Health Internet of Things: Recent Applications and Outlook

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Abstract

The Health Internet of Things (Health-IoT) is a milestone of the health information system development, and it will play an important role in improving people’s healthy level and enhancing the quality of life and health service level, and will promote the change of health service mode. Health-IoT is a very complex system, involving computer science, microelectronics systems, wireless communications, medical and health, and many other related fields. In this paper, we review the background and state-of-the-art of Health-IoT. We first introduce the general background of Health-IoT and the difference between Health-IoT and traditional IoT are given. Then we give the definition of Health-IoT and the Health-IoT’s features. We then focus on the researches closely related to the Health-IoT, including physiological information collection, data transmission, wearable computing, and health big data analysis. We introduce the four typical application scenarios of the Health-IoT, including the medical industry, health monitoring, exercise promotion and mental support. Finally, we give the outlook of Health-IoT and the summary.

Keywords: Health Internet of things, Internet of things, Physiological information collection, Health big data, Wearable device.

1 Introduction

The report of World Health Organization (WHO) indicates that the medical systems of various countries are under intense pressure for the population aging problem, which is more and more severe due to the limited quantity of medical facilities and medical personnel. Especially, the supply in the medical service industry of developing countries is insufficient severely for the public demand. For example, in recent years, the Chinese Government are constantly increasing the financial expenditure on the medical health service, and the expenditure has been increased to more than 204.8 billion Yuan in 2012 from original more than 118 billion Yuan in 2009, and the high medical expenditure causes extremely great financial burden to the society and the Government. Another example is that, chronic diseases develop slowly in normal conditions and the disease course is long, heart disease, stroke, cancer, chronic respiratory system disease and diabetes mellitus are the foremost death causes in the world up to now, which occupy 63\% of all deaths. In 36 million people who died of chronic diseases in 2008, 29\% of them were under 60 years old. The recovery and care to these chronic diseases is a long-term task, which needs nursing from hospital, community and family [1]. According to the definition of health made by the WHO, more than 1/3 population is under the transition from health to illness, which is called as sub-health situation. If the treatment to the sub-health is proper, the body may turn to health; on the contrary, the body may turn to illness. Nowadays, many people may be flagging in spirit and depressed in mood, or may be under sleepless and dreamy or nervous conditions in daily life, which present tiredness and fatigue, or short breath when doing exercise in physiology. In addition, cardiovascular system symptoms such as palpitation and arrhythmia may occur. Many patients have missed the optimal treatment time when they are sent to hospital. The World Health Report 2013: Research for Universal Health Coverage indicates that the universal health coverage widely pays attention to services required by guaranteeing the healthy status. These services cover the clinical nursing of individual patient to public health service of guarding the health of all people, including various services within and out of the authority of health administrative departments [2]. Realizing the universal health coverage and making all citizens obtain fair and available health service and guaranteeing reliable quality has an important and positive impacts to the political stability, society safety network establishment and society fairness enhancement. These existing problems propose many new challenges to the current medical and health service industries.

Health Internet of Things (Health-IoT) is an important path to solve the medical health problems mentioned above, and it also has an important realistic meaning for promoting the development of the medical health industry and improving the people’s quality of life. Compared with the traditional things-centered IoT, the Health-IoT is “human-centered”, and all network accesses, data analyses and services are conducted surrounding human; the sensor at the data collection layer is not a common sensor any more, but a human body sensor for collecting physiological...
The previous Health-IoT emphasized the design of human body sensor and the collection of human body physiological data, and didn’t fully consider the users’ mobility. Therefore, it is inconvenient to use in daily life and may even affect the daily life. The development of mobile internet brings the integration of physical world, virtual world and social network, thus generating Cyber-Physical Society Systems (CPSS). Integrating the Health-IoT into CPSS, and making users may obtain the service and convenience brought by mobile health and mobile medical treatment while users are under highly mobile conditions in the physical world and the social network space is an inevitable trend for development of Health-IoT. This thesis considers that the Health-IoT in the future possesses the following features:

1. It supports the high mobility of users and uses portable device, wearable device and intelligent terminal device; and users can obtain the health service at any site and time in any mobile occasion such as family, working and social communication.

