Internet of Things in medicine and healthcare: Challenges and applications

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IoT Definitions

• The internet of things (IoT) is a **computing concept** that describes the idea of **everyday physical objects being connected to the internet and being able to identify themselves to other devices**.

• The internet of things, or IoT, is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers (UIDs) and the ability to **transfer data over a network without requiring human-to-human or human-to-computer interaction**.

• In other words, with the internet of things, the physical world is becoming one big information system.

Sources: https://www.techopedia.com/definition/28247/internet-of-things-iot
IoT Applications

1. **Consumer applications**
   1.1 Smart home
   1.2 Elderly care

2. **Commercial applications**
   2.1 Medical and healthcare
   2.2 Transportation
   2.3 V2X communications
   2.4 Building and home automation

3. **Industrial applications**
   3.1 Manufacturing
   3.2 Agriculture

4. **Infrastructure applications**
   4.1 Metropolitan scale deployments
   4.2 Energy management
   4.3 Environmental monitoring

Source: [https://en.wikipedia.org/wiki/Internet_of_things#cite_note-Definition-IoT-5](https://en.wikipedia.org/wiki/Internet_of_things#cite_note-Definition-IoT-5)
IoT in Health Care

• The **Internet of Medical Things (IoMT)** is the collection of medical devices and applications that connect to healthcare IT systems through online computer networks.


• Medical devices equipped with **connectivity** allow the machine-to-machine communication that is the basis of IoMT.

• IoMT devices link to cloud platforms such as Amazon Web Services, on which captured data can be stored and analyzed.
Challenges in IoMT

- Interoperability
- Standardization
- Users’ acceptance
- Cost
- Reimbursement
- Data analytics
- From statistics to personalized medicine
The evolution from data sources to analysis results passes through several steps. Raw data (captured in databases [DB], flat files, and text documents) must first go through various data preparation methods to prepare them for analysis. The prepared data can then be analyzed using a variety of data analytic techniques to summarize and visualize the data and develop models and candidate solutions.

https://www.nap.edu/read/23670/chapter/6
Integration strategy

• Generation of new **big data sets** on patient health and behaviour by portable and wearable medical devices or gadgets of patients’ own choice

• Enabling use and integration of information from existing databases from the health care system (HIS, GPs, Labs) - **connectivity**

• Enabling use of data for **advanced analytics** (data mining)

• Generation of new **knowledge**
When connected to the internet, medical devices collect valuable data, which may give extra insight into symptoms and health/disease trends, enable remote monitoring and care, and give patients more control/power over their lives and treatment.

Applications of IoT in medicine and healthcare are numerous and in different stages of development, so only a limited number of examples of IoMT applications may be presented within this presentation:

- Asthma and Pulmonary Diseases
- Cardiovascular diseases
- Diabetes
- Ingestable Sensors
- Cancer Treatment
- Parkinson Disease
- Mental Health
MEDICAL APPLICATIONS – ASTHMA AND PULMONARY DISEASES

Prepared by Prof Vedran Bilas, Dr. Sc. Dinko Oletić and Prof. R. Magjarević
Tracking Asthma therapy

• *Smart blister* packages, pharmaceutical packages capable of monitoring when a pill is taken out of its packaging.

• Sensorization of the inhaler pump
  - Objective measure of the frequency of asthmatic seizures + correlation with ambiental triggers
  - Patient social networks

Asthmapolis (http://asthmapolis.com/)
Tracking of ambiental triggers

• What?
  • Meteorological conditions
  • Gass concentration
  • Pollen

• How?
  • Fixed infrastructure
  • Mobile sensor
  • In the immediate vicinity of the patient
MEDICAL APPLICATIONS – CARDIO-VASCULAR DISEASES
Chronic Diseases - Cardiovascular

• Each year cause over 4 million deaths in Europe and over 1.9 million deaths in the European Union (EU).
• CVD causes 47% of all deaths in Europe and 40% in the EU.
• CVD is the main cause of death in women in all countries of Europe and is the main cause of death in men in all but 6 countries.

