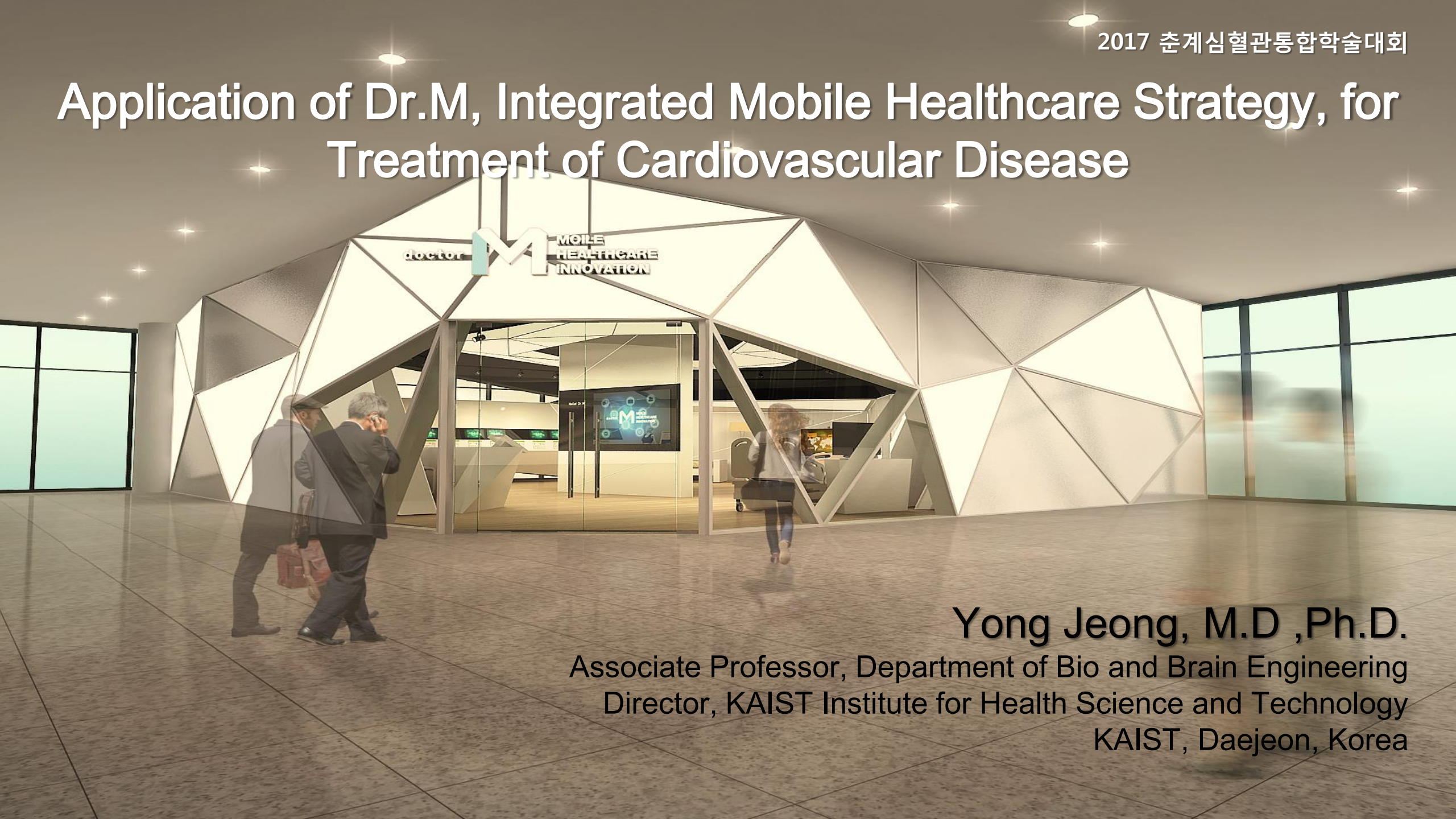
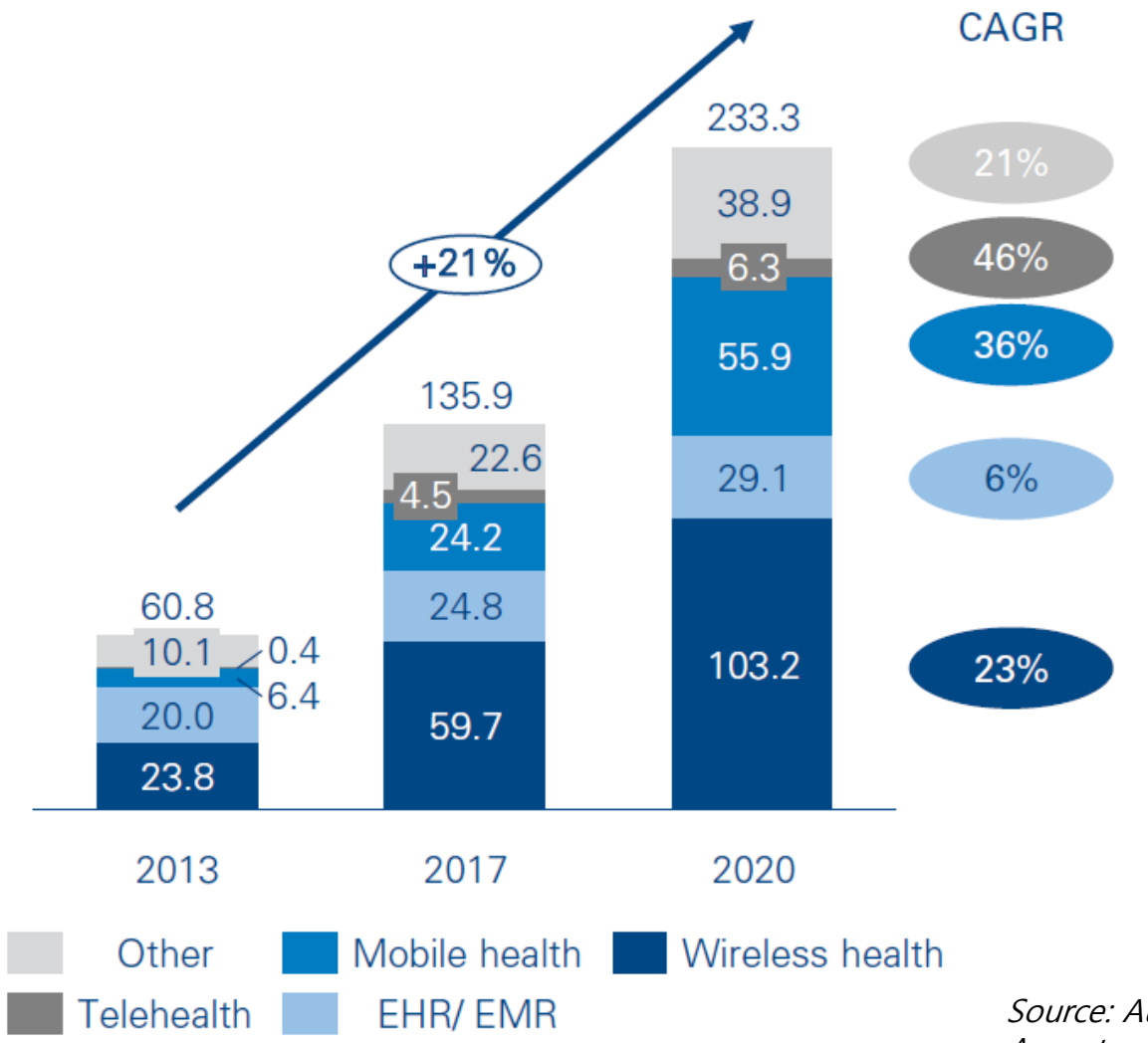
Application of Dr.M, Integrated Mobile Healthcare Strategy, for Treatment of Cardiovascular Disease



Yong Jeong, M.D ,Ph.D.
Associate Professor, Department of Bio and Brain Engineering
Director, KAIST Institute for Health Science and Technology
KAIST, Daejeon, Korea

Digital Healthcare Market ($B)