2. The human centered Health-IoT which faces to the integration of three-dimensional space of “human-machine-things” is an inevitable trend of the development of the Health-IoT in the future.

3. By virtue of the powerful computation and analysis capabilities of cloud computing and mobile cloud computing, it can provide more accurate and real-time health services for users, which will also become an important development direction of the Health-IoT in the future.

4. The Health-IoT in the future will not only pay attention to users’ physiological health, but also pay attention to users’ mental health. It will establish the emotional interaction feedback with users by virtue of wearable device, and provide integrated services including physiological health and psychological health.

This paper contributes the following contents: proposing the future Health-IoT based on mobile equipment (intelligent terminal, wearable device, portable device, etc.), combining with social communication network seamlessly, integrating mobile cloud computing and mobile cloud service and possessing affective interaction and feedback functions.

The rest of this paper is organized as follows: Section 2 illustrates the definition the Health-IoT, Section 3 introduces typical applications of the Health-IoT, and Section 4 presents the application outlook of Health-IoT, and the last section refers to the conclusion of this paper.

2 The Definition of Health-IoT

The traditional IoT has been widely applied in the traffic, logistics and retail industries and has obtained obvious achievements. With the maturation of technology and promotion of application demand, the IoT attracts people's attention in the health service field. However, most applications which promote health service into families and to individuals by utilizing the technology of IoT reference to prove that it was not successful. The health information is one of important manners to improve medical treatment quality and service efficiency, and the Health-IoT will make the health information develop towards the era of IoT from the era of internet. The Health-IoT is a milestone of the health information development, and it will play an important role in improving people's healthy level and enhancing the quality of life and health service level, and will promote the change of health service mode.

The transformation of the health service mode brought by the Health-IoT not only benefits patients, but also makes the whole industry form an organism of health services, and the connotation of the Health-IoT is shown as below:

1. The active service at any time and in any place which is provided by the IoT may make patients judging their own healthy situations more objectively, and reduce the mindless occupancy of medical resources resulted from that people go to the large hospitals for their mild diseases;

2. Patients can enjoy professional nursing and health guidance in the community or at home, thus reducing the bed occupancy rate of hospitalization, improving the using efficiency of resources and relieving the economic burden of patients;

3. Health institutions in communities and some new type health service centers may issue terminals through leasing or only charging service fees, thus becoming healthy consultants closest to patients and knowing patients' physical situations most, and improving patients' loyalty and finally forming stable service crowds;

4. By virtue of the terminal sensing capability of the IoT, the monitoring on sudden health events and running of emergency system directed by the Government may be more accurate and efficient;

5. Providing efficient solutions for monitoring on the health of crowds with high risk may cause group injury due to personal emergency health problems of employees in occupational disease monitoring and special industries (such as driver of taxi and civil pilots).

The contents of the next section introduces researches closely related to the Health-IoT, including four aspects, i.e.,
physiological information collection, data transmission, wearable computing, and health big data analysis.

3 Related Work

3.1 Physiological Information Collection

The physiological information collection is the basis of the Health-IoT, while the sensor is the most important link of physiological information collection, and it is the bridge between the physiological world and the electronic system. The sensing device is responsible for collecting the physiological data from human body, and these collected data will help users check their own physical situations at any time and in any place or help doctors diagnose for patients. According to users’ demand for mobile medical treatment and health system summarized by literature [3], the physiological information collecting devices in the applications of the Health-IoT are divided into two large categories, one category collects the physiological information through sensing components integrated on universal mobile devices (GMD: General Mobile Device) (like mobile-phone); and the other one refers to dedicated medical health collecting device (MHS: Medical Health Sensor), which collects health information through designing and integrating one or multiple dedicated health sensors. The following refers to respective features of these two kinds of collecting devices.

