Research on mobile intelligent medical information system based on the Internet of things technology

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***Abstract*—Research Purpose:** Design a mobile intelligent medical information system based on the Internet of things technology**. Proposed Methods:** First, sort out the basic theory and research status through the literature research, including the Internet of things technology, mobile medical systems and smart hospitals. Then conduct on-site research through field visits, questionnaires, opinion evaluation and other methods, including hospital diagnosis and treatment process, charging process, hospital process and the function of hospital information system. Finally, according to the survey results, use the method of software engineering to complete system requirement analysis and system design. **Results:** Based on the mobile phone near field wireless communication technology and indoor navigation technology, complete the various business processes carding, functional design, interface design and software and hardware environment support analysis. **Conclusion:** The mobile intelligent medical information system based on the Internet of things technology can greatly reduce the patient's treatment time, improve the patient's treatment efficiency and hospital management efficiency, and can further regulate and promote the development of intelligent medical treatment.

Keywords- Intelligent medical system; hospital management; Internet of things

I. INTRODUCTION

In recent years, with the development of social economy and the improvement of people's living standard, the popularity of smart phones has increased year by year. By the end of December 2015, according to the latest data of the Ministry of industry and information technology, the number of users of mobile phones reached 1.306 billion, mobile phone users penetration reached 95.5 per one hundred people, and the scale of mobile phone users reached 620 million people. With the wide application of the new generation of information technology such as cloud computing and Internet of things, mobile Internet applications have been developed from the simple information browsing, query, to e-commerce, financial services, public services and other areas, many applications can be easily realized by mobile phone APP, such as the online shopping, online ticket, pay bills, transfer the remittance, map navigation, social networking, and movement monitoring. The extensive application of information technology has greatly enhanced the work efficiency of traditional industries, reduced the operating costs of enterprises and improved the availability of various services.

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In the medical and health industry, with the proposed "Internet + health" concept, mobile Internet ,Internet of things and other emerging technologies continue to be introduced, there has been more and more convenient innovative information products and services for the people. However, due to the weak information base of medical and health industry, the low personnel information literacy, complex medical procedures, multi-sectional cross and many other reasons, the "Internet + medical" applications mostly stay in peripheral businesses such as appointment register and online inquiry, cannot go into the in-depth medical core business. For example, the general outpatient service process of large-scale third-grade class-A hospitals can be divided into medical guide, registration, waiting, treatment, payment, check, report collection, referral and medicine. Although many hospitals have set up a platform for appointment registration, patients can stay at home to make an appointment, save queuing time of patients, patients still cannot enjoy the convenience brought by information technology in other aspects.

Since the new medical reform, the government is committed to solving the problem of the difficulty and high cost of getting medical service. However, there are still many problems such as difficult registration, long waiting time, cumbersome payment, inconvenient medical guide, and miscellaneous documents in the large-scale third-grade class-A hospitals. Therefore, it is urgent to study how to use the new generation of information technology to improve the utilization ratio of existing resources, to achieve the requirements put forward by Premier Li Keqiang in the 2016 National Health and Wellness Conference, which is to guide and support the healthy industry to accelerate its development, in particular, to promote integration with pension, tourism, Internet, fitness and leisure, and food , increase the support of the frontier research field of health care, eliminate the institutional obstacles, gave rise to more healthy new industries, new forms and new patterns to improve the health status of residents[1].

II. RESEARCH OBJECTIVE

Design a mobile intelligent medical information system with the method of software engineering, combined with the hospital information system business process analysis and on the basis of the research of mobile wisdom medical related theory, near field wireless communication (NFC), indoor navigation and other Internet of things technology. Use information technology to optimize the treatment process, improve the patient's environment, shorten the waiting time, improve medical convenience, reduce hospital costs, and further build a modern wisdom hospital, regulate and promote the development of Wise Information Technology.