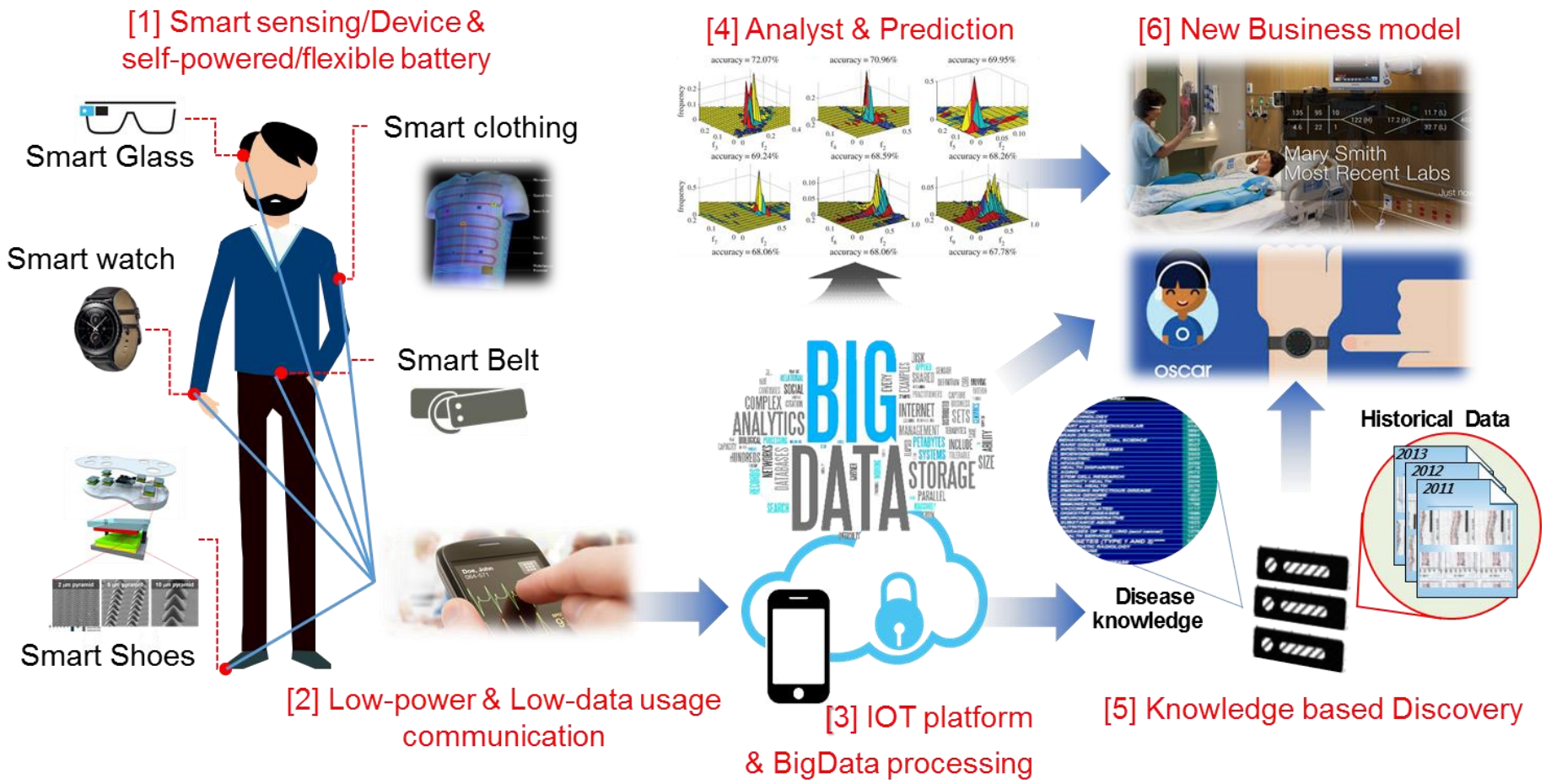


Source: Author D. Little, GSMA, Allied Market Research, Accenture, IHS, MarketsandMarkets

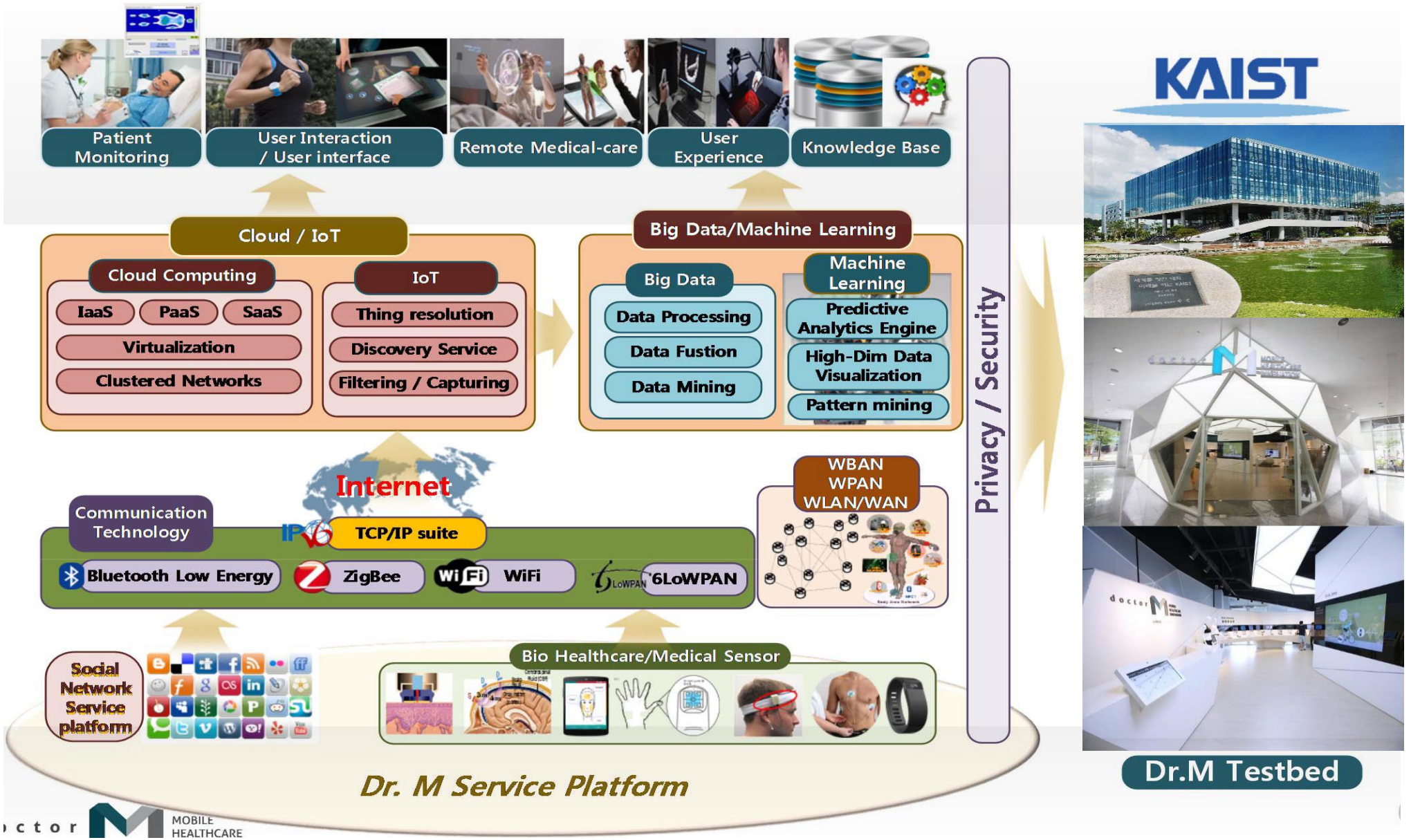
Dr.M-mobile healthcare innovation @KAIST

Dr.M Platform aims for the integrated mobile healthcare service

- ITC technology + Medical service ⇒ **Personalized Healthcare (or Wellness) service**
- Real-time measure/transmission/cloud based storage/analysis