3.1.1 GMD Collecting Method

The universal mobile collecting devices possess advantages of low cost as well as convenient carrying and using. However, they also have disadvantages. For example, the precision of data collecting is low and the collected physiological information types are limited, and their concrete features are shown as below:

- Independent running: they can complete the health data collecting without adding other devices, and only relying on themselves and the integrated sensor functions.
- Short collecting process: at present, the power supply for mobile devices is limited, and many other functions are also running on mobile devices. Therefore, the data collecting in this manner can only last a relatively short period.
- Low precision of data collecting: at present, although there are some mobile devices with professional medical health services, the medical health data collected by most mobile devices are not precise, and these data can only be used in detecting human body’s signs simply, but cannot be directly applied in the medical field.
- High participation degree of users: mobile devices integrate rich functions, so users may need to install dedicated software on devices, and activate corresponding sensing elements, so as to collect the data. Sometimes, users even need to input words, take pictures and record audios and video documents.

In a word, collecting the medical health data in this manner is convenient, but the provided functions are limited.

3.1.2 Medical Healthcare System (MHS)

For the MHS device adopts dedicated sensor, and possesses the advantage of high collecting precision, while it is also featured by disadvantages including high cost and insufficient portability and usability. This kind of device possesses the following features:

- Wearability: Most MHSs must be provided on the human body so as to collect data exactly for it takes vital signs of humans as collecting targets. Therefore, almost all existing medical health collecting devices take wearability as the basic requirement. In this case, the users’ comfort feeling can be improved and the accuracy of the collected data can be guaranteed during the collecting procedure. The layout of common human body sensors are shown in Figure 1.

![Figure 1 The Layout of Common Human Body Sensors](image)

- Long working time: The method of the dedicated medical health collecting device is different with universal mobile collecting devices. The purpose of the former one is to collect data from the human body for a relatively long time, which requires highly for the power supply capability of MHS.
- Stability: MHS still can collect data normally when users are under strenuous exercise or in extreme environment.
- Low participation degree of users: Different with the method of GMD, the functions of MHS are relatively independent, and most MHS devices do not need the intervention of users during the data collecting procedure, and users only need to start up the power source, and the MHS will start collecting.
• Possessing data interim storage mechanism: The weight and dimensions of MHS may be limited strictly to meet the wearable feature. Therefore, most MHS devices will not integrate the data transmission module, but will select the data storage module with relatively small dimensions, and adopt the data interim storage mechanism to store the collected data in advance, and then transmit the data through other network access devices.

3.2 Physiological Information Collection

The progress of wireless communication technologies promotes the development of Health-IoT. However, the high power consumption and low rate of data transmission of existing health collecting devices are still important restriction factors for the development of the Health-IoT. The IEEE 802.15.6 standard and Bluetooth 4.0 standard which were passed recently have been improved greatly in these two aspects, and their popularization will greatly promote the popularization of applications of the Health-IoT. In addition, the integration of the short range wireless communication technologies and traditional mobile communication systems (such as GSM and 3G) is also a development trend [4]. For example, the mobile-phone integrating the ZigBee module can communicate with the ZigBee physiological collecting device directly, and then, these physiological data will be transmitted to the central server through 3G network, and this method can make the collecting and transmission of physiological information more convenient.

3.3 Wearable Devices

In recent years, with the rapid development of circuit materials, manufacture processes, wireless network and mobile network transmission, mobile computing and other relevant technologies, numerous breakthrough progresses have been made in research fields of wearable devices, human body local network based on wearable devices as well as data collecting and transmission of wearable devices. These technological progresses provide powerful guarantee for the development of the Health-IoT.

In May 2012, the Google Glass promoted by Google predicts the rising of wearable devices. According to the prediction of Juniper Research, the market scale of wearable devices in 2014 will achieve USD 1.5 billion, and the out-going quantity of wearable devices in 2017 will achieve 70 million. In the filed of applications of numerous wearable devices, what the academic circle and the industrial circle most care is the medical health field. Wearable sensing devices mainly consist of various sensors, processors, memories, transceivers and energy units, and their basic functions include physiological information detection and processing as well as wireless communication. In addition, they possess the features of low energy, small memory, low computing capability and low communication rate. At present, there have been many sensor nodes with different usages and functions, such as sensors for measuring temperature and pulse rate, polyvinylidene fluoride(PVDF) sensors for sensing pulse pressure [5], activity sensors for monitoring the human body’s action [6], three-axle acceleration and gyroscope sensors for reporting the human body’s moving direction [7-8], ultra-low energy consumption sensors based on the ultra-wideband communication protocol [9], and Eco sensors which are ultra-close and scalable [10] and wearable sensors for detecting physiological signals [11]. Although the research on wearable devices has obtained great progress, while the limited energy is the largest bottleneck of wearable devices, and the ultra-low energy consumption with high efficiency design is always one of the most challenges of data collecting and communication based on wearable computation. However, each wearable node will collect a large amount of physiological data to meet the demand of emotional analysis on physiological data collecting in the time scale and data variety. On the one hand, a large amount of physiological data may consume the bandwidth and energy when they are transmitted to network access points from wearable devices; on the other hand, these collected data without targeting may have no value for specific emotional analysis. Therefore, how to collect data and eliminate redundancy according to health services is critical for saving energy consumption of wearable nodes.