http://www.ehnheart.org/, Sept 2013

• 80% of premature heart disease and stroke is preventable

http://www.euro.who.int, Sept 2013
Wearable ECG monitor

- Block diagram of a mobile battery powered ECG and its realisation as a wearable device

Source: Filip Šklebar i Matej Ferenčević, Pametni senzorski čvor za praćenje elektrokardiografa i tjelesne aktivnosti, Zagreb, 2016
Wrist worn devices

- Aple Watch
- Basis Peak
- ePulse2
- Fitbit Surge
- Microsoft Band
- MIO Alpha 2
- PulseOn
- Samsung Gear S2
Implantable Cardiac Stimulators

Dual chamber pacemaker: Position of electrodes in right atrium and ventricle

Block Diagram of a Multiprogramable Stimulator
Leadless Pacemakers

25.9 mm, < 1cc miniaturized VVIR pacemaker

World’s smallest, minimally invasive pacing system

10 year longevity

Percutaneous access to RV apex via femoral vein

Active fixation via 4 self-expanding “tines”

First Implants of Global pivotal: Dec 2013
Design for connected health

Key Design Changes

Bluetooth® Low Energy (BLE) enabled to automatically and securely communicate with BLE smartphones or tablets.

Encryption Module
Data are encrypted in the pacemaker using NIST® standard encryption.

High Density Integrated Circuit
Reduces current drain for increased longevity.

Pacemakers are completely redesigned for secure wireless communication via Bluetooth® Low Energy without compromising longevity.

BlueSync™ Technology enables Azure to communicate directly with a patient-owned mobile platform.

PMs offer timely alerts of clinically relevant events with accurate AF detection.

Conclusions

• New technologies that are currently developing or will be developed over the next five to ten years, will substantially alter the healthcare and social environment.

• In addition to IoT, these include information technology, wireless data communication, man-machine communication, on-demand printing, bio-technologies, advanced robotics, machine learning, artificial intelligence ...
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From: http://www.businessdictionary.com/definition/emerging-technologies.html

THANK YOU FOR YOUR ATTENTION!
MEDICAL APPLICATIONS - DIABETES
Diabetes - Worldwide

• Growth of elderly population influences society and economics of all countries

• Europe and North America: enhanced by unhealthy diet and lack of physical activity

• Engineering solutions for monitoring and rehabilitation, prevention?

Information taken from: http://www.diabetesatlas.org/
Commercially available Glucometers in Croatia

Screen shoot from diabICT system
Self-Management and Telecare

“Artificial pancreas”

- Closed loop glucose control systems
  - Insulin pump
  - Continuous blood glucose monitoring
  - Algorithm for BGL control
Evolution of closed blood glucose control systems

**2006: The Foundation**
- World’s first integrated insulin pump and CGM system. Shows real-time CGM information on the pump and delivers alerts/alarms based on sensor values.

**2009-2013: Taking Action**
- Automatically stops insulin delivery when sensor reaches low threshold.

**2015: Predicting Low**
- Stops insulin before the sensor reaches low threshold and resumes when sensor glucose levels recover.

**Under Investigation: Hybrid Closed Loop**
- Fully automatic insulin delivery with minimal patient interaction required. Automatic insulin delivery, patients need only to calibrate the sensor and enter mealtime carbs.

**GOAL**

* Not approved for use nor commercially available in the US.
Non-invasive measuring of blood glucose

Research for easy and less-invasive way to measure glucose daily:

- tears,
- airway mucus,
- sweat,
- saliva or
- the interstitial fluid of subcutaneous tissue
An electronic skin patch that senses excess glucose in sweat and automatically administers drugs by heating up microneedles that penetrate the skin.

See also: Hyunjae Lee et al., A graphene-based electrochemical device with thermoresponsive microneedles for diabetes monitoring and therapy, Nature Nanotechnology, 2016
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