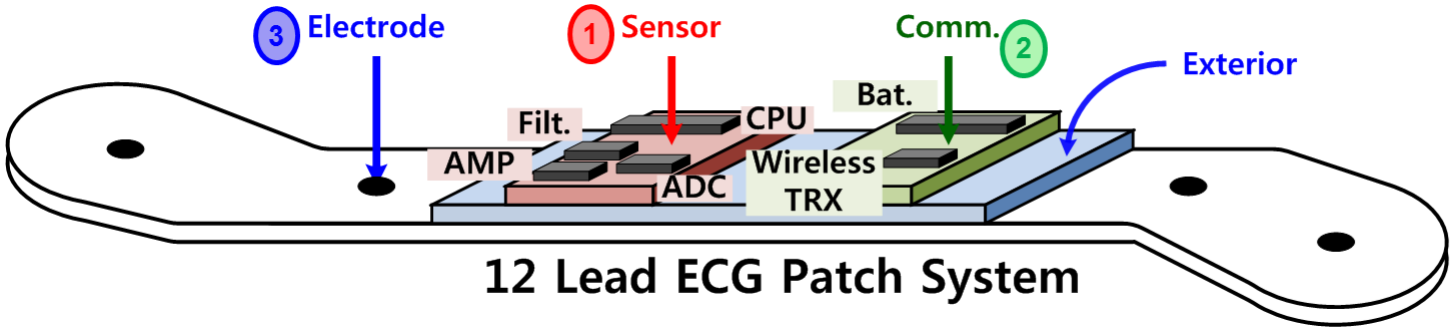
Classify of the Dr.M technology



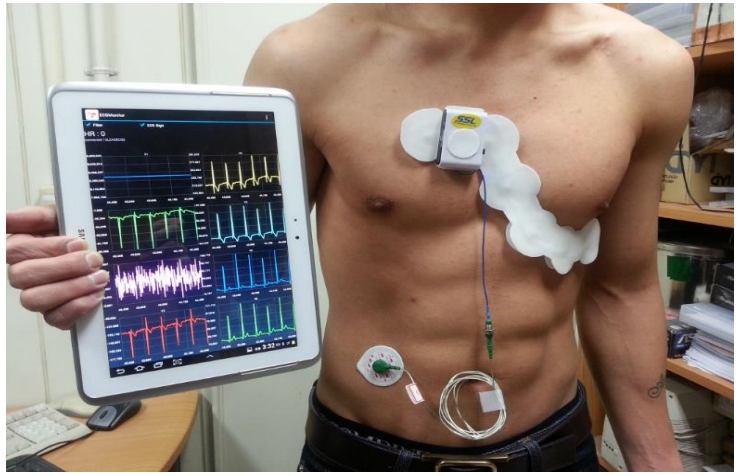
Dr.M tech. for Cardiovascular Diseases

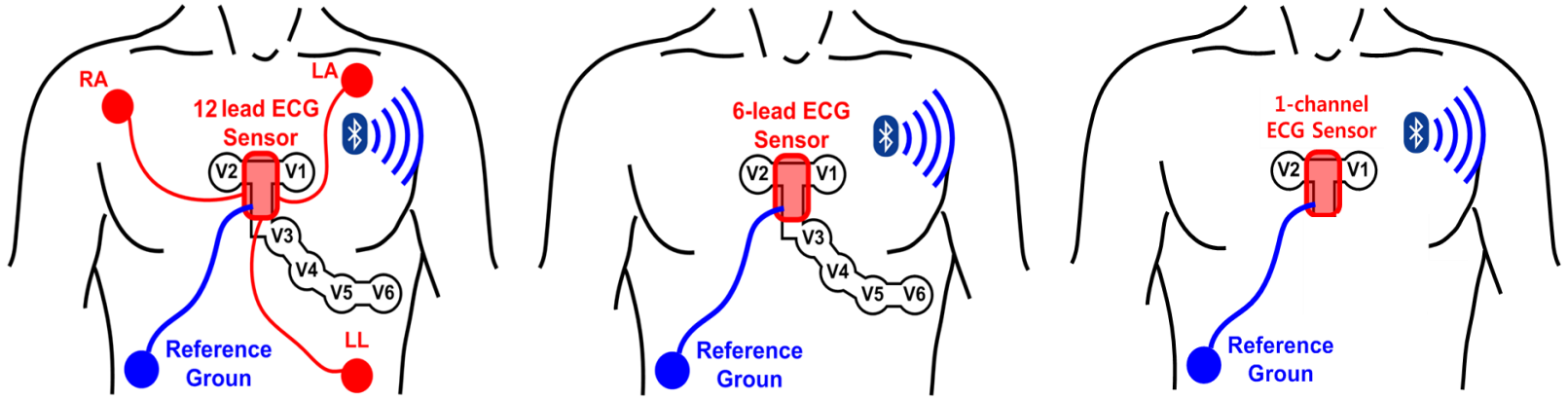
K-PATCH: Mobile ECG PATCH

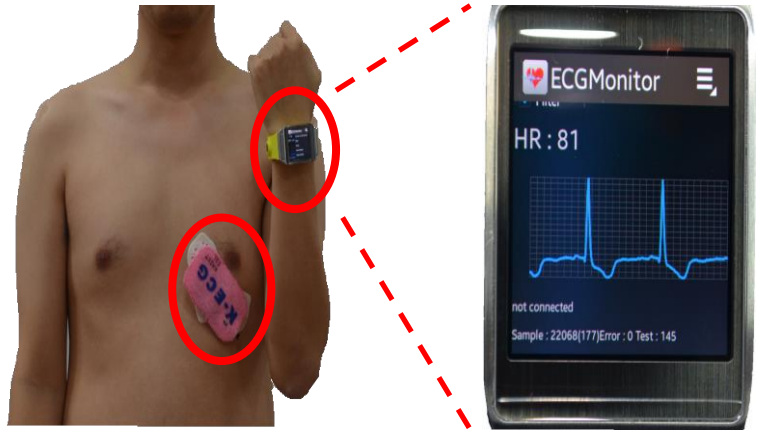
- Using wearable type of multi-channel ECG Patch
- ECG can be easily measured at anytime and anywhere



12 Lead ECG Patch System



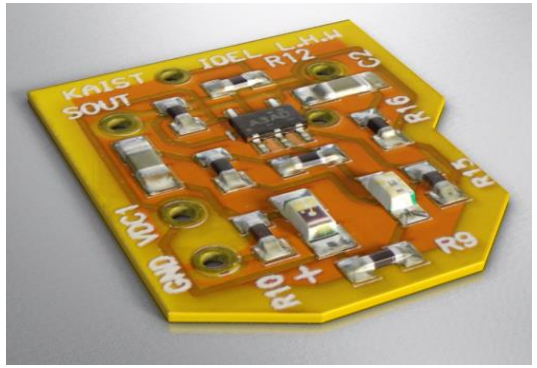


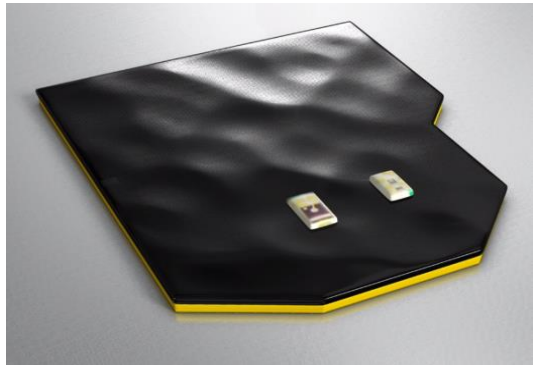


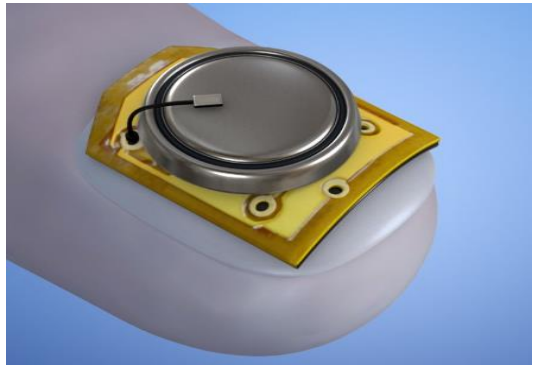
Dr.M tech. for Cardiovascular Diseases

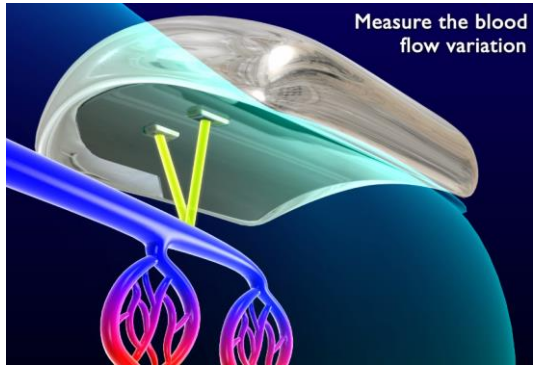
Thumbnail Heart-rate Monitors

- As the sensor is attached to the nail which is insensible, it is convenient for use ,and its conformal contact makes the measurement of the heart rate much easier.