3.4 Analysis of Health Big Data

The varieties and quantities of networking devices in the Health-IoT are more than those in the past, and the increasing of generated data volume is quicker, and the traditional data analysis technology is far from enough to meet the explosive increasing of data volume and the daily increasing situation of users’ demand. Meanwhile, adding the emotional care also becomes an important feature of the big data analysis technology of the Health-IoT different with the big data analysis technology in the past.

The multi-dimensional integration and preprocessing core of physiological health and emotional drive are the health big data integration scheme of “one key value, two categories of processing and three-dimensional space.”

4 Health-IoT Applications

There have been some typical applications (Table 1) of the Health-IoT in the medical industry, health monitoring, exercise promotion and mental support. The following
Health Internet of Things: Recent Applications and Outlook

refers to respective instructions of typical applications of the Health-IoT.

4.1 Medical Applications

With the rapid integration of technologies of IoT and hospital information, the clinical medical applications based on wireless network have obtained more and more attention by virtue of its fast and convenient features as well as its future development trend. The medical information based on the IoT has developed to the mobile medical era, and doctors can complete almost all medical matters with mobile clinical terminals. The combination of mobile clinical terminals and hospital processes greatly improves the working efficiency of doctors, and also can provide better service and treatment for patients. At present, many hospitals have started the hospital wireless application deployment in many aspects including wireless clinic, wireless diagnosis and treatment, wireless positioning and wireless tracking.

The solutions which are put into operation at present are almost based on the WLAN technology, which can realize the wireless tracking, calling system, medical device positioning and assets management, hospital medicine positioning and automatic inventory management, medical personnel and patient positioning, anti-theft of infants, physical sign detection of patients, electronic guide system, wireless outpatient infusion system, wireless mobile ward-round system, medical waste transport monitoring, etc. The detailed architecture is shown in Figure 2.

The medical Health-IoT is based on that the hospital establishes wireless coverage. Firstly, the hospital needs to construct a dedicated wireless network, and this network shall be accessed with high density, roam seamlessly, and can be deployed in the co-frequency way. Secondly, the whole system can cover various working links, including management of major patients, ID check, health education, ward visit, special patient hints, physician’s order hints, physician’s order review, physician’s order execution, nursing degree and diet treatment, vital sign collection, medicine check and patient follow-up, and utilize the

<table>
<thead>
<tr>
<th>Applications</th>
<th>Service contents</th>
<th>Major applicable objects</th>
<th>Device type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medical care</td>
<td>It includes positioning of medical staff and patients, physical sign detection of patients, wireless mobile ward-round system and other routine medical businesses.</td>
<td>Doctors, patients, management personnel, and other hospital employees</td>
<td>Dedicated devices</td>
</tr>
<tr>
<td>Health monitoring</td>
<td>Monitor physiological indexes of patients of chronic diseases for a long time, and provide reference for disease treatment.</td>
<td>Patients of chronic diseases</td>
<td>Dedicated devices</td>
</tr>
<tr>
<td>Exercise promotion</td>
<td>Monitor physiological indexes during the exercise, and provide guidance for physical exercise.</td>
<td>Common people and athletes</td>
<td>Wearable devices</td>
</tr>
<tr>
<td>Mental support</td>
<td>Relieve psychological stress and treat psychological diseases.</td>
<td>Patients of psychological stress and psychological diseases</td>
<td>Dedicated devices or wearable devices</td>
</tr>
</tbody>
</table>

