

Mobile Phone Based Health Care Technology

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Abstract: According to the World Health Organization reports, chronic diseases are by far the leading cause of mortality in the world, which places an ever enormous strain on the world's healthcare industry. At the same time, mobile phones have been gradually adopted for solving some tough health care issues which are hard to tackle otherwise from conventional medical strategies. Since mobile phone is a most easily available electronic device which supports a variety of technical functions for human daily activities, efforts are being made to dig out its roles in the delivery of healthcare services and the promotion of personal health. At the present stage, application of mobile phone in health care is a combination of sensor and communicating technology. In this article, some most typical technical approaches leading to several patented health care mobile phone are outlined and digested. They include but are not limited to mobile phones combined or integrated with sensors, modified with additional functions, such as stethoscope, etc. Future prospects along this direction will be discussed.

Keywords: Mobile phone, health care, wearable medical device, low cost medicine.

INTRODUCTION BACKGROUND

The advancement of science and technology in the field of health care has improved the quality of people's life significantly. However, chronic diseases, such as heart disease, stroke, cancer, chronic respiratory diseases and diabetes, are by far the leading cause of mortality in the world, representing 60% of all deaths. Moreover, 80% of chronic disease deaths occur in low and middle income countries [1]. In addition, in almost every country, the proportion of people aged over 60 years is growing faster than any other age group, as a result of both longer life expectancy and declining fertility rates. Most old people, around 70 percent, live in developing countries [2]. The large amount of patients with chronic diseases and the increasing percentage of older adults, combined with the rising cost of medical procedures, will place an ever enormous strain on the world's healthcare industry, especially on that of the developing countries.

The rapid adoption of powerful mobile computing devices brings up the creation of a new preventive healthcare opportunity. Mobile computing devices capable of collecting and processing sensor data acquired by wearable sensors and informing a user via audio or display panel, for instance, mobile phones, personal digital assistants, watches, etc. are emerging. Moreover, these devices are becoming smaller, lighter, and less expensive. Mobile computing devices are carried nearly everywhere by an increasing percentage of population, and therefore, can be used to deliver daily health information [3].

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THE RECENT DEVELOPMENT IN HEALTH MONITORING

At the present stage, health monitoring is mostly implemented in hospital or health care center. However, this augments the costs of ailments, and at the same time, the treatment of chronic diseases requires a long-term health data monitoring. To some extent, the resource allocation is unreasonable. The requirement for mobile monitoring is increasing rapidly.

In mobile health monitoring applications, the patients are located at a distance or mobile. Small portable devices such as mobile phones, personal digital assistants and watches rather than settled equipment, are used for collecting and processing health information. Transmission technologies such as Bluetooth, USB, Global System for Mobile Communication (GSM), and General Packet Radio Service (GPRS), are used to communicate information between patients and health care providers.

To meet the increasing demands for health monitoring and healthcare management, many research projects and public administrative reforms are being carried out worldwide. Since mobile phones that integrate various functions, such as personal information management, camera and application platform, are increasing, and 3G mobile phone makes it possible to transfer large data, such as photos, movies, and application files, a lot of big enterprises and research institutes, universities are applying mobile phone-based infrastructure and matured IT technologies to provide new services for mobile health monitoring and daily healthcare management [4-15].

TYPICAL USE OF MOBILE PHONE IN HEALTH CARE

According to the research in latest few years, the most common use of mobile phone in health care is a combination of sensor technology, such as home based patient monitoring devices, and web-based programs, etc. The overall system

implementation is structured into three functional layers: sensing, communication, and management [4] Fig. (1). Sensing layer implements a mobile monitoring for health data, signal processing, and data analysis. Communication layer includes short range wireless connection via Bluetooth, or different technologies for short range communication, and worldwide wireless connection via a mobile phone. Management layer carries out data processing and management tasks, mostly through internet. Researchers have proposed several systems based on the above three layers [16- 25].