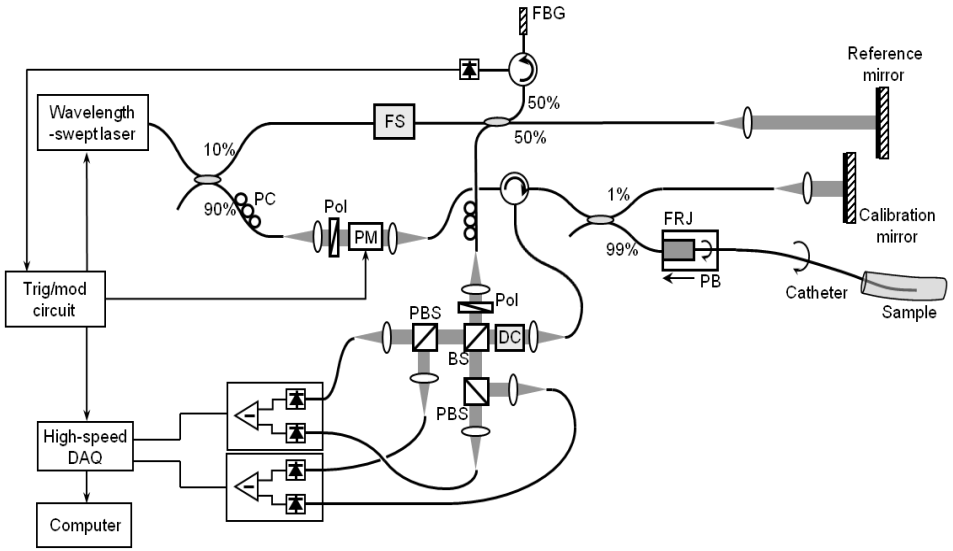




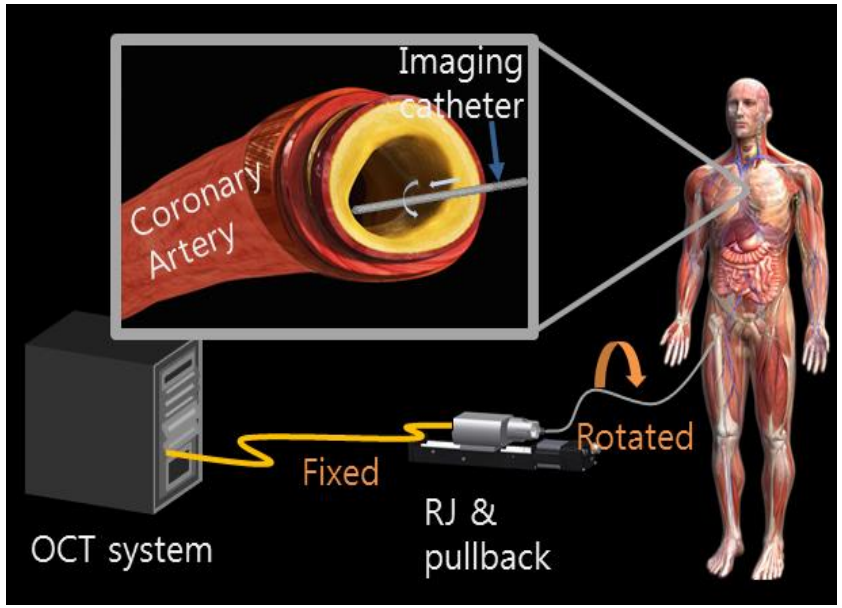
Dr.M tech. for Cardiovascular Diseases

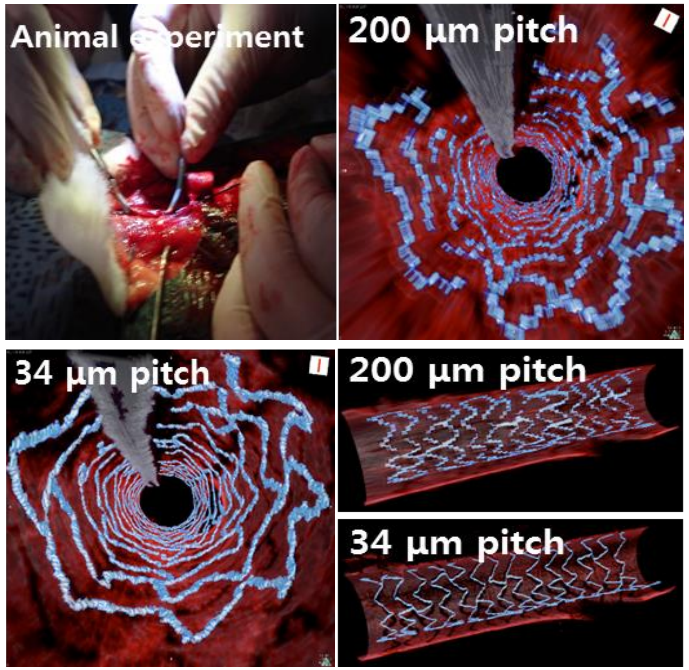
Intravascular OCT: High-speed scanning unit for cardiovascular OCT

- Development of high-speed rotary junction(RJ), imaging catheter and pullback stage for 3-D intravascular images
- To diagnose coronary artery disease accurately, high-speed and high-resolution intravascular OCT system is essential



PC, polarization controller; FBG, fiber Bragg grating; Pol, polarizer; PM, polarization modulator; FRJ, fiber-optic rotary junction; PB, pull-back; FS, acousto-optic frequency shifter; DC, AMTIR dispersion compensator; BS, beam splitter; PBS, polarization beam splitter



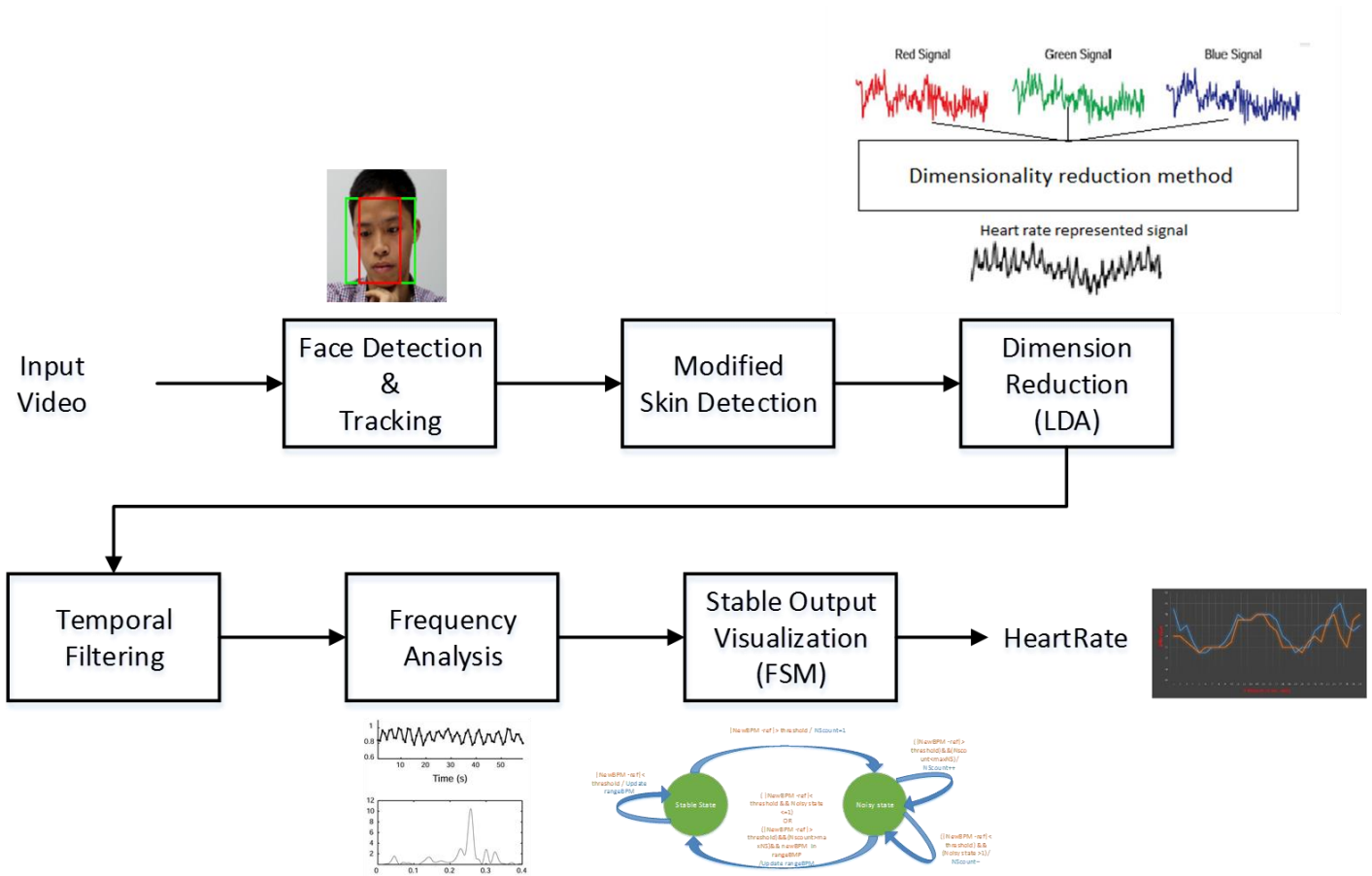


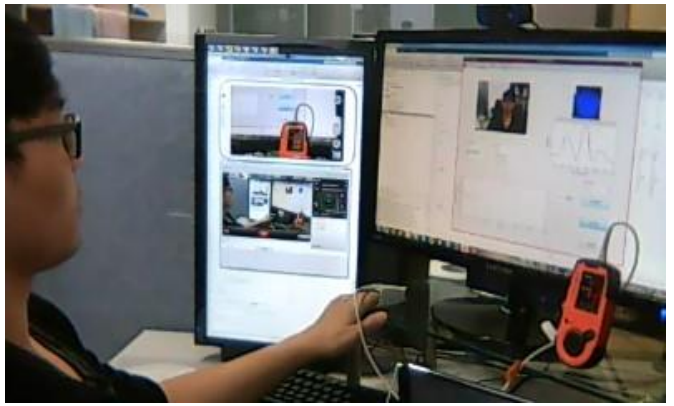
OCT: optical coherence tomography

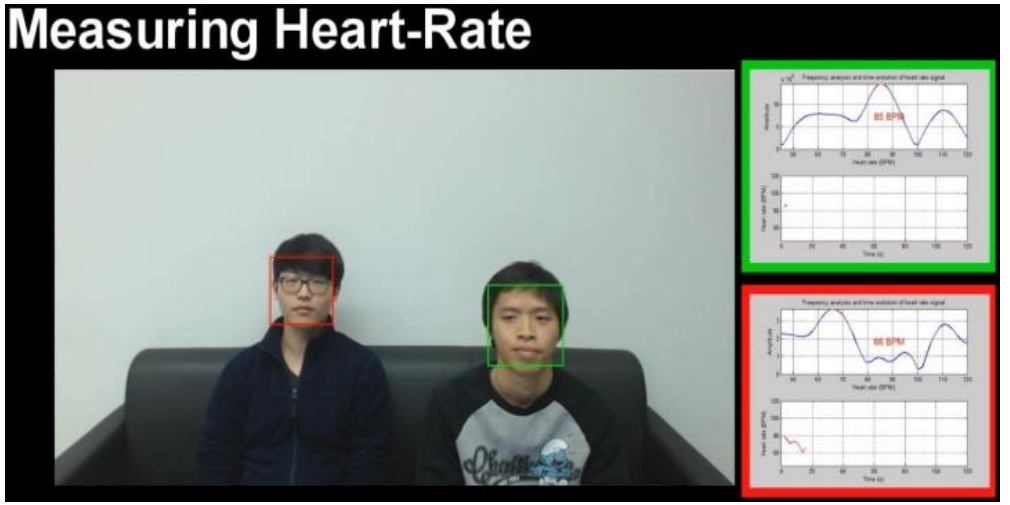
Dr.M tech. for Cardiovascular Diseases

A Robust Real-time system for Heart-rate monitoring system via Camera

- Anyone who wants to monitor their heart-rate status non-invasively. Hospital can also use this software to monitor heart rate of patients remotely, especially for elderly people







Dr.M tech. for Cardiovascular Diseases

Acute Coronary Syndrome prediction & diagnosis

- Through Big Data analysis using machine learning algorithms, we support cardiologists' decision making to avoid unnecessary coronary angiography.

