IoT Applications for Healthcare and Wellness Management

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1 Industry Opportunity and Challenge
2 IoT Technology Empower Healthcare Industry
3 Health Service Model Revolution
Health Related Big Data in China

- Hypertension: 160-170M
- Hyperlipidemia: 100M+
- Diabetes: 92.4M
- Overweight: 200M
- Dyslipidemia: 160M
- Fatty Liver: 120M
Patients are Getting Younger

Middle-aged Chinese die of heart and brain disease

- Young women are easy to get gynecology, cardiovascular and cerebrovascular diseases
- Young men face sudden death, fatigue and cancer
- The prevalence of chronic diseases
  - Accounted for 83% of all deaths

Intellectuals are on the verge of "being overworked"

- 35-46 years old patients died of Cardiovascular disease: China 22% vs. USA 12% (2013 - 2014)

White-collar workers suffer from sub-health

- China has spent 300 billion RMB per year on the treatment of cardiovascular and cerebrovascular diseases

From: Healthcare Forecast Report 2020
China Talent Development Report
The Importance of Healthy Lifestyle

- 75% of cancers are associated with lifestyle
- With proactive prevention and intervention, at least 40% of the tumors can be prevented
- In the cause of chronic diseases
  - Genetic factors 15%, social factors 10%, climatic 7%, medical conditions 8%, and personal life style 60%
Strong Push from National Strategy & Policy

- "Healthy China" has officially risen to a national development strategy
- Following the Internet industry, the health industry has become the new engine of China's economy growth
- China's health industry will have a market size of 16 trillion RMB by 2030
Great Challenge Ahead

Limited medical resources, scarce senior doctors, short of beds in hospitals, poor service quality, unbalanced usage

The beds in hospital have been occupied!

Patients prefer to visit senior doctors for flu.

Very few patients visit community hospital or healthcare center

My God, we have to wait for another two months!

Patient: I cannot get an appointment with any senior doctor even if we wait in line at 6 A.M.

Doctor: There is no need for patients to visit senior doctors if they only got common diseases
Call for Life-Cycle Healthcare Management

Treatment Centric

One-Time Treatment

‘Prevention + Treatment + Rehabilitation’ Life-Cycle End-to-End Healthcare Management

Post-Evaluation, Continuous Treatment

Intelligent technology, innovative medical equipment for personnel empowerment

- Closed Collaboration btw Medical Specialist and Engineering Experts
- The change of diagnosis/treatment mode leads to the change of healthcare service mode
To Tackle the Challenge

End-to-End Health Management

Prevention

Medical Treatment (One-time ➔ Continuous)

Management and Rehabilitation

Senior Doctors

Suitable Technology & Product

Senior Doctors

Suitable Technology & Product
IoT Technology Empower Healthcare Industry

- Sleep monitoring (住)
- Dietary monitoring (吃)
- Walking assessment (行)
Rise of Smart Devices

8.0 billion in 2016, may reach 11.6 billion in 2021

101.9 million shipments in 2016, 29% growth over 2015

6.4 billion connected things worldwide in 2016, will reach 20.8 billion by 2020

Application Scenario for Wearable in Healthcare

Professional Level

Medicare

Wellness

Future Market Potential Hot Areas

- Assisted Diagnosis
- Disease Verification
- Continuous Monitoring
- Early Intervention
- Personized Treatment
- Effectiveness Assessment
- Chronic Disease Management

Pre-Sick-Post Time

Exercise Monitoring

From: 动脉网
Sleep Quality

Dietary Monitoring

Walking Assessment

(住)

(吃)

(行)
1) Sleep Rhythm and Sleep Apnea Monitoring

- 27% of people have sleep problems, the prevalence of sleep disorders in China's residents as high as 42.7% (WHO data)
- More than 90 types of diseases are related to sleep disorder
- The diagnosis of sleep disorders require the analysis of circadian rhythms, ECG, EEG, blood oxygen, respiration and other data
- 93% of male patients and 82% of female patients suffering from OSAS miss the most suitable time for treatment due to lack of proper diagnosis

Collaborate with The Sleep Medicine Research Center of PLA General Hospital (301 Hospital)
Sleep Quality Analysis with IoT Device

- Different types of sleep disorders have different signs
- Effective vital signs monitoring
- Data analysis helps doctors develop personalized treatment plan


- Analysis of sleep stage
  - HRV
  - Detrended Fluctuation Analysis (DFA)
  - Activity analysis
- Sleep apnea detection
  - Blood oxygen analysis
  - Heart rate periodic analysis
Monitoring → Personalized Treatment

Sleep Quality Monitoring
- Sleep apnea detection
- Sleep quality/sleep rhythm monitoring
  - Sleep, awake, stage