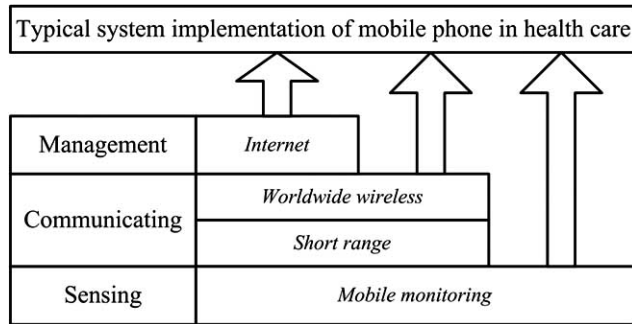


Fig. (1). Typical system implementation of mobile phone in health care comprised of three functional layers.

A mobile phone combined with physiological function detector was disclosed by Shen [26]. The system comprises a physiological function signal receivable mobile phone, a measurer used to touch on the human skin and transmit detection signals to the mobile phone by wire or wireless transmission method, as shown in Fig. (2). The mobile phone can show measured data in its display for reminding a user of his health conditions [26].

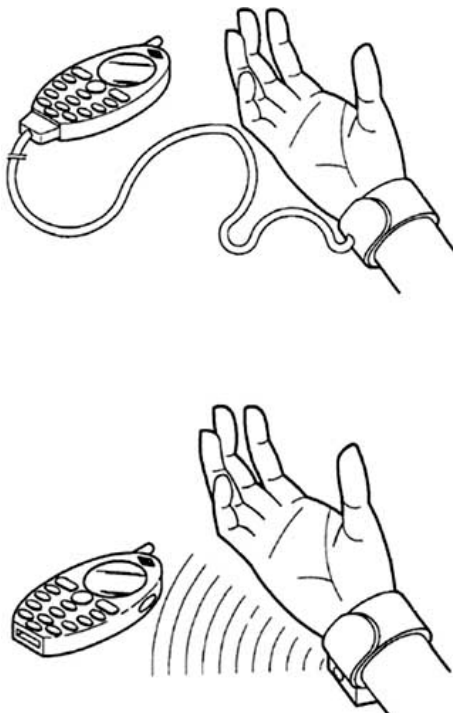


Fig. (2). Signal transmission of the measurer in different ways [26].

Apodaca and Peralta presented an apparatus that combines a cellular phone with medical monitoring devices, such as blood glucose monitoring, etc [27]. The invention is capable of audibly alerting the user of abnormal test results. Furthermore, for monitoring and managing chronic diseases, it can store multiple test results for further analysis. In addition, the apparatus is capable of transmitting test results to healthcare providers and, when highly abnormal results are obtained, to emergency responders.

Generally, the above inventions mainly comprise four modules: a user management module, managing user information; a data analysis module, analyzing user's health condition based on the user information and health data stored in the memory and/or received from sensors and generating analyzed result; a data management module, managing the user health data and the result, and a communicating module transmitting both.

RECENT PATENTS OF MOBILE PHONE IN HEALTH CARE

Some applications of mobile phones used for health care are emerging in the commercial field. Mobile phone can be used on its own or combined with other technologies. Obesity is a major health challenge with over 65% of U.S. adults either overweight or obese. Some mobile phone applications allow users to self-monitor caloric balance in real time and help users track their behaviors related to weight management [9]. Applications such as calorie counting can be supported by software on the phone, and customized meal recommendation can be delivered to the user's mobile phone during the day [28]. The phone camera can be used to take a picture of a meal which is sent to a dietician who interprets meal content and makes recommendation about dietary needs [29].

In the following part, according to the innovativeness of the inventors' work, we have chosen several patents related to mobile phone used in health care. Some of them have been applied in several areas throughout the world, and US patent numbers are selected with priority in this article.