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III. RESEARCH CONTENT

A. Related theories, methods, and successful cases of mobile Wise Information Technology.

Card related concepts such as mobile health, smart hospitals, internet medical treatment, clear the theoretical basis for the construction of mobile wisdom medical information; Sorting out the theory and method of radio frequency identification (RFID), near field wireless communication (NFC), indoor navigation and other Internet of things technology. Investigate successful cases of the application of mobile Internet and Internet of things in the medical field at home and abroad, and summarizes the successful experiences and existing problems [2-4].

B. Research on identification of patients based on mobile phone in the near field wireless communication technology

Near-field wireless communication technology (NFC) is a contactless identification and interconnection technology that can be for short-range wireless communications between mobile devices, consumer electronics, PC and intelligent control tools [5-6].

Currently, the major hospitals for patient identification rely mainly on the Patient ID Card (IC card) issued by the hospital on their own, which is not conducive to carry and use for patients in different hospitals to handle a large number of medical cards. In this study, we establish the association with unique identification code of the patients with mobile NFC chips to the patient ID of the information systems, and use the mobile phone with NFC chip to replace the traditional medical treatment card. In addition, due to the same working frequency of NFC and IC card, so it can be through swing phone for treatment with no need to replace the existing card equipment.

C. Research on guiding service based indoor navigation technology

Indoor navigation technology is a technology that uses Wifi hotspot to realize indoor positioning and navigation, and can solve the problem that GPS satellite cannot be located caused by building block [7-8].

Currently, outpatient services can generally be divided into medical guide, registration, waiting, treatment, payment, check, report collection, referral and medicine and other steps. The process is very complex, the patients for initial treatment or older patients cannot be completed independently. Meanwhile, the major medical institutions have the characteristics of large area, multi-department and unclear signs, resulting in a large number of patients to waste time in the inquiry, in line and to find the way. This study relies on indoor navigation technology, which can clearly locate the position of every patient in the hospital, and provide automated and personalized guiding service combined with medical information of the hospital information system, significantly reducing the time inquiry.

D. Demand analysis and design of mobile wise medical system

1) Carding business process

Systematically comb the patient medical treatment process, including out-patient flow, hospital procedures, inspection and examination processes [9-11].

2) System functional requirements

Research on the functional requirements of the mobile wise medical system, which mainly includes medical card registration, registration, waiting, treatment, payment, inspection and examination, dispensary and information services.

3) Interface requirements

Mobile wise medical system is a mobile phone APP independent of the existing hospital information system, which needs for data exchange and interoperability with the relevant hospital information system, then complete the corresponding interface program.

4) Software and hardware environment requirements

Based on a comprehensive analysis of the function of the system and combined with the construction of information system of large-scale third-grade class-A hospitals, research on the software and hardware environment of mobile wise medical system.

E. Empirical research

Build the hardware and software environment and design the application system in view of the conventional medical treatment process, then carry out the empirical research, sum up experience and put forward the improvement plan.

F. The technical route of research

The technical route of this study is shown in Figure 1.

IV. RESEARCH METHODS

A. Literature research

By retrieving CNKI, Wanfang and VIP literature database and portal sites of health administrative departments at all levels, sort out the basic theory and research status of this research, including the Internet of things related technologies, mobile medical systems, smart hospitals, hospital information systems, etc.

B. In-depth interview

Interview with the business backbone of the information center ,the clinical departments, the medical detection departments, the admission office, the medical affairs section, the finance department and the medical insurance office of large-scale third-grade class-A hospitals, understand comprehensively the diagnostic and treatment process, the charging process, the hospital flow and functions of the hospital information system of large medical institutions.

C. Site investigation

Through field visits, questionnaires, evaluation comments and other methods to conduct an investigation of the hospital's existing medical procedures, collect opinions and suggestions of patients and medical staff, discuss the feasibility and the actual results of this project to optimize and upgrade the existing medical process.

D. Software engineering

According to survey results, based on systematic analysis of existing hospital information systems, combined with the method of software engineering, analyze the functional requirements, interface requirements and security requirements of mobile wise medical system, and then complete the preliminary design and planning.