Figure 2 Application Architecture of the Health-IoT in the Medical Industry
mobile computing, intelligent recognition and data fusion

realizing the health management, realize the intelligent
technologies can solve difficulties and problems for
important branch, and the Health-IoT and its relevant
Israelita Albert Einstein (HIAE).

and this system has been deployed in the famous Hospital
wireless monitoring refrigerators and freezing chamber,
manage temperatures of thousands of medical devices and
monitoring solutions [14], which can be used to track and
system (RTLS) to develop assets tracking and temperature
solutions supplier AeroScout utilizes real-time location

addition, doctors can view the values through PC and other
time way when patients wear dedicated instruments; in

the solutions of detecting radiation doses provided by the
RaySafe i2 produced by GE Healthcare Company, doctors
can obtain the radiation doses values of patients in the real-
time way when patients wear dedicated instruments; in
addition, doctors can view the values through PC and other
display devices, and can change their behaviors instantly
to reduce the radiation dose [13]. The medical assets visual
solutions supplier AeroScout utilizes real-time location
system (RTLS) to develop assets tracking and temperature
monitoring solutions [14], which can be used to track and
manage temperatures of thousands of medical devices and
wireless monitoring refrigerators and freezing chamber,
and this system has been deployed in the famous Hospital
Israelita Albert Einstein (HIAE).

The intelligent remote medical treatment is also an
important branch, and the Health-IoT and its relevant
technologies can solve difficulties and problems for
realizing the health management, realize the intelligent
remote medical treatment, provide real-time dynamic
health management service for patients, and provide real-
time dynamic medical service platforms for doctors,
provide real-time dynamic data of health records for health
managers, and combine the three parties organically. It is a
kind of enclosed circulating system, and consists of three
parts: self-health management (health education, health
record, etc.), health monitoring (including detection of
health indexes, such as blood pressure, blood glucose, blood
oxygen, ECG, intelligent health early-warning, viewing
health records of residents, viewing health common senses
and health guidance, etc.), remote medical assistance
(including medication guidance, dietary guidance, exercise
guidance, chronic disease cases, etc.); they interact
mutually and are linked with each other, which guarantee
the whole-process monitoring to the health of individuals.

The realizing of the whole-process monitoring is
reflected thoroughly in the digital health management
idea and principle: one is fine granularity, which means
providing individual health solutions targeting different
people groups. The second one is new concept, which
makes the professional medical treatment go into families,
intervene with potential health crisis, and turn the passive
treatment to active health management. The third one is
all-round, i.e., conduct overall management to the health
of the masses through physical examination, assessment,
prevention, intervention and consulting. The fourth one
is multi-path, i.e., realize the seamless communication
with medical experts in multiple ways, such as website,
telephone, email, audio, video and field. The fifth one is all-
cycle, i.e., provide the health records of the whole life and
various health management services. The sixth one is high
technology, i.e., utilize remote family health devices and
advanced IT technologies to make you enjoy professional
medical health services without outgoing. The seventh one
is high quality, i.e., the intelligent medical treatment is an
important field of research on the IoT, and it utilizes sensors
and other information recognition technologies and realizes
the interaction between patients and medical personnel,
medical institutions and medical devices through wireless
network.

The sensing health service mode is a contraction
of intelligent medical treatment. Firstly, select target
customers, and search the health information completely
through the health experience and remote monitoring,
and establish health records. Secondly, conduct the health
assessment and risk prediction to health records. If the
monitoring result refers to healthy groups, conduct health
care to them; if the monitoring result refers to disease
risk groups, conduct the health promotion education to
them; in case of disease groups, organize the medical
services. Thirdly, conduct health services by adopting
health monitoring, reassessment, intervention, health tracking, early warning, education, self-management and other methods according to different results of monitoring. Finally, conduct the updating and management of health records after completing detection, intervention and other processes.

The ideal health-medical treatment mode shall be human centered, and meet the different levels of medical health demand of different people, and realize the “prevention first, combining prevention and treatment” and “slight illness treated in the community, serious illness treated in the hospital and back to the community after recovery” by virtue of health management, thus utilizing medical resources effectively, improving the service level, relieving the problem of “difficult and expensive medical treatment,” and we believe that the application of the IoT will make us close to this target.