HEALTH MONITORING METHOD AND APPARATUS USING THE TONGUE IMAGE

Samsung Electronics Company disclosed a method of extracting a region of interest from a tongue image and a health monitoring method and apparatus using the tongue image [30]. According to the invention, the tongue image is acquired by a typical digital camera, such as a camera attached to a personal computer, or a camera attached to a mobile phone. The health monitoring method includes constructing a database in which a tongue image obtained from a person, a template image set for the person, and a result of determining a health state of the person. A person whose health state is to be determined uses the camera to acquire a tongue image, and then a region-of-interest extractor extracts a region of interest from the image, using template matching between the tongue area and a template image stored in the tongue image database. After that, a characteristic extractor detects characteristic factors from the extracted region of interest; a comparator compares the data extracted with the data stored in the database. Finally, a health state determiner, which determines the person's health

state based on the result of comparison, informs the person of the result of determination (Fig. (3)).

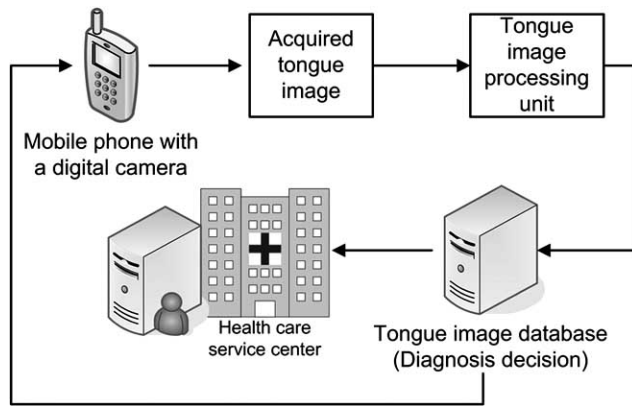


Fig. (3). The components of the health monitoring method and apparatus using the tongue image. The tongue image database provides results to the user and the health care service center both.

This invention requires that the tongue image is photographed under constant illumination in order to reduce color distortion, and assumes that the tongue has almost the same length or makes the same angle every time when photographed. These restrictions would defeat the utility of the device.

MOBILE DIAGNOSTIC SYSTEM USING AUDIBLE SOUND

A system using a mobile phone of simple structure for the purpose of making diagnosis was disclosed by Yoshimine [31]. With respect to this invention, a user’s audible sound is registered when he is in good health, and when not feeling well, he may pronounce words to his mobile phone. The audible sound will be stored and processed by a computer which provides diagnosis to the user and the user will be informed of the health status (Fig. (4)).

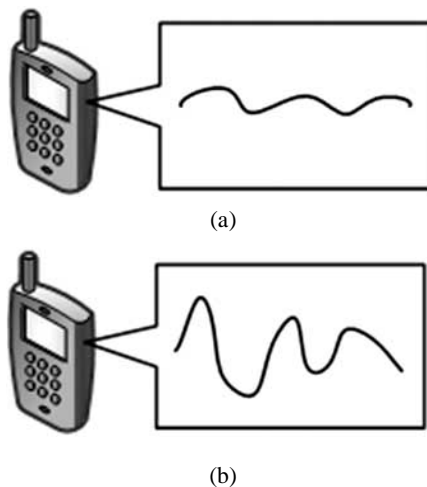


Fig. (4). (a) Audible sound data of a person in good health; (b) Actual audible sound information picked up when the user’s health is abnormal (Modified from US2004109571).

This patent also claims the following statement. By providing a CCD near the microphone, when a user speaking over the mobile phone, a bit of saliva which should spatter around the microphone, can be photographed and magnified. Therefore, the patient can receive more detailed diagnosis. After analyzing the image and the sound data by medical institution, the diagnosis would be delivered to the mobile phone owned by the patient, and the patient will thus be able to obtain his diagnosis. However, the method of acquiring saliva image is passive. It would be better to transform this procedure to be active.

Another patent using audible sound was presented by Lee [32]. The principle is similar with the above.

SYSTEMS MODIFYING BATTERY PACK OF MOBILE PHONE

The battery pack of a mobile phone is an alternative. Users can choose whether or not to use a special battery pack. By modifying the battery pack [33], researchers have provided several systems.

