet service providers are the three key actors in a mobile healthcare system. Surprisingly, patients' concerns about "what happens" to their data when being exchanged grow as a result of the diversity of players participating in their care [13, 14]. A general system organization for m-Health systems is shown in Figure 2. The person detectors are either wired or wirelessly connected to the individual tracking system. It is possible to incorporate a wearable health monitoring device employing PAN or BAN into the user's apparel. The GATECH Wearable Circuit or Smart Shirt project is a typical example.

3.2 Data-driven mobile health decisions

The patient is the node at which the decision tree starts (Figure 3). The patient's fundamental data assemblages make up the first branches. Sub-assembly, which is one level higher, makes up the second branching. From the second limbs, a diagnosis is selected for a sample investigation [15]. While a patient has an invisible sensor device with an attached cell phone, their physiological indices can be gathered, examined, and computed. The patient and the doctor receive copies of all conclusions. These findings could help doctors make timely diagnoses for their clients.

The procedure is explained in the following manner for various diagnosis circumstances:

- A sensor gadget gathers previous diagnostic records by history records.
- The imaging device can make computations and analyze past data.
- The sensor expedient can determine the likelihood of specific illnesses in actual time using the time together and by matching the patient's documents with typical information.

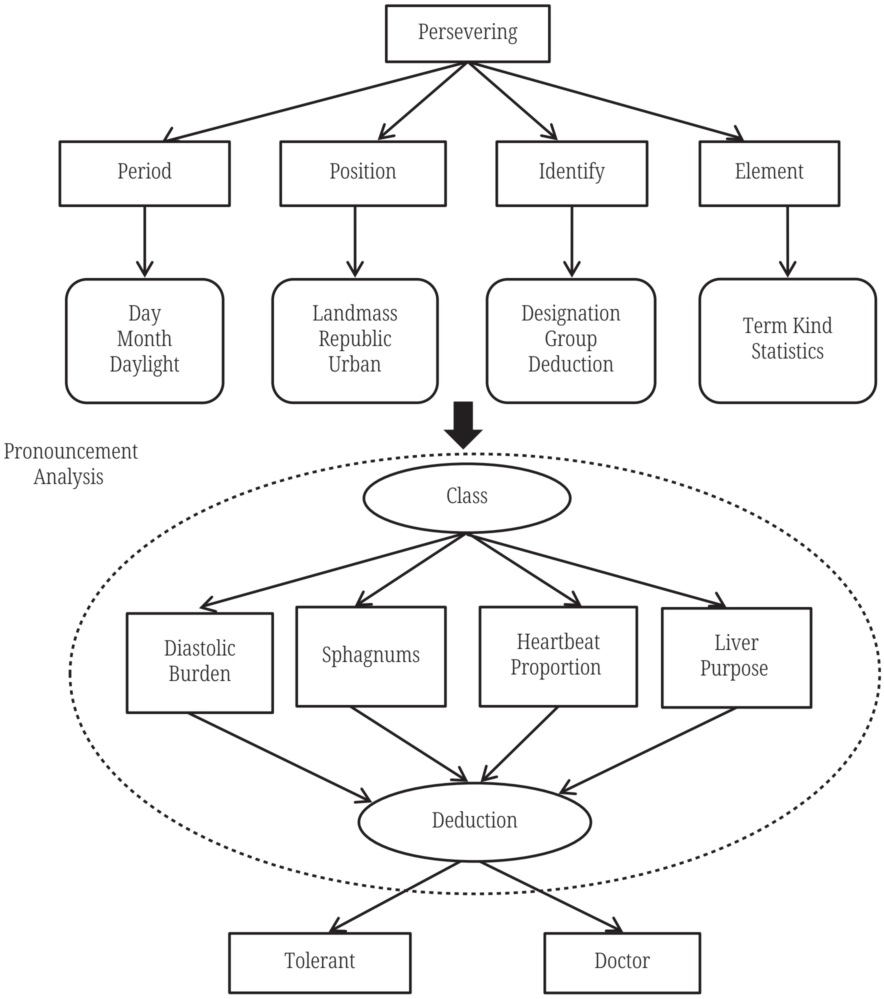

Fig. 3. Decision-making in mobile healthcare

- The likelihood of a particular disease is calculated by combining historical disease data with data currently being collected, and the results are communicated to patients and medical professionals.
- After the sensor gadget has analyzed the disease probability, the doctor must decide and calculate the disease chance if a condition or diagnosis is extremely complex.
- Patients may obtain accurate information about the likelihood of a disease occurring through the diagnosis decision-making process, which may help guarantee proper treatment.

3.3 Classifier for decision tree (DTC)

Integer comparisons are made at each node of the decision sapling, and the contrast results are then subjected to polynomial evaluation (bis). It is possible to formulate the appropriate polynomial assessment of *FheEmc* to obtain the classification outcome (Clsdct) utilizing bi at each node of d_0 as in Eqn. (1).

$$clsdct = (d_1) * d_0 + (2 - d_2) * (d_3) * (2 - d_4) * d_5 \tag{1}$$

Integer comparisons at each node of the decision tree and exponential assessment of the DTC should be conducted in an encrypted area to create a privacy-preserving decision tree classifier. Due to the fact that assessing in the plain domain entails both division and addition, the polynomial-based assessment of *FheEmc* in the scrambled realm necessitates a *Fhe* technique [16]. So, Eqn. (2, 3, 4, and 5) provides the polynomial valuation in the encrypted dominion that corresponds to Eqn. (1).

$$FheEmc_{ql}(clsdct) = FheEmc_{ql}(d_0) * d\,B_1 + s \tag{2}$$

$$FheEmc_{ql}(clsdct) = FheEmc_{ql}(d_0) * d\,B_1 + s \tag{3}$$

$$FheEmc_{ql}(2 - clsdct) = FheEmc_{ql}(d_0) * d\,B_1 + s \tag{4}$$

$$FheEmc_{ql}(2 - clsdct) = FheEmc_{ql}(d_0 - 1) * d\,B_1 + s \tag{5}$$

Where $FheEmc_{ql}$ stands for the *Fhe* encryption of data using the *Fhe* scheme's public key (d_0). They *Fhe* scheme's additive and multiplicative homomorphisms are denoted, respectively, by 2 and S. In the *Fhe* approach, c stands for continuous multiplication.

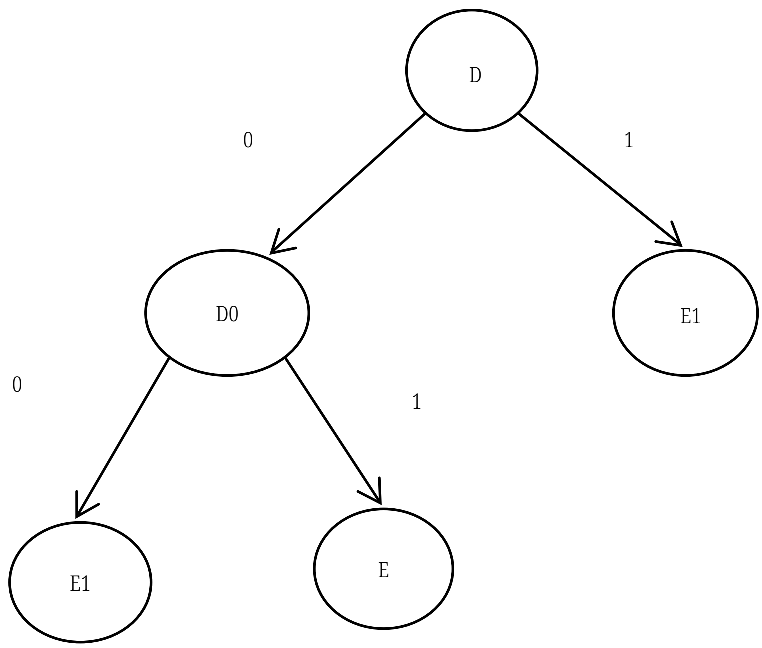

Fig. 4. The decision-tree

Figure 4 illustrates a binary decision tree for a two-class problematic (d0 and d1), where bi denotes the outcome of comparing the weight and input story at the i-th branch. In this study, we make the supposition that medical users and the health cloud (inner enemies) who participate in the implementation of private DT algorithms are truthful and adhere to the algorithm's stages without altering the data that belongs to each entity. However, by reading the communication transcripts they receive, internal opponents may attempt to obtain more information than is permitted [17, 18]. The statistics transmitted between the healthcare user and the fog may be intercepted by passive external attackers.

4 IMPLEMENTATION AND EXPERIMENTAL RESULTS

4.1 Assessment of the m-health app activity identification model online

We can confirm the possibility of the m-Health App activity detection model during runtime thanks to the online testing. The entire MHEALTH dataset serves as the foundation for the recognition model used in m-Health App [19]. A separate group of subjects than those used for the simulation training are used for validation purposes. Five volunteers in all were requested to complete the entire set of activities (Table 1). Given the nature of the exercises, 40 seconds were deemed sufficient for each task to be completed. For the convenience of the users and to minimize their involvement as much as feasible, the activities were carried out in a variety of outdoor settings.

Table 1. Regular activity

Regular Activity	
M1: (1 minute) Still position	M6: Arms raised in front (20 mm)
M2: 1 minute of calm sitting	M7: Knees bent in a 20-degree crouch
M3: 1 minute of lying down	M8: Cycling for a minute
M4: Moving (1 minute)	M9: Jog (1 minute)
M5: Stair climbing and descending (1 minute)	M10: (1 minute) running

This is further supported for each specific activity by the results for each performance parameter (Table 2). In actuality, routine actions like sitting, lying downward, strolling, and standing still are distinguished. Other activities, like running or knee flexing, that are more dependent on the patient's physical state also exhibit subtle incorrect classifications. The proposed system is a potential activity recognizer, at least according to the positive results of this study.

Table 2. Recognizes each activity class's achievement for the offline assessment

Activity	SE	PPV	SP	F-Score
M1	2.00	2.00	2.00	2.00
M2	2.00	2.00	2.00	2.00
M3	0.88	2.00	2.00	2.00
M4	1.66	2.00	2.00	2.00
M5	1.99	2.00	2.00	2.00
M6	2.00	2.00	2.00	2.00
M7	2.00	2.00	0.98	1.00
M8	1.00	0.88	0.96	0.66
M9	0.99	2.00	2.00	0.44
M10	2.00	2.00	2.00	0.99

Figure 5 and Table 2 display the findings following the examination. The system under development has highly promising identification abilities for the activities under consideration. The confusion matrix in Figure 6 is almost diagonal, which denotes a nearly absolute performance.

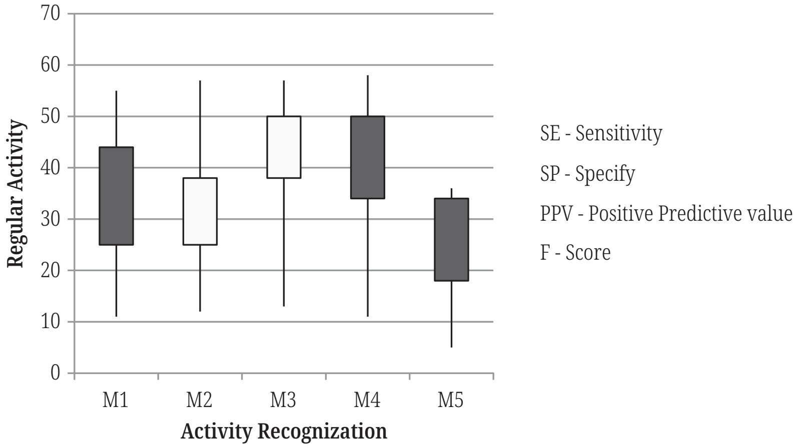

Fig. 5. Activities are detected using the labels introduced in Table 1 and the confusion matrix produced from the offline assessment of the activity recognition system

Figure 6 shows the activities that each user's m-Health App identified. Broadly speaking, the system demonstrates strong recognizing abilities [16]. There aren't many anomalies or misunderstandings found. For instance, the model occasionally interprets "standing and resting" to mean that people are stretching their waists forward or raising their arms. This is explained by the jarring movements that some of those involved made while this activity was being completed. Similar mistakes are made when detecting "knees bowing or crouching", which is once again confused with "midriff bend backwards". This is a result of certain challenges that some users had when completing this workout, which caused a mild rocking back and forth. The categories of "walking", "jogging", and "rushing" are occasionally incorrect, primarily due to the individuals' varied cadences while carrying out these activities.

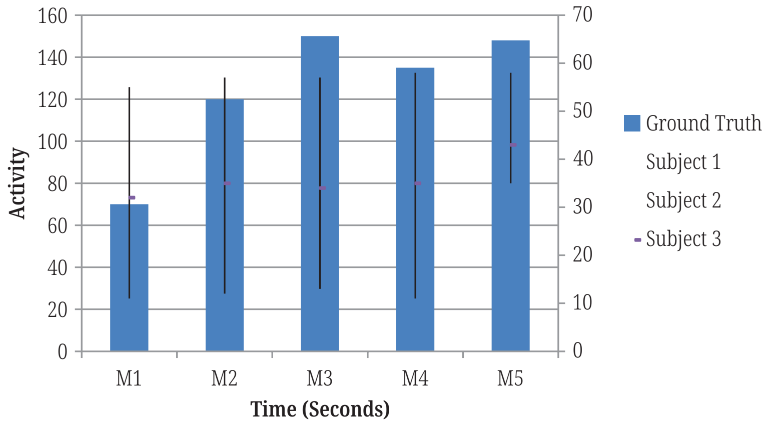

Fig. 6. Activities spotted by the suggested recognizer for numerous themes while the system was being evaluated online

The confusion matrix (Figure 7) and the unique performance indicators for each activity provide additional evidence in support of all of these conclusions. In conclusion, the created m-Health-App recognising activities model is not only demonstrated to work on an experimental basis but is also demonstrated to work effectively when the system is used regularly.

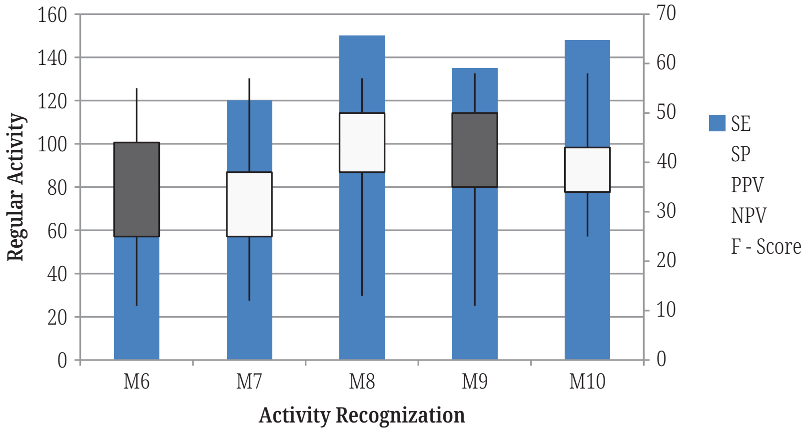

Fig. 7. Confusion matrix derived from the activity recognition model's online evaluation labels used in Table 2 allow for the identification of activities

In this research, a unique m-Health framework that aims to simplify and speed up the creation of mobile health applications is introduced. The framework was created with an eye on the important needs of m-Health technology and apps. This work also launched mHealthDroid, an Android OS-based open-source application of the proposed m-Health Foundation. The integration of mobile devices with heterogeneous multimodal sensors, encompassing both research and industrial systems, is the goal of this implementation. The mHealthDroid platform provides support for both fundamental and sophisticated mHealth application features, including resource and interaction conceptualization, medical data acquisition, medical information extraction, ongoing data storage, adaptive visualization, system administration, and value-added services like intelligent alerts, suggestions, and instructions.

In the end, mHealthDroid hopes to bring together programmers, medical experts, academics, and health lovers to share ideas and work together to define useful tools for a better society. In light of this, the authors call on the community to support the usage of cutting-edge sensors, include new behavioral algorithms, or simply use the platform to create cutting-edge mobile health apps.

5 CONCLUSION

The field of mobile health is young and promising, and it has the potential to transform many aspects of healthcare for both infectious and non-communicable diseases. Governments, organizations, and even particular patients should make investing in m-Health a top priority. Emerging mobile technologies should be adapted to assist people and nations in enhancing national health and addressing significant public health crises. The data supplied here will also be used for comparative reasons in the future to document the influence of m-Health on research. This research suggests a private illness detection method based on decision trees for mobile healthcare networks that use little user-side resources.

Modern smartphones and tablets, as previously mentioned, have adequate computational power, media-rich capabilities, and context-aware characteristics that make them suited for mobile electronic-health apps. As a result, m-Health applications are increasingly targeting these devices. The fast-rising quantity of m-health applications in the Apple App Store is proof that many m-health application developers have selected iOS mobile phones as the target device to offer a more convenient and rich user experience. There were various trends found by looking at the top 300 of these apps in the App Store.

6 ACKNOWLEDGMENT

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