4.2 Health Monitoring

In recent years, the remote health monitoring application based on families is developing rapidly, and it integrates the health sensor, wireless communication and cloud computing, and thoroughly overturns the traditional health monitoring mode, and becomes an important branch of development of the Health-IoT. For the data collected by the sensor can be transmitted to the mobile-phone, while the mobile-phone and the sensor can be connected through Bluetooth, and the data can be transmitted to the health management service platform in the background, thus realizing the omnipresent health monitoring and making people monitor their own physical situations at any time. This kind of application is especially applicable to the old, patients of chronic diseases and sub-health groups. It can monitor the physiological parameters of people, including blood oxygen/pulse, blood pressure, blood glucose, bone mineral density, ECG, body temperature and respiration (as shown in Figure 1). The health monitoring modes include family type monitoring and community type monitoring, and monitoring methods include continuous monitoring or interrupted monitoring. Figure 3 refers to the overall architecture of common health monitoring system based on the community service.

Services are usually provided by the health monitoring system are shown in Table 2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Service contents</th>
<th>Service method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Providing 24h remote ECG/blood pressure/blood glucose/blood oxygen/pulse/respiration/sleeping service</td>
<td>Real-time monitoring service</td>
</tr>
<tr>
<td>2</td>
<td>Providing real-time warning of monitoring abnormality</td>
<td>Short message</td>
</tr>
<tr>
<td>3</td>
<td>Providing the service of notifying relatives of monitoring information</td>
<td>Short message</td>
</tr>
<tr>
<td>4</td>
<td>Providing the service of booking expert consultancy</td>
<td>Video or short message</td>
</tr>
<tr>
<td>5</td>
<td>Providing the emergency calling and aid service</td>
<td>Automatic telephone calling</td>
</tr>
<tr>
<td>6</td>
<td>Providing the family positioning service</td>
<td>Positioning</td>
</tr>
<tr>
<td>7</td>
<td>Regular health assessment report service</td>
<td>Short message or email</td>
</tr>
<tr>
<td>8</td>
<td>Regular health promotion care service</td>
<td>Short message or email</td>
</tr>
<tr>
<td>9</td>
<td>Regular follow-up service</td>
<td>Telephone</td>
</tr>
<tr>
<td>10</td>
<td>Life-long health record management service</td>
<td>Website inquiry</td>
</tr>
<tr>
<td>11</td>
<td>User data self-help inquiry service</td>
<td>Website inquiry</td>
</tr>
<tr>
<td>12</td>
<td>Providing 24h consulting hotline service</td>
<td>Telephone</td>
</tr>
</tbody>
</table>

Figure 3 Architecture of Common Health Monitoring System Based on the Community Service

4.3 Exercise Promotion

With the rising of wearable devices and people’s more and more attention on health, the exercise promotion industry based on wearable devices develops vigorously.
The wearable devices can record the exercise amount, consumed energy, food intake and sleeping status of users per day, thus effectively supervising and urging users themselves to increase exercise amount and keep the body healthy. However, professional exercise intelligent devices can measure various physical indexes such as heartbeat and respiration more exactly, monitor their data including speed, running distance and endurance on the sports grounds and provide supports for improving their exercise achievements, and coaches can know situations of team members more visually, and select the most suitable athletes to participate in the match. The communication architecture of exercise promotion device is shown in Figure 4.

![Figure 4 Communication Architecture of Exercise Promotion Device](image)