A blood sugar tester and data uploading method was disclosed by Lee and Kim [34], which later leads to a product of Healthpia Company, and is perhaps the world’s first All-in-One Diabetes Phone (Fig. (5)). According to that invention, two embodiments are provided. One is a mobile phone integrated with blood sugar test function, and another is a mobile phone with a connection terminal which connects a blood sugar test adaptor used to perform blood sugar tests. Both can transmit measured blood sugar level to the blood sugar level administration server. A strip connector allowing a strip applied with blood sample to be inserted into it is integrated into the battery pack in the former while a strip is located at an outer face of the adaptor in the latter. Furthermore, the battery pack in the former includes a sensor part for measuring electric current corresponding to a glucose level, a temperature sensor part for measuring temperature, and a signal conversion part for converting a measured electric current into a glucose value referring to the respective temperature, while in the latter all these are integrated into the adaptor [34]. The method provides a blood sugar test adaptor that allows a conventional mobile phone to be used as a blood sugar test device.



Fig. (5). (a) Diabetes Phone, Convergence products of mobile phone and glucose meter; (b) Regardless of phone model, it works with mobile phone through the phone connector [35].

Another invention presented by Lee relates to a battery pack of a mobile communication device to be capable of measuring quantity of motion and body fat as well as

counting the user's walking number of steps (pedometer) [36]. The pack comprises an acceleration measuring section, a mobile quantity measuring section, which calculates the quantity of motion of the pack by calculating the acceleration value of four directions arithmetically, a counting section which counts the device user's walking number of steps, data input and output controlling section and main frame interface section interfacing data between the I/O controlling section and the main frame of a device [36]. This invention also leads to a product of Healthpia Company Fig. (6).



Fig. (6). Diet Phone, used to measure body fat and exercise level [35].

Another product of Healthpia is a Stress Zero Phone Fig. (7) [35], which is used to monitor stress level, analyze physical and mental stress level simultaneously, and provides de-stress methods such as music and respiration. This apparatus works through the test of HRV (Heart Rate Variability). The details of the operation principle are not clear yet according to this review.



Fig. (7). Stress Zero Phone monitoring stress level [35].

MULTIFUNCTIONAL MOBILE PHONE PERFORMING HEARING AND VISION TESTS

Since the effectiveness of the current screening methods to detect early the hearing impairments in babies and young children is poor or unavailable in some countries, Nowasielski disclosed a multifunctional mobile phone performing the hearing and vision tests [37]. According to the invention, the modified mobile phone acoustic channel delivers the amplified environmental noises, including speech, through the special earphone to the patient's ear. The acoustic sounds patterns for the purpose of the hearing test can be stored in the mobile phone internal memory. Selection of the testing sounds patterns and their intensities is controlled from the mobile phone keypad and shown on the display. The test result can be stored in the mobile phone internal memory for further data processing. If there is any

incoming call, the hearing aid mode can automatically changes to the normal mobile phone communication. The inventor also claims that the further extension of the mobile phone functions will allow to control the built in or externally connected devices typically used for monitoring the cardiac and respiration rate, blood sugar level, etc.

MOBILE PHONE DETECTING EEG

An invention assigned by LG Electronics using a mobile terminal integrated with built-in sensors for detection of temperature, vibration, conductive response and brain waves to sense the body condition of the user was disclosed by Kwoen [38]. The mobile terminal repeats the user's body condition information sensed by the detector to the server. The special point of the invention lies in that when the sensed value of the EEG sensor is transmitted to the server, the mobile terminal receives it from the server and discloses music and/or light and/or image for improving the psychology of the user.

HEALTHCARE RELATED TO ENVIRONMENT

According to the truth that some chronic diseases such as asthma, is largely influenced by the environmental factors, for instance, air pollution index, temperature and moisture, an invention providing method, internet platform, and mobile phone analyzing and managing for the health state and the environment of a patient was disclosed by Taiwan Chest Disease Association [39]. A user may complete a physical state information survey provided by the software and send a message via a mobile phone to an internet platform. The internet platform determines present location information of the user, obtains environment information of the user's present location, and then analyzes the health data according to the environment information.