A total of 9,539 patients presented with chest pain who visited outpatient clinic or emergency room and underwnet coronary angiography from Jan 2004 to May 2014 in Cardiovascular Center of Korea University Guro Hospital

↓

ACS was defined as STEMI, NSTEMI, and unstable angina which was confirmed using CAG and underwent percutaneous coronary intervention (PCI) due to siginificant coronary artery stenosis. Non ACS was defined as non significant coronary artery lesion (luminal norrowing <50%).

↓

Patients were excluded if they had one of the following conditions: Advanced heart failure (New York Heart Association functional class III or IV), increased creatinine level ≥ 2 mg/dL

↓

A total of 8,633 patients were finally enrolled

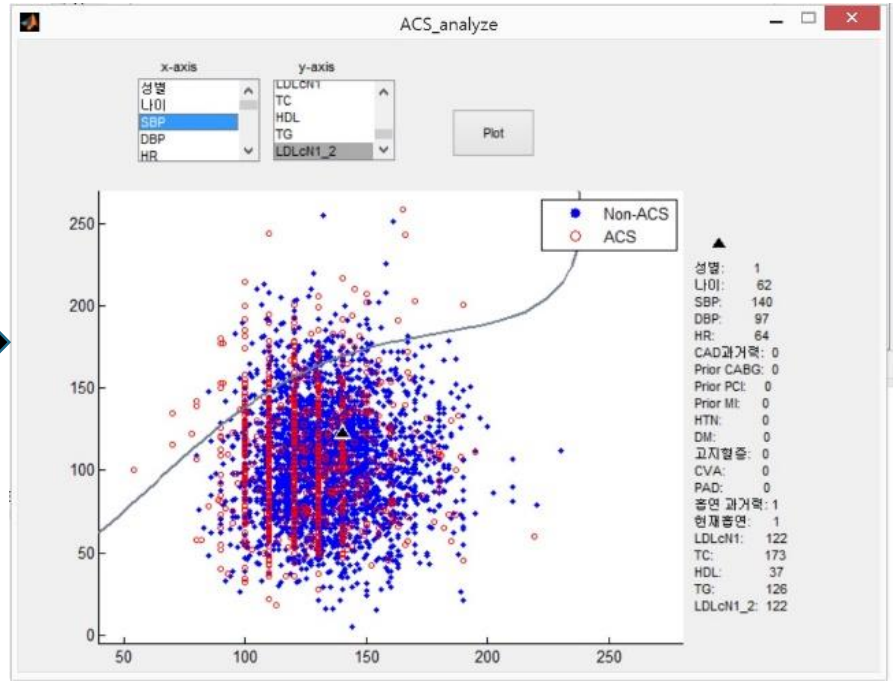
↓

2,344 patients were enrolled as ACS group

6,289 patients were enrolled as non ACS group.

- **Input information**

1. 성별
2. 나이
3. SBP
4. DBP
5. HR
6. CAD과거력
7. Prior CABG
8. Prior PCI
9. Prior Mt
10. HTM
11. DM
12. 고지혈증 여부
13. CVA
14. PAD
15. 흡연과거력
16. 현재흡연
17. LDLcN1
18. TC
19. HDL
20: TG
21: LDLcN1_2

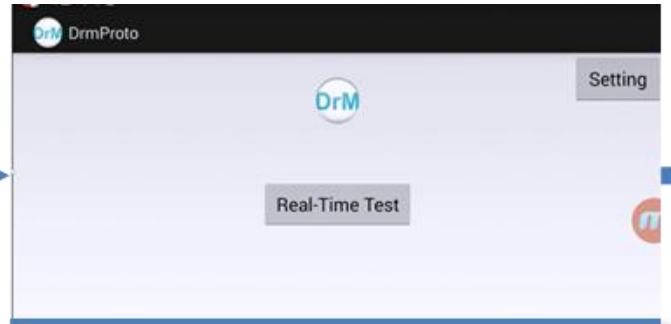


Dr.M tech. for Cardiovascular Diseases

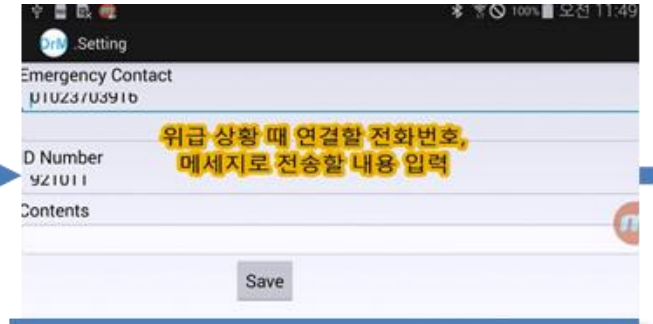
Secure Sensing and Network for sudden cardiac death (SCD)

- To develop the system preventing acute heart failure (AHF) of single residences who cannot adequately be helped in Gold Time.

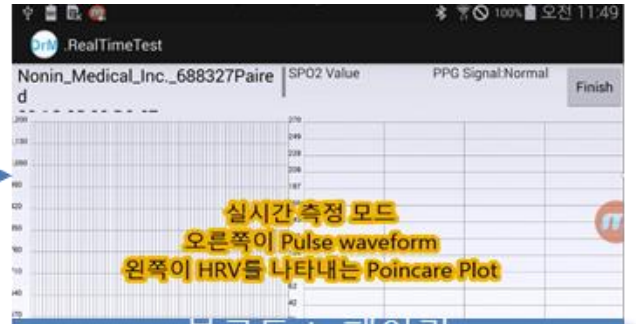
PPG 손가락 착용(시계타입 대체 가능)



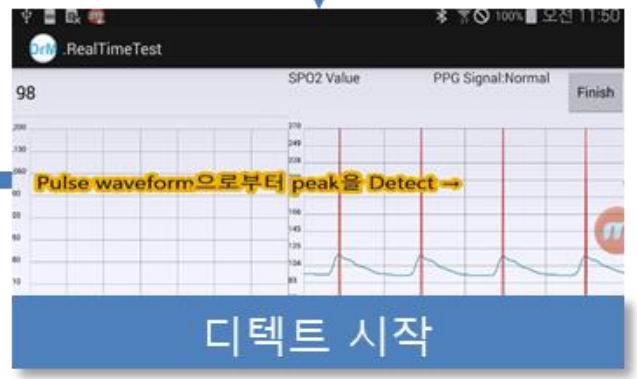
Dr.M 심장돌연사 앱 실행



설정 정보 입력

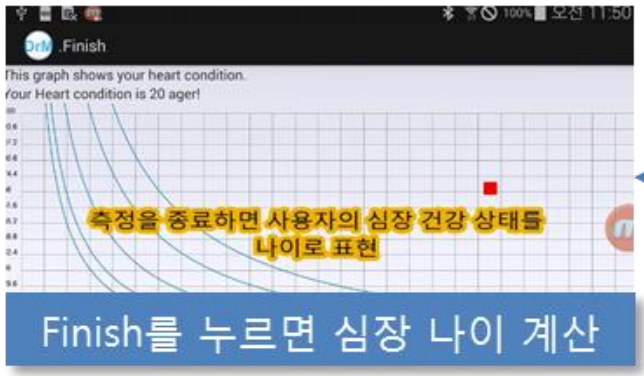


블루투스 페어링 (디바이스 텍스트 클릭)



디텍트 시작

위급상황시 알람 발생

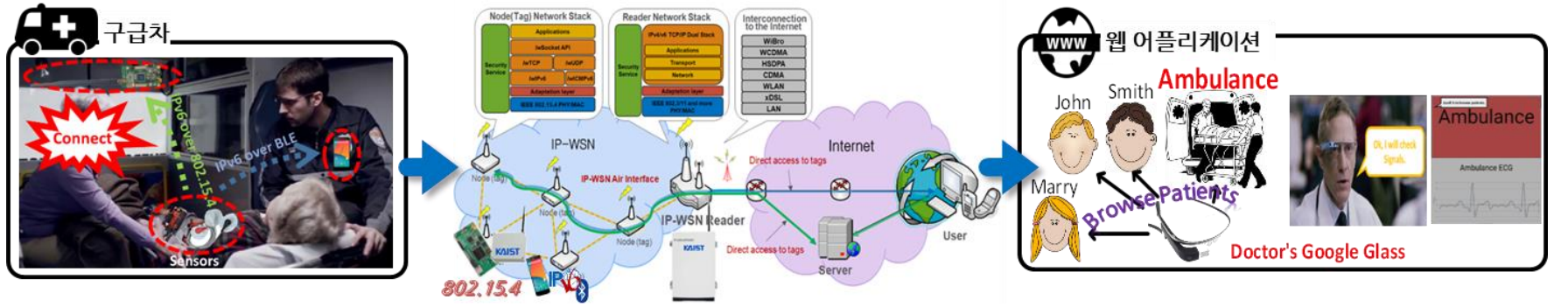


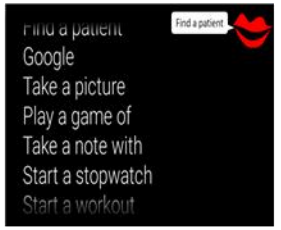
Finish를 누르면 심장 나이 계산

Dr.M tech. for Cardiovascular Diseases

SNAIL IPv6 IoT Connectivity Platform

- IoT connectivity platform, SNAIL : Sensor Network for an All Ip-world
- Patient browsing Scenario for real-time diagnosis and fast action
- Browse patient's health condition quickly using smart devices (i.e. Google glass.)





1

게이트웨이와 헬스 센서를 무선을 통해 서로 연결시킵니다.

2

구글 글라스를 쓰고 메인 화면에서 "ok glass" 라고 말합니다.

3

위의 메뉴 화면에서 "find a patient" 라고 말하면 Patient Browsing 웹 서비스가 실행됩니다

4

환자 목록이 나타나면 구글 글라스 오른쪽의 터치패드를 조작하여 환자를 선택합니다.

5

구글 글라스를 통해 환자의 생채 신호를 실시간으로 확인합니다.

6

환자의 다른 생체신호를 확인하기 위해서는 터치패드를 아래로 드래그하여 NEXT 버튼을 클릭합니다.

Dr.M Showroom (KI building 1F, KAIST)

Dr.M Home

Dr.M Hospital

Dr.M research contents

Wearable Device & User

- Sensor & wearable device accuracy
- Sensor accuracy based on behavioral action (rest, walk, run.. Ect)
- User's personal behavior classification (typing, walking with smartphone, rest with smartphone)
- Smart Device Usage Pattern
- .....

Individuals & Group & Community

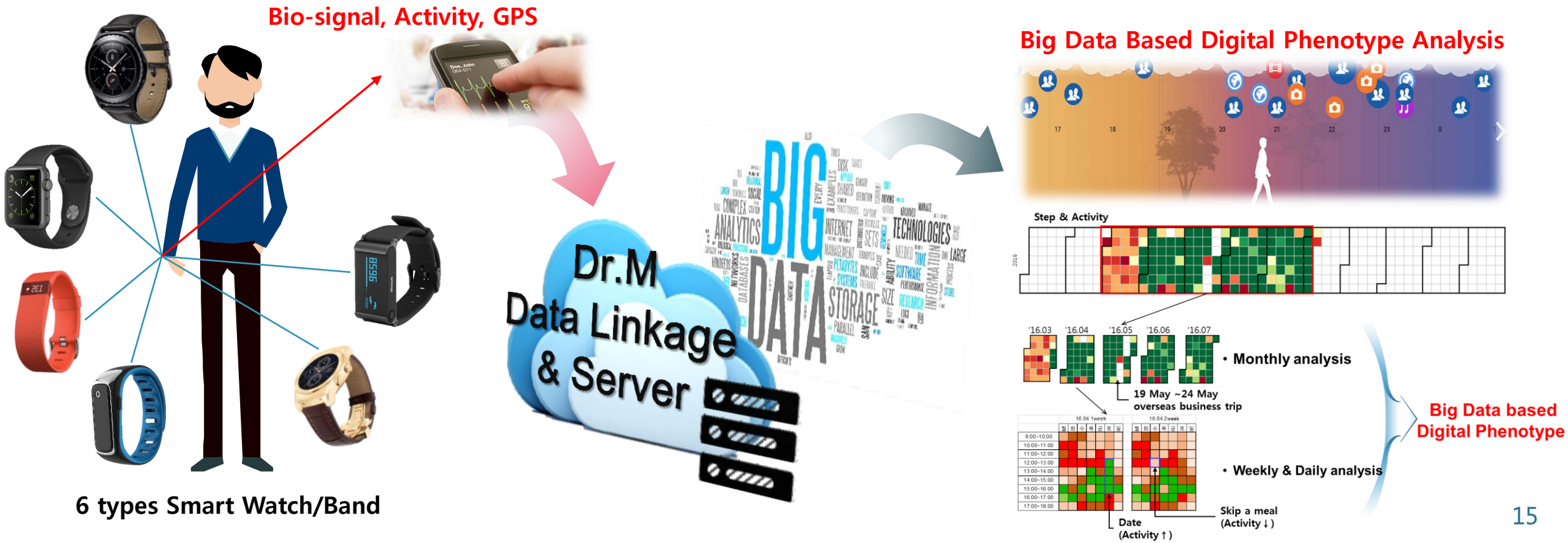
- Behavioral changes in individual populations
- Big data analysis
- Survey on device users
- .....

Personal Healthcare & Wellness service model

Utility of the Dr.M testbed

Utility of the Dr. M testbed for Digital Phenotype

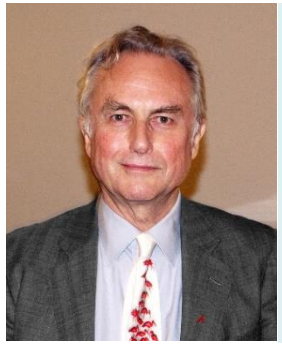
- 6 types sensor device was distributed to 350 members of KAIST (April 2016 ~)
- Real-time Sensor data (Heart rate, Activity, GPS) collection/monitor/analysis



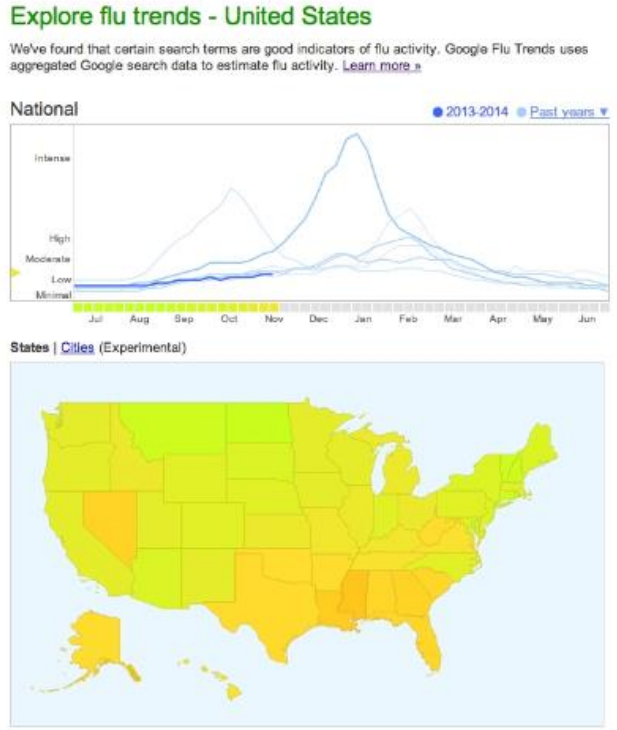
Digital Phenotype

'Digital Phenotypes' describes the use of new digital technologies to capture individual data, outside of current healthcare settings.

- anything from wearable fitness devices and mobile phone apps, to social media and citizen science



Clinton Richard Dawkins (1941-03-26~)
The Extended Phenotype: the Gene as the Unit of Selection.
(Oxford: Oxford University Press; 1982)
"phenotypes should not be limited just to biological processes, such as protein biosynthesis or tissue growth, but extended to include all effects that a gene has on its environment inside or outside of the body of the individual organism."



The digital phenotype

NATURE BIOTECHNOLOGY VOLUME 33 NUMBER 5 MAY 2015

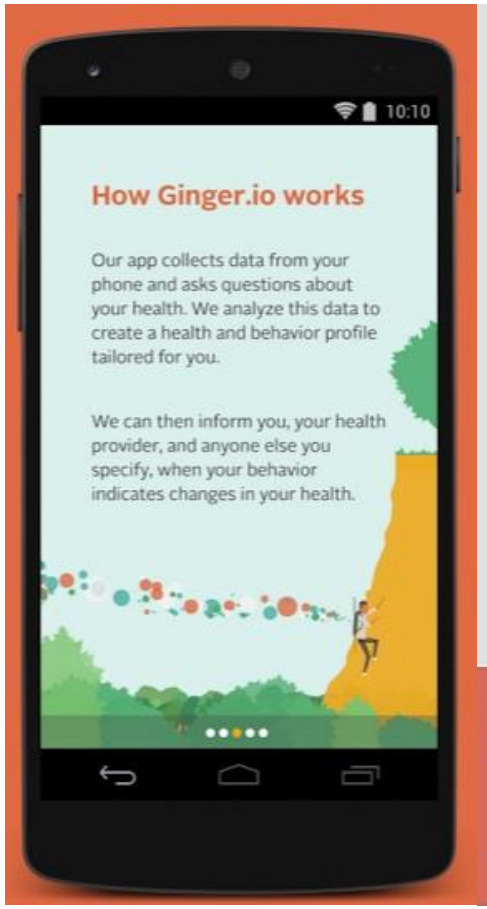
Sachin H Jain, Brian W Powers, Jared B Hawkins & John S Brownstein

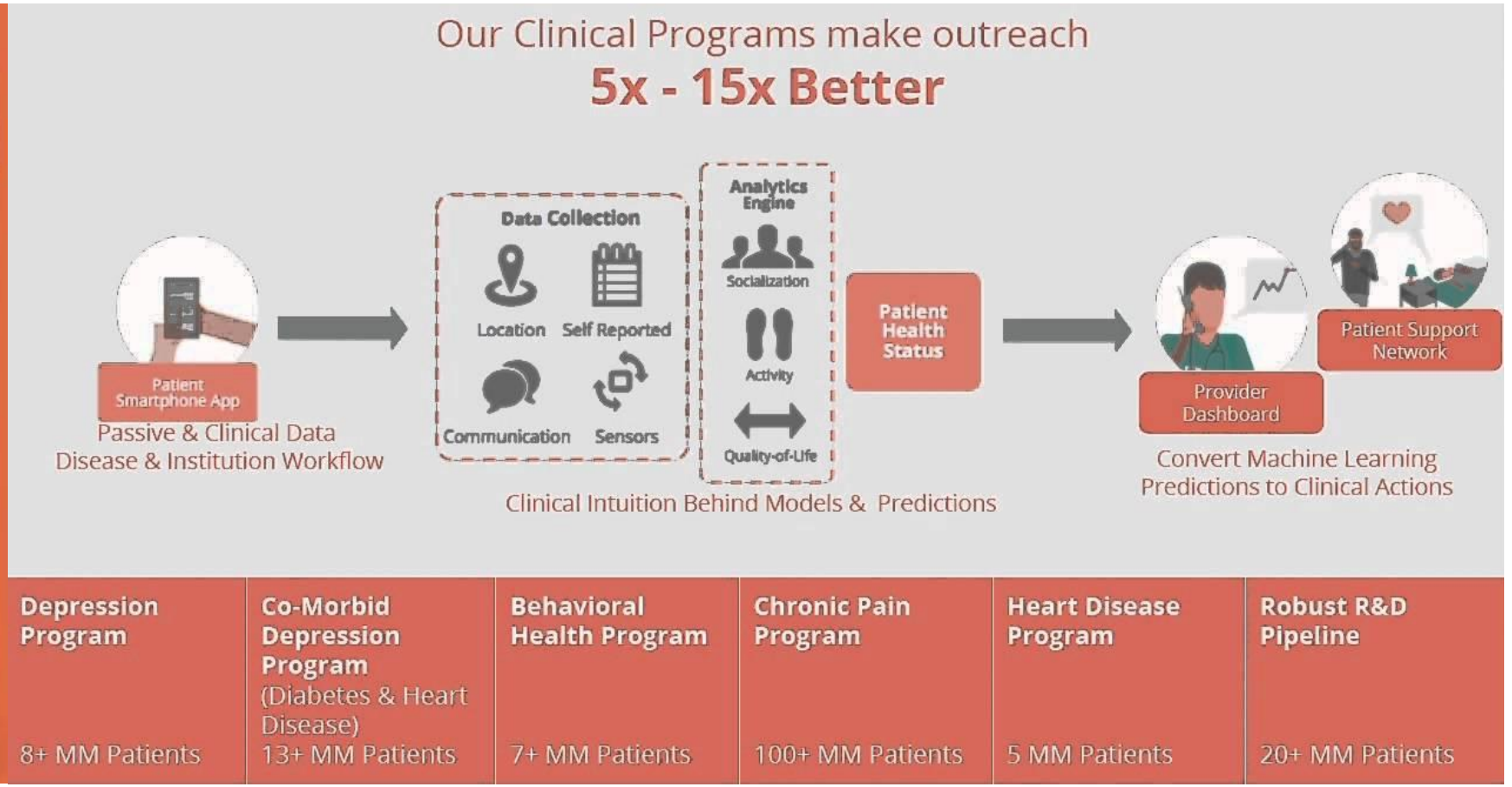
In the coming years, patient phenotypes captured to enhance health and wellness will extend to human interactions with digital technology.

Digital Phenotype – Ginger.io

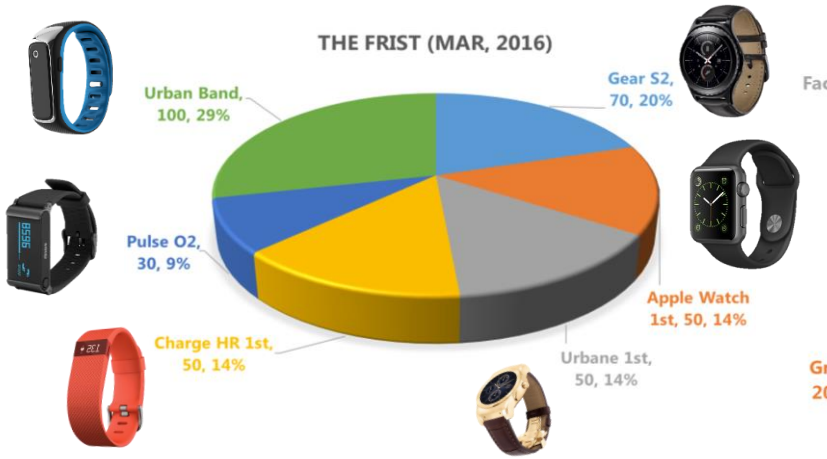
Your phone knows if you're depressed

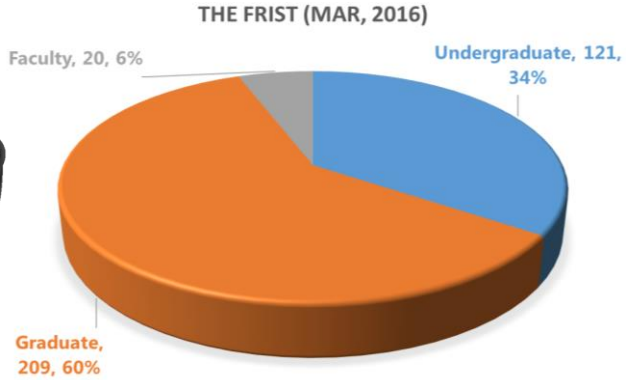
- Time spent on smartphone and GPS location sensor data detect depression

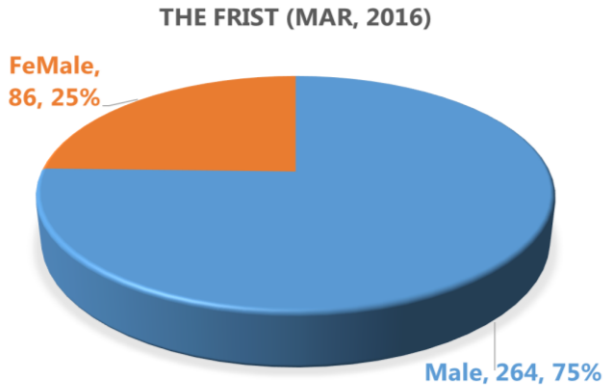


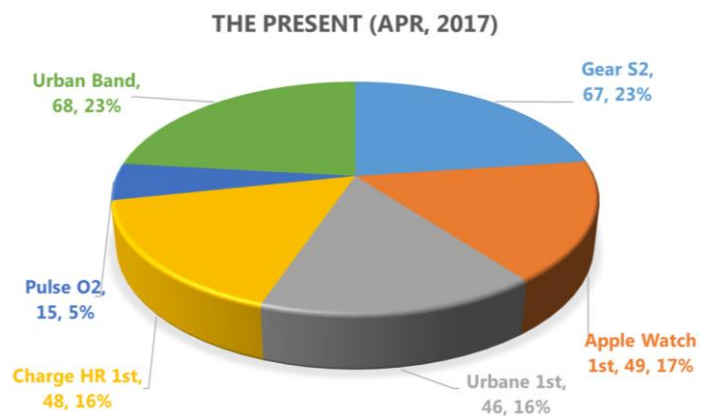


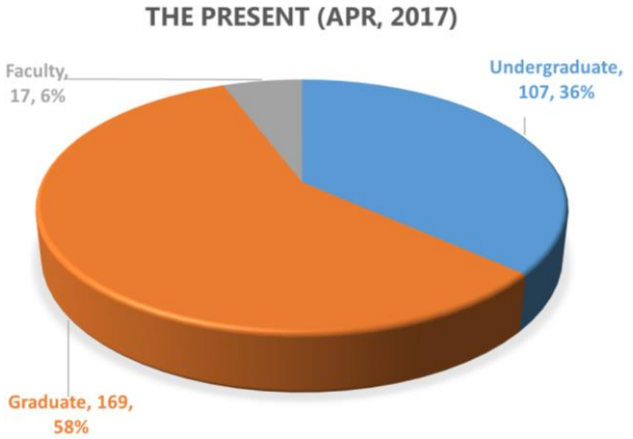
Utility of the Dr.M testbed

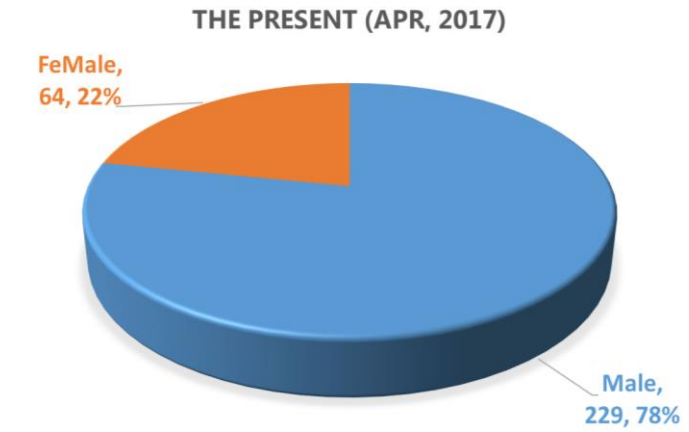








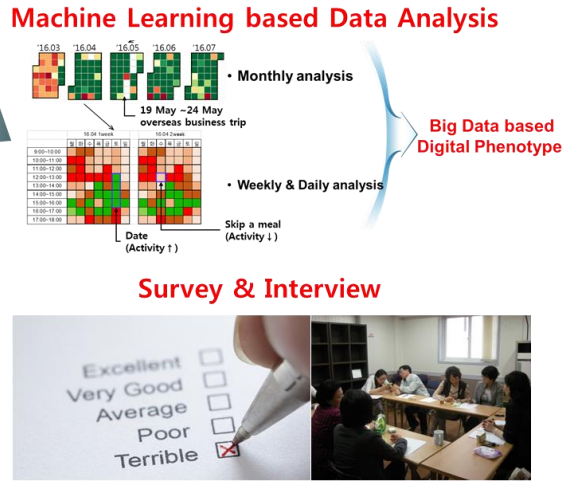




- 57 participants gave up: graduation, change jobs, device breakdown, inconvenience of use
  - 25 urban band user: **breakdown of the device**
  - 15 Pulse O2 user: **inconvenience of use** (Pulse O2 dose not support automatic Heart rate measurement)

Utility of the Dr.M testbed

Data Analysis, Survey, and Interview of Large-scaled Dr.M research



- Loyalty
(daily usage/1yr)
- Automatic detection of wearing/taking-off
- Wearing satisfaction
- Factors affecting wearing

- Daily wearing patterns (wearing/ taking off time, frequency)
- Pattern clustering according to Daily wearing
- factors affecting wearing/taking-off behaviors

- Loyalty: **Apple Watch**>GearS2 = Charge HR > Urbane > Pulse O2 = Urban band
- Correlation with Satisfaction and Loyalty

Satisfaction	Correlation with Loyalty
Design	$\rho = 0.78$
Notifications (call, text, email, alarm)	$\rho = 0.81$
Health information	$\rho = 0.27$
Useable time (battery)	$\rho = 0.43$
Durability	$\rho = 0.72$

Case study: wearing behaviors of Apple Watch

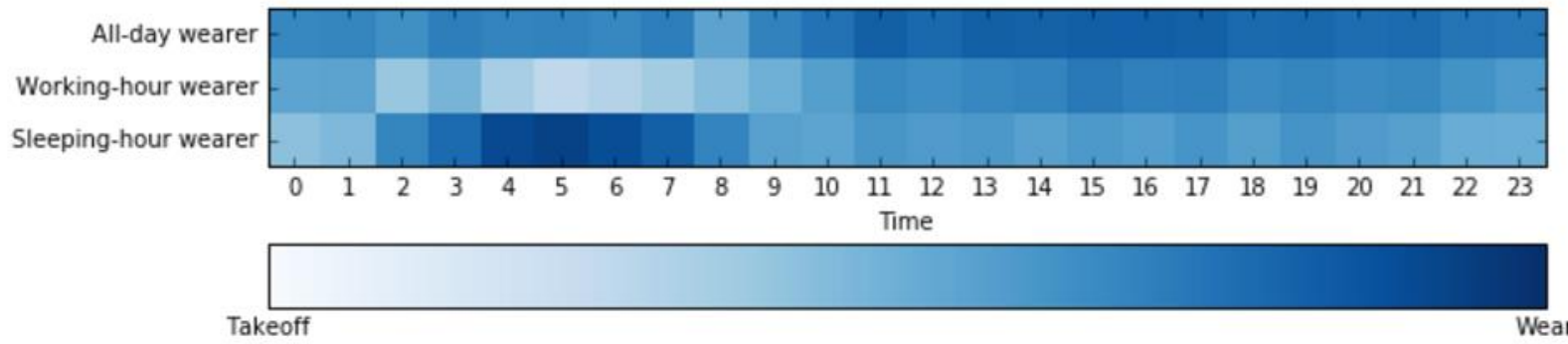
- **Daily wearing patterns:**

	Average wearing hours
All days	10.48 hours (SD = 3.47)
Weekdays	11.32 hours (SD = 3.53)
Weekends	8.66 hours (SD = 3.60)

- Don't want to be interrupted, and the costumes on weekdays and weekends are different , Longer wearing hours on weekdays than weekends

- **Diurnal wearing pattern: 3 groups found from spectral clustering**

	More wearing times	Less wearing times
All-day wearer (35 people)	Working hours (9AM-midnight) (Mean=77.68%, SD = 4.04%)	Off-hours (midnight-9AM) (Mean=65.85%, SD = 4.66%)
Working-hour wearer (7)	Working hours (9AM-midnight) (Mean=64.22%, SD = 5.82%)	Night-time (2AM-9AM) (Mean=36.60%, SD = 6.82%)
Sleeping-hour wearer (4)	Night-time (2AM-9AM) (Mean=80.55%, SD = 10.56%)	Working hours (9AM-midnight) (Mean=56.87%, SD = 3.36%)



- Users can separate the user into three groups depending on their wear time, which can be applied to the development of the service model

Case study: wearing behaviors of Apple Watch

- **8 factors affecting wearing/taking-off behaviors**

- : Positive factor of wearing
- : Negative factor of taking-off

Factors	Affecting wearing behaviors	Affecting taking-off behaviors
Need of Immediate Response	**Ability to detect incoming notifications without missing** **Ability to quickly distinguish importance of notifications**	No need of immediate response (In situations **like off-working hours or weekends** Desire to be away from notification alarms
Engagement of Social Activities	Less disturbing others when checking information Glancing at watch is more socially acceptable action Less disturbing and easier to ignore alarm	No relevant theme was found
Availability of Personal Workspace	Less likely to take-off smartwatch in **shared spaces (e.g. café, restaurant)**	More likely to take-off smartwatch in **places with personal working area (e.g. office, classroom)**
Need for Multitasking	**Activities with both hands occupied (e.g. driving a car, riding a bicycle)** **Activities with significant attention required (e.g. conducting an experiment)**	No relevant theme was found
Charging Smartwatches	No relevant theme was found	Take-off smartwatch multiple times a day to charge when user is near charging stations Forget to wear smartwatch after charging Often forget or decide not to take charging stations (e.g. when traveling)
Aesthetics	More generous about the aesthetics as smartwatch is a 'wrist-worn electronic device'	**Smartwatch as a substitute of conventional watch (expectation as a smart fashion accessory)**
Daily Activity Tracking	Motivations from getting daily movement information Refresh from occasional physical movement status alarm	Disturbance from activity status update alarms Confusion with other useful notifications (e.g. emails or messengers)
Exercise Tracking	Desire to track and record their workout progress To keep track of their body status during workouts	Limited options of exercise types Unavailability to capture movements

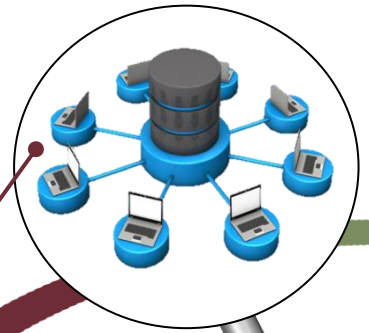
Lessons so far…

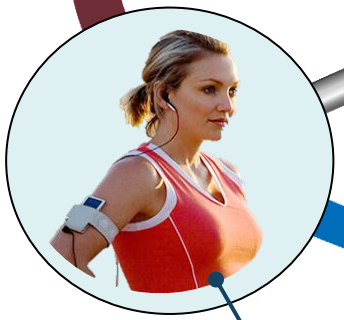
- **Sensor accuracy, measured bio-signal (or information)**
  - **Inaccuracy of measured values (bio-signal, activity type, step count..)**
  - **Not enough current information (Heart-rate, Activity, GPS) to provide personal physical healthcare**
- **Lack of Healthcare function or service**
  - Most user are satisfied with smart watch, but not with smart band
  - Also, most smart watch user are satisfied with notification function but it is not healthcare function
  - Healthcare service and functions are required based on personal characteristics
- **Factors of Long-term Engagement: Design, Durability, Battery (Usable time)**
  - Design ∝ wearing loyalty
  - Frequent replacement and A/S → stop using, negative recognition about smart device
    - At least 3months to 12 months, Most smart bands suffer damage to strap or broken down
  - Frequent battery charging, charging station → stop wearing due to frequent loss, Spatial constraints of charging





“Dr.M” project Consortium





총괄

KAIST

한국과학기술원

Korea Advanced Institute of Science and Technology

Platform & SW & Device

HANCOM GROUP

LG U+

Healthcare idea elicitation & Clinical verification

ASAN FOUNDATION 아산재단

서울아산병원

Asan Medical Center

국립중앙의료원

National Medical Center

대전선병원

Development of Service Model & Trial Application

Noble County

노블카운티

THE CLASSIC 500