<table>
<thead>
<tr>
<th>Name of device</th>
<th>Monitoring content</th>
<th>Additional functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood Pressure Monitor [15]</td>
<td>Blood pressure</td>
<td>Recording the historical blood pressure data</td>
</tr>
<tr>
<td>e-health Cloud Blood pressure monitor [16]</td>
<td>Blood pressure</td>
<td>Integrating the cloud platform, historical data curves and transmitting distress information</td>
</tr>
<tr>
<td>sunstudy GPS LBS [17]</td>
<td>Tracking the old</td>
<td>Mobile-phone communication function, SOS distress help-seeking alarm, and successively dialing three monitoring numbers; uploading the tracking position regularly and low-power alarm.</td>
</tr>
<tr>
<td>Smart blood pressure device [18]</td>
<td>Blood pressure and heart rate</td>
<td>The blood pressure and heart rate monitoring may avoid atrial fibrillation, with the feature that it can communicate with famous doctors about the disease situation, obtain the treatment opinions and know situations of other patients.</td>
</tr>
<tr>
<td>jWotch wristwatch [19]</td>
<td>Blood pressure and heart rate</td>
<td>Data analysis and manual calling center</td>
</tr>
<tr>
<td>Intelligent remote infant monitor [20]</td>
<td>Monitoring infants</td>
<td>Monitoring infants in a remote way, and able to add other guardians.</td>
</tr>
</tbody>
</table>

4.4. Mental support

The mental support is an emerging research field of the Health-IoT. Although there were some tools and electronic pet products about mental support in the market, this kind of products are single in functions and are featured with insufficient intelligence, and are far away from the effect of mental support. The following refers to summary of several practical mental support schemes.

Multi-functional interactive robot pillow: with the speeding up of pace of life and increasing of life stress, the communication times among relatives and friends are reducing, and the being-with time is shortening, thus individual loneliness is increasing, and more and more people regard pets and tools as their soul mates. This multifunctional interactive robot pillow possesses not only tracking, smart alarm clock, customized alarm, emotional tracking, distance course, step collection, calorie burning measurement, sleeping quality, motion reminder, smart no-sound alarm clock, step counting, distance counting and measuring calorie consumption.

![Figure 5 Exercise Promotion Products](image)
practical functions, but is able to comfort souls and relieve the loneliness. It is featured by that it includes external body, as well as microcomputer, sensor, functional module and power supply inside the external body. The in-built sensor includes temperature sensor and beating frequency sensor, and the function module includes heartbeat simulation module, audio module, respiration simulation module, heating module and beating module; the external body can be human shape, animal shape or carton shape. The temperature sensor shall be installed at the head of the external body; the beating frequency sensor shall be installed at the back of the external body; the heartbeat simulation module shall be installed at the chest of the external body; the heating module shall be installed at the head of the external body, the beating module shall be installed in the limbs of external body; and the audio module shall be installed inside the external body. Various sensors and function modules shall be connected with the microcomputer telecommunication signals, and the power source shall provide electric energy for the microcomputer, all sensors and functional modules. This is shown in Figure 6.

![Figure 6 The Components of Robot Pillow](image)

The multiple functional modules in the pillow make the pillow not only practical but able to relieve negative emotion, and the pillow features multiple functions. In this pillow, the heartbeat simulation module, respiration simulation module, heating module, beating module and the embracing module make people feel that the robot pillow is viable, and is able to relieve the loneliness. The heating module can also make people warm; the lighting module and the wake-up module are practical and convenient. The lighting module can be used under conditions of power off and users getting up at night. The wake-up module can wake users up in the audio or beating method at the present time; the audio module features the practical and unique voice play function. The voice play function refers to playing audio documents inside the memory. This audio module can collect the rhythm and frequency of users beating the robot pillow through the motion sensor, so as to adjust the voice play speed, and this function can achieve the hypnotic effect.

The famous Japanese robot designer Hiroshi Ishiguro promoted a pillow named “Hugvie.” After connecting it with mobile-phone, users can make phone calls while embracing it to feel the existence of the person on the other side of the phone [21-22]. The total length of Hugvie is 75 cm, and it is 600 g in weight. Open the two “hands” attached on the pillow, and then the pillow will show as a human shape. In addition, the touch feeling of this kind of products is soft like vinyl ester resin rubber. When the old is making phone calls with relatives and friends far away or when the children are making phone calls with their parents, this kind of products will bring them with warmer user experience. The design target of “Hugvie” is to provide a closer and warmer communication environment for users. During the communication through phone, users can realize making phone calls while feeling the existence of the person on the other side of the phone after they connect their mobile-phones with the pocket of “Hugvie.” The head of this invention is installed with a voice sensing device, and the voice sent out through microphone can control its internal vibrator, and can represent the vibration feeling of heart when people are speaking. Therefore, when users are making calls while embracing it, they will feel that the people far away are beside them. Moreover, the vibration strength of the vibration built inside the “Hugvie” has different changes according to the speaking tones of the person on the opposite side. The larger the voice and the higher the tone of the opposite’s voice are, the stronger and quicker the vibration strength will be.

The Sony AIBO robot with motion and voice recognition and voice feedback researched and manufactured by Sony Company can realize the dialogues [23] with family members at home, and the price is about USD 4,000. Furby Boom is a kind of electronic tool produced by David Hampton, which features entertainment and mental support functions, and it can be networked with application software in the mobile-phone, with the price of about USD 50. The dancing robot “My Keepon” is researched and manufactured by BeeBots Company (http://www.mykeepon.com). It can make respond to various touching actions, and dance along with music. In our study, it is used to study the social phobia and treat the autism, shown in Figure 7.

In a word, the Health-IoT for mental support just begins, and the corresponding products are not many. The existing products are single in functions, and are not intelligent enough, and are far away from the mental support requirements. Their communication functions...
with the exterior are not strong enough. With more social network functions being integrated into the existing products, the research of the Health-IoT on the mental layer of humans will be promoted extremely, and more and better mental support products will be produced.

5 The Application Outlook of Health-IoT

Health is an important direction of the future development. The Health-IoT possesses huge social demand, and also has obtained vigorous support of Governments of various countries. It makes the health service development become a huge industrial chain, covering microelectronics, communication, computer, health and medical service, exercise health and other relevant fields. At present, it is still at the initial stage of the industrial development. Although there are some devices based on the Health-IoT, such as household health (ECG, blood pressure and blood glucose) monitoring products which are based on the medical information service of the IoT, generally speaking, these existing devices and service levels are still not mature and have extremely large development space, and many challenging problems are to be overcome. In addition, the commercial mode of the Health-IoT also just begins, and it needs a relatively long period of exploration to develop. Next refers to current application situations and mainstream existing law and ethical problems of the Health-IoT at present, and illustrates the prospect to the future development.

At last, we will discuss the law and ethical problems faced by the Health-IoT. On the one hand, the long supervision and review process delays the instant application of the advanced technology of the Health-IoT. Especially for medical devices, it needs several years to approve and issue licenses, which obstructs the rapid adoption of advanced technologies. On the other hand, there is no enough law and ethic protection, and the health data and personal privacy of users of the Health-IoT may be confronted with some risks.

The Health-IoT shows an overall development trend, and we can predict that the health electronic industry and relevant health service industries will be developed greatly in the future several years, and there will be more health products for benefiting humans, which may improve the health situations of all people extremely.

6 Conclusions

The Health-IoT is an emerging application field related to humans’ healthy. It deploys sensors inside the human body, on the surface of human body or around the human body, so as to realize the detection on activities of the human body and physiological signals, and apply the sensed data into the medical treatment, health care, exercise, entertainment and other relevant fields, so it possesses wide application prospects and market potential.

Although with the occurrence of many practical applications, the Health-IoT has become a research hotspot, the theories and technologies in this aspect are at the development stage, and are not mature enough. For example, during the designing period of sensor nodes, more attention shall be centralized on the node miniaturization and energy saving, and the designers shall pay attention to how to prevent the human body from being injured due to the heating of sensors implanted into the human body. When designing the data processing algorithms and communication protocols, the energy consumption problem and the robustness problem due to node moving also shall be solved. In addition, the Health-IoT is closely related to the human health, so there are still many moral and law restrictions during the practical application. In short, the Health-IoT is an integration of multiple fields and multiple subjects, and the research personnel needs further exploration to solve key technology problems of relevant fields.

This thesis described the concept of the Health-IoT, introduced the physiological information collection, data transmission and communication architecture and wearable devices and other research fields related to the Health-IoT. It also especially introduced the multi-information integration, emotional analysis and interaction theories and methods in the Health-IoT, as well as new technologies such as big data, and introduced the development trend and existing challenges of the Health-IoT, and put forward paying more attention to the mental layer of humans is an important development trend of the Health-IoT.

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Health Internet of Things: Recent Applications and Outlook

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