According to this invention, one can imagine that it is possible to integrate sensors used to collect environment information into the mobile phone, which would be more convenient for users.

MOBILE PHONE WITH A VIBRATION MODULE FOR HEALTH CARE

The low frequency vibration is helpful to arteries and veins in the hand, and even beneficially affects entrails in the user's body [40]. For instance, waves with a frequency of 1Hz are helpful to the liver. According to this truth, a mobile phone with functionality for health care was provided by Chen (Fig. (8)). The mobile phone, which is made of flexible plastic material, includes a body, a vibrating module, a vibration control switch, and a function switch. When the mobile phone is used as a general phone, the switches are in a closed state. A user can identify an incoming call or message according to a ring tone, a type of vibration, or a combination of both by pressing the power switch and the vibration control switch. By pressing the function switch, the user can use the mobile phone as an instrument for health care since the vibration module is turned on to produce low frequency waves.

Although this invention is creative at the first glance, however, as a result of the special realization form, there could be several obstacles in the way of this device's

promotion. It is unpractical for one to wear this device all the time and the radiation issue could be a problem.

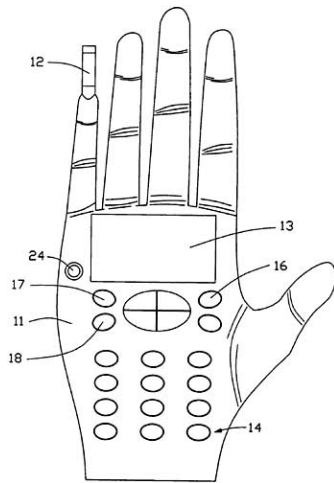


Fig. (8). A mobile phone in the form of a glove, including a body and a vibration module [40].

MOBILE PHONE WITH AN EAR TEMPERATURE SENSOR

People infected with SARS or avian influenza have similar symptoms such as fever, cough, pneumonia and respiratory at the beginning, which makes it difficult to diagnose in the early stage. Moreover, because of the fast human-to-human transmission, it is recommend that people visiting Southeast Asia should be cautious about any symptoms related to avian influenza. Therefore, it is vital to detect body temperature to find out if a person is having a fever [41]. According to these truths, Shen disclosed a mobile communication device provided with an ear temperature sensor. By using the device, a user can detect the ear temperature immediately and the mobile phone performs display, alert, storage and communication functions. The inventor provides several ways to install the ear temperature sensor on the mobile phone, such as fixed type, sliding type, pin type, pivotal rotation type, or wirelessly transmitted detecting pen type of methods, one of which is shown in Fig. (9). The user can enable the ear temperature sensor by pressing the measuring key to get the data, and then the ear temperature is shown in a display of the mobile phone.

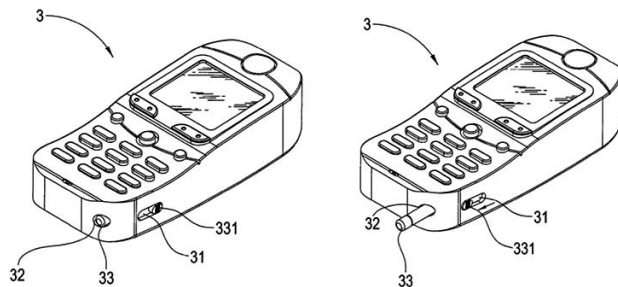


Fig. (9). One of the embodiments of the mobile communication device provided with an ear temperature sensor [41].

MOBILE PHONE WITH A STETHOSCOPIC FUNCTION

Lee disclosed a mobile phone with a stethoscopic function [42]. A user can contact the mobile phone with a stethoscope with the medical examination place of human body. The analog auscultated sound data collected by the stethoscope are converted into digital data after noises are filtered and data are amplified. The digital auscultated sound data are then inputted into the search and comparison unit, which identifies corresponding sound data in the pre-stored standardized digital auscultating sound data with allowable errors of data. Finally, the diagnostic data are outputted and displayed in the name of an illness, waveform or picture on the mobile phone display monitor. Besides, the user can store and transmit the data to a physician using the communication function of the mobile phones without visiting hospitals.