Treatment Plan Adjustment
- Insomnia
- Sleep Apnea
- Rhythm Disorder
- Low Quality
- Sleep-assisted Device/Exercise
Adjustable Pillow System

- Monitor the sleep apnea
- A patient is recommended to adjust the height and appearance of the pillow to keep the airway open. Real-time feedback can be achieved to relieve and cure the OSAS
- Auto-adjustment or remote and manual adjustment by doctors
- **Advantage**: advanced technology, comfort, safety and efficient

2) Dietary Monitoring

Heavily related to diabetes, overweight, cardio-cerebrovascular disease

- **When**
- **How Much**
- **What**

- **On-body: Smart Glasses**
- **Off-body: Smart Utensils**

Challenges

- Confounding activities, e.g., talk, head movement
- Unpredictable signal quality

Chewing is a periodic activity

Use adaptive thresholding
System Design

- **96%** accuracy for counting the number of chewing cycles
- **80%** accuracy for distinguishing different food categories
2) Dietary Monitoring

Heavily related to diabetes, overweight, cardio-cerebrovascular disease

**When**

**How Much**

**What**

On-body: Smart Glasses

Off-body: Smart Utensils

Food Recognition

Drawback: Cannot handle occlusion
Smart Utensils

Smart utensils provide opportunity to track what we eat
Light Reflected Depends on the Chemical Properties of Food
For now, we can classify 20+ foods with very high accuracy (>95%)
3) Walking Assessment -- Heel Problems

- The heel (hind-foot) is a central mechanism in foot biomechanical movement during gait, and is also a common site of foot pain

**[Internal causes]**
- Plantar fasciitis
- Overweight
- Weakness of the heel fat
- Arthritis in the heel joint

**[External causes]**
- Long-time standing
- Wearing hard-soled footwear
- Bad foot gesture
Motivation

• Monitoring the pressure under heel can be important for patients and even normal users

Plate-based systems

- High manufacture and installation cost
- Restricted to research laboratories or medical clinics

In-shoe systems

- Heavy calibration burden to overcome drift of pressure transducers overtime
- Limited life-span: unfordable for continuous daily usage
Observation

- Heel strike is a process of collision between the foot pad and ground.
- Collision force is generated by inertial change of partial human body.
- **Impulse-momentum theorem** The change in momentum (the product of the mass and velocity) of an object equals the impulse (the product of force and time).

\[
\int_{t_b}^{t_e} (F_G - M_e g) dt = M_e (v_e - v_b)
\]

Pressure Measures

Kinematics Parameters
Heel-Guard: IMU-based Heel Pressure Monitoring through Momentum-Impulse Analysis


- 10 participants, 5 paths with different textures and inclines, self-selected speed
- Our system achieves $\sim 0.1505$ normalized root-mean-square error
Contents

3 Health Service Model Revolution
Networked Hospital Service Model

Diseases Treatment + Outside Hospital Management = End-to-End Health Management

Hospital

Cloud Computing

Remote health monitoring platform and Healthcare IoT

Health Station

Networked Hospital

Treatment within Hospital

Health Service extended outside hospital
Chronic Disease Management, Follow-up, Health Consultation, Check-up Booking
Periodical Healthcare Management

**Patients**
- Abnormal vital sign
- Time for re-checking

**Hospital**
- Finish consultation and back to health station for daily management

**Confirmation**

**Assign to Health Station**

**Daily Management**
- Vital sign monitor
- Healthy lifestyle tracking and suggestion
- Med&Pill reminder
- Chinese med suggestion
- Re-check suggestion

**Health Station**

**Health-carer**

**Create management task**

**GP**
Use Case in Shenzhen

The first “Networked Hospital” based on Cloud Platform

Based on Shenzhen People’s hospital, leveraging the remote monitoring IoT platform to achieve the end-to-end healthcare management

- Aims at disease classification management, based on general practitioners, with clinical experts as the core, and health stations as extensions to guide patients to obtain reasonable medical treatment, and provide end-to-end medical care services
- In 2016, 660K person-times of services were provided for out-patient and post-physical examination users
  - Continuous tracking and management of 60K person-times for common chronic diseases (diabetes, hypertension)
  - Continuous follow-up management of early cancer prone populations for 8 common cancers (lung cancer, cervical cancer, colon cancer, liver cancer, thyroid cancer, breast cancer, prostate cancer, and gastric cancer)
Enjoyable Personalized Service from End-Users

Always available personalized healthcare service from big health data

- Personalized Pill Reminding
- Personalized Health Insurance Planning
- Personalized Excising
- Personalized Food
Vision

Through the combination of science/technology and medical science, promote the development of intelligent life-cycle health management.
Thanks!

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