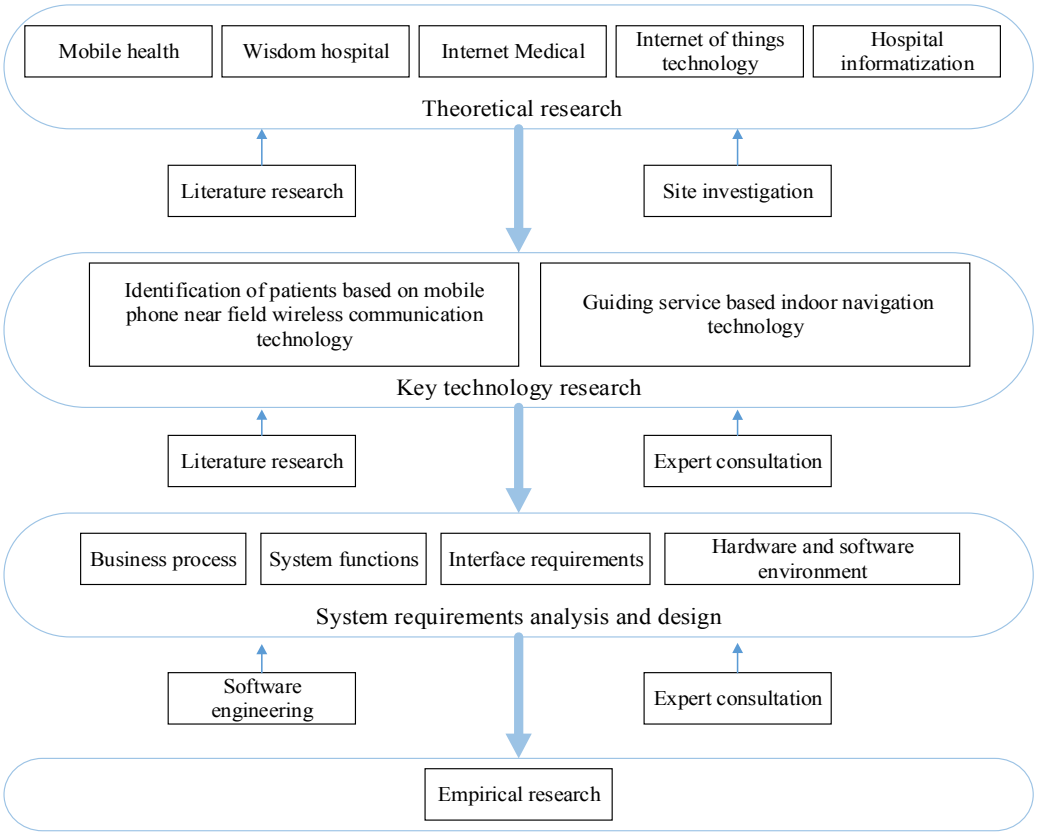

Figure 1 Technology Roadmap

V. DESIGN OF MOBILE WISE MEDICAL SYSTEM BASED ON INTERNET OF THINGS TECHNOLOGY

A. Business process

1) Overall business processes

Patients with a medical card or a smart phone with NFC function go to the outpatient department for registration, if the patient did not apply for a medical card, apply for a new card, and then for treatment. If you do not need to be hospitalized, then charge fees with a prescription, and then to the dispensary, do check-ups or physical therapy. If you require hospitalization, outpatient doctors assign the hospital departments, patients go to the out/in-patient department for hospital registration and payment of prepayment, and then the nurse workstation allocates beds in hospital. Residents issue orders through hand-held computers, the doctor workstation informs to put medicine, then make an appointment to check and the system automatically calculates the price. If the prepayment is insufficient (prepaid line can be customized), the system will automatically notify to pay the fees, and then put drugs by the pharmacists .When patients are discharged from the hospital that informed by the doctor, take discharge notice to the payment office to pay the fees, then discharged from hospital.

2) Outpatient business processes

Existing out-patient business process exists the following problems: there are many non-treatment areas in the entire treatment process, patients need to go back and forth; and the phenomenon of long lines for waiting is serious ;waiting order is chaotic and noisy that have affected doctor 'work; Unexpected circumstances such as input errors due to indecipherable handwriting and no drug inventory, which increases patients' burden of back and forth and queuing; failure to achieve the integration of registration appointment

with the hospital information system. All of these problems increase the patient's waiting time. The method to solve patients' long-time waiting is the medical card system and smart mobile phone with NFC function APP.

After the implementation of the medical card, smart mobile phone with NFC function APP and comprehensive hospital informatization, the hospital can use the card to establish a new outpatient service process. Patients need to hold a hospital-issued medical card for treatment, or register on APP of their mobile phone to get a unique patient code. Information input by one department or NFC reading machine is shared to related departments, thereby reducing operator duplicate entry, shortening patient waiting time, avoiding isolated operation of each module, and establishing the patient's basic information file. The outpatient parts include: treatment card management, mobile phone APP registration, registration fees, nurse triage, outpatient doctor's office, pharmacy and medical departments.

3) Hospital business process

After the patient is admitted to hospital, nurses assign beds for them according to hospital bed usage. The doctors can use handheld computers to make the rounds of the wards, the doctor's order will be automatically checked by the computer to avoid possible incompatibility. Doctors' prescribe and check items will be automatically transferred to the nurse workstation and other departments. Hospitalized parts include: the admission, hospital charges, hospital nurses, hospital doctors, pharmacies and medical laboratories.

4) Inspection business Process

Clinical departments issue a test application, the LIS can firstly send the patient's history test (including the outpatient inspection, inspection time in hospital, department application, doctor application) to do the diagnostic reference, then the doctor decided whether to consult. The payment office charges patients for treatment. After receiving electronic reservation application information , the LIS generate bar code according to the category of inspection items，make a prompt for the types of samples, the capacity and the requirement of the specimen collection. After the application form is confirmed, the inspection station manually or automatically checks the patient samples, then send the collecting information to LIS, and analyze information provided by the equipment. After checking, generate an electronic version of the inspection report, and sent the report to the clinical department.

B. System function design

Relying on the existing hospital information system, design a mobile wise medical system based on Internet of things technology. System functions can generally include the following parts.

1) Patient ID card registration

The inpatient and outpatient systems of the whole hospital use a unified medical record number coding, the medical record number is used as a medical card or smart phone APP software registration only identification code. When setting up a new medical card, print the medical record ID number and the bar code in the medical record book cover. Establish a unified database to manage the cardholder and patient information, the cards will be implemented centralized management, including issuing, cancellation, reporting the loss and make-up.

Patients need handle a medical card who come to the hospital for treatment for the first time ,or you can use the mobile phone APP of the mobile intelligent medical system to register the electronic medical card, filling in the "basic patient information", including patient name, sex, age, ID number (or address), work units, nationality and regional information. You can get an electronic medical card through a simple check by the system.

In addition, patients who have a medical card can use the mobile phone APP of the mobile intelligent system, reading the card information directly by NFC technology and completing the mobile phone and medical card association.

2) Registration

Patient registration function supports all types of registrations, such as health insurance, commercial insurance, at public expense, at their own expense. It supports multiple registration modes (such as appointments, phone, online registration and phone APP), and generates registration information; supports a variety of registration payment methods such as online banking, Alipay, WeChat payment and Apple Pay; supports centralized registration, triage registration and so on; supports queue, triage service, calling number, restricting number and preferential treatment. It has real-time shadow function of the data, when the primary server is not working properly standby server immediately hired, to achieve a single operating function. Users can also set the input mode by themselves (keyboard or mouse).

① Inquire doctor visits according to the disease, hospital departments. According to the department information obtained from the previous step, patients can use the APP to query doctor visits according to the disease, hospital departments, patients can brush the registered equipment to realize the automatic registration (or self- registration on the Internet);

② Provide online registration and payment service. At the same time, automatically deduct the registration fee by UnionPay (WeChat or Alipay payment function);

③ The registration information is automatically synchronized to the hospital information system, the registration is automatically assigned to the corresponding sections, and display the ranking, doctor, waiting time and other information;

④ For non-medicare patients, there is no need to exchange for a paper registration form, they can use NFC medical card.

3) Hospital business process

According to the registration information, the system automatically arranges the order queue and waiting time, patients can choose when to go and where to go according to information of the APP real-time display and medical

guiding display screen, the patients don't have to stay at the station all the time(for registered patients to make an appointment in advance, they can get a specific time point to wait, then directly for treatment, saving the waiting time). During the waiting time, the system can also give some simple precautions according to some basic conditions of the patients.

①Provide navigation services for medical department, and plan a reasonable route;

② Provide automated reports and queuing waiting function based location services, then give the expected time for treatment;

③ Provide automated reports and queuing waiting function based location services, then give the expected time for treatment;

4) Doctors' office visiting

①Doctor can directly use the phone (NFC module) to determine the patient's identity, condition and other information to achieve identification of patients;

②The doctors store the doctor's advice, prescription and check-ups to the hospital's PC clinical system, while patients can automatically synchronize the doctor's advice, prescription and check-ups to the phone.

5) Payment

① After the doctor submitted, there will be a payment reminder function, you can brush NFC to achieve intelligent payment online and offline, providing bank card binding services to achieve automatic payment.

②Develop the third party payment platform interface, providing a variety of ways to pay. If possible, do a link to the social insurance system, realizing two lines of payment: cash and social insurance;

6) Inspection and examination

The mobile phone with the function of NFC APP provides automatic distribution and service to call the name in due order. At the same time, APP can prompt the project to be checked, and give the optimization scheme according to the distance and number of people queuing ahead(the order of examination, how to go and other information)(If the patient needs to do a number of checks, they can make an appointment in advance: Patients can first go to the corresponding examination department to scan the code by NFC function, and then get a specific inspection time according to the actual situation, greatly shortening the inspection time and improving the efficiency of inspection).

① Provide navigation services for inspection department, and plan a reasonable route;

② Provide automatic distribution and service of calling the name in due order;

③ Prompt inspection and inspection progress through the LIS, PACS and other system information sharing, and give the phone sound and vibration alert after the completion;

④ Achieve the function of automatically downloading inspection results;

⑤ Provide historical check and inspection results query function.

7) Taking the medicine

①Provide navigation services for pharmacy, and plan a reasonable route;

② Provide pharmacy windows automatic distribution service;

③Prompt drug sorting progress, give a phone sound and vibration alert after the completion.

8) Information service

① Drug basic information (rational drug use) query

Including the name of medicine, properties, pharmacology and toxicology, contraindications to pharmacokinetics, indications, dosage, adverse reactions and drug interactions. The data is imported directly from the rational drug use module.

② Drug interaction analysis

You can enter two or more drugs, the system displays the interactions between the input drugs. Realize medication safety review before prescribing, effectively avoid medical errors caused by drug interactions

③ Nursing information and doctor patrol room information inputting

Input the nursing inspection information and the doctor's inspection room information immediately to the mobile medical equipment, which synchronizes with the terminal data, mobile terminal interface maintain consistency as far as possible with the doctor and the nursing station interface.

④ Patient oriented information service.

Mainly including information service after treatment, such as drug taking regularly reminding, subsequent automatic registered service, and pushing service of disease rehabilitation knowledge.

C. Interface design

Mobile intelligent medical system is a mobile phone APP independent of the existing hospital information system, the system needs to exchange data and interoperate with the relevant hospital information system, mainly including the following interfaces(Table 1).

TABLE 1 THE CORRESPONDING INTERFACE TABLE

Functional systems that require interfaces of mobile intelligent medical system	**The existing functional systems that require interfaces of hospital**
Medical card registration	Hospital physical NFC reader system
	Outpatient and emergency management systems

	Electronic medical records system
Registration	Hospital physical NFC reader system
	Outpatient and emergency management systems
	Outpatient and emergency registration system
	Outpatient and emergency charge system
	Triage Management System
	Clinical Information System
	Electronic medical records system
	Patient admission, discharge and referral management system
Waiting	Outpatient and emergency registration system
	Triage Management System
	Clinical Information System
	Electronic medical records system
Treatment	Hospital physical NFC reader system
	Outpatient and emergency registration system
	Triage Management System
	Clinical Information System
	Electronic medical records system
	Patient admission, discharge and referral management system
	Hospital charges system
	Hospital management system
	Drug management system
	Wireless Medical Systems
Payment	Hospital physical NFC reader system
	Outpatient and emergency management systems
	Outpatient and emergency registration system
	Outpatient and emergency charge system
	Clinical Information System
	Electronic medical records system
	Patient admission, discharge and referral management system
	Hospital charges system
	Drug management system
Dispensary	Hospital physical NFC reader system
	Clinical Information System
	Electronic medical records system
	Patient admission, discharge and referral management system
	Drug management system
Service after treatment	Clinical Information System
	Electronic medical records system
	Wireless Medical Systems

D. Software and hardware environment requirements

Based on a comprehensive analysis of the function of the system, combined with the construction of hospital information system of existing large-scale third-grade class-A hospitals, discuss the hardware and software environment for building the mobile wisdom medical system, mainly including the following parts.

TABLE 2 SOFTWARE AND HARDWARE REQUIREMENT TABLE

Hospital treatment process	**Software support**	**Hardware support**
Charging by	Hospital NFC mobile	Patient's smart phone
NFC smart phone	phone software APP	Reading NFC machine in hospital
Registration and payment	Hospital NFC mobile phone software APP	POS machine in hospital
	Hospital HIS system	NPC reading and writing equipment in hospital
Information prompt	Hospital NFC mobile phone software APP; Hospital HIS system; Hospital clinical system; Hospital medical platform database; Hospital database	NFC smartphone for patients
		NPC reading and writing equipment in hospital
		WEB server in hospital
Completing registration		NFC smartphone for patients
		NPC reading and writing equipment in hospital
		WEB server in hospital
Guiding patients		NFC smartphone for patients
		PC computers in hospital
		WEB server in hospital
Waiting		NFC smartphone for patients
		Navigation monitor in hospital
		WEB server in hospital
Treatment		NFC smartphone for patients
		NPC reading and writing equipment in hospital
		WEB server in hospital
		PC computers in hospital
Payment		POS machine in hospital
		NPC reading and writing equipment in hospital
		PC computers in hospital
		WEB server in hospital
Inspection		Navigation monitor in hospital
		NPC reading and writing equipment in hospital
		PC computers in hospital
		WEB server in hospital
Receiving reports		NPC reading and writing equipment in hospital
		WEB server in hospital
Further consultation		NPC reading and writing equipment in hospital
		PC computers in hospital
		WEB server in hospital
Taking the medicine		NPC reading and writing equipment in hospital
		PC computers in hospital
		WEB server in hospital
		Hospital dispensary display

VI. CONCLUSION

With the rise and development of the "Internet + health", hospitals have been gradually developed towards informatization, digitization and wisdom direction. Due to a wide range of hospital departments, a growing demand of hospital fine management, complex medical information and the huge amount of data, the hospital informatization has been also put forward higher requirements. The mobile wise medical information system ,designed for this study based

the Internet of things, can reduce patient treatment time and improve the efficiency of treatment of patients, use information technology to reflect humanity care, but also improve the quality and efficiency of hospital work, which embodies the "patient centered" purpose to make patients enjoy convenient and safe medical services.

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