A DIAGNOSE SYSTEM BY ANALYZING FACE IMAGE AND VOICE CHARACTERS

Sanyo Electric Company disclosed a mobile phone set having a display panel and a camera with a disease database in which symptoms and disease names are stored so as to correspond to each other [43]. By analyzing a face image and/or voice characters using a face image and voice characteristic analyzing function, the system is able to select matched symptoms from the symptoms stored in the disease database. The disease name will be extracted corresponding to the symptoms, and then the disease name can be viewed by the patient at the display panel.

CURRENT & FUTURE DEVELOPMENTS

Advances in the technologies that underlie mobile phones are enabling them to become better, faster, and less expensive. Mobile phones will play a part and parcel role in health care. There have already been some examples [44].

T+ medical, who works with Oxford University, uses mobile phones, mainly working on diabetes, to offer cost effective Disease Management and Remote Monitoring Solutions [45].

Researchers have presented a new medical imaging system made of two independent components connected through cellular phone technology [46]. The cellular phone technology transmits unprocessed raw data from the patient site, which includes a data acquisition device with limited controls and no image display capability, and receives and displays the processed image from the central site, which includes an advanced image reconstruction and hardware control multi-server unit.

The health conscious phone, designed by Lee [47], enables users to track their health through nutrition and fitness, other users of this phone with similar goals such as lose weight networks together to motivate, and hold the others accountable for their workout sessions (Fig. (10)). The phone is capable of recognizing foods eaten by their unique chemical signature. It tracks intake wherever one goes, and will periodically analyze info to let one know what food groups are missed.



Fig. (10). eNose health phone, used to track one's health through nutrition and fitness [47].

A wellness phone prototype is promoted by N-TT DoCoMo Fig. (11) [48]. The built-in sensor within the health handset is able to measure one's body fat, heart rate, bad breath (halitosis) and footsteps.



Fig. (11). Wellness phone prototype, measuring one's body fat, heart rate, bad breath and footsteps [48].

Qualcomm is also working on mobile phones for healthcare [49]. Qualcomm has launched a mobile virtual network operator company focused on healthcare, which is called LifeCOMM. The mobile network would allow people to use their cell phones to manage their health information.

Evidence is beginning to emerge about the value of mobile phones used for health care. At the same time, many enterprises have noticed the feasibility of using internet in healthcare for patients to manage their health records and to contact with doctors [50-53]. The Committee on the Quality of Health Care in America proposed six aims and ten simple rules for improvement [54]. One of the rules is that the patient is the source of control. According to the current trends, combining mobile phone with internet to work on health care will be of great value and challenge. In the future, patients will be able to collect health data anywhere at anytime and view their records at any computer or mobile phone connecting to internet.

However, some problems are still in the way. Technologies intended to be used for health care should be accessible by all types of individuals, while the majority of mobile phones on the market are sophisticated devices with relatively complicated user interfaces. It is expected that the user interface of the phone can be simplified. Some researchers have already been working on this problem [55]. Moreover, the quality of network connections varies in geographic location, and data security must be taken into consideration. Another barrier to the development and adoption of mobile phone used in health care lies in various software operating systems for mobile phones [56]. In addition, development environments for mobile phones vary, including systems such as Microsoft Windows Mobile, J2ME, Palm OS, Symbian, Blackberry, and Mobile Linux. The programming language differs, and applications developed to run in one environment are not compatible. All these barriers can slow the innovation, adoption, and improvement of information technologies.

CONCLUSION

This paper has attempted to give a snapshot of completed, ongoing and emerging applications of mobile phone based health care technologies. With regard to the concerns mentioned here, it is worth noting that mobile phone technologies are affecting but not limit to the medical field of life. Emerging technological trends provide promising solutions for mobile health care applications. In order to facilitate wider application of mobile health care and offer better service to the patients, efforts in compatibility, standards, and security are needed.

CONFLICT OF INTEREST

We declare that we have no conflict of interest in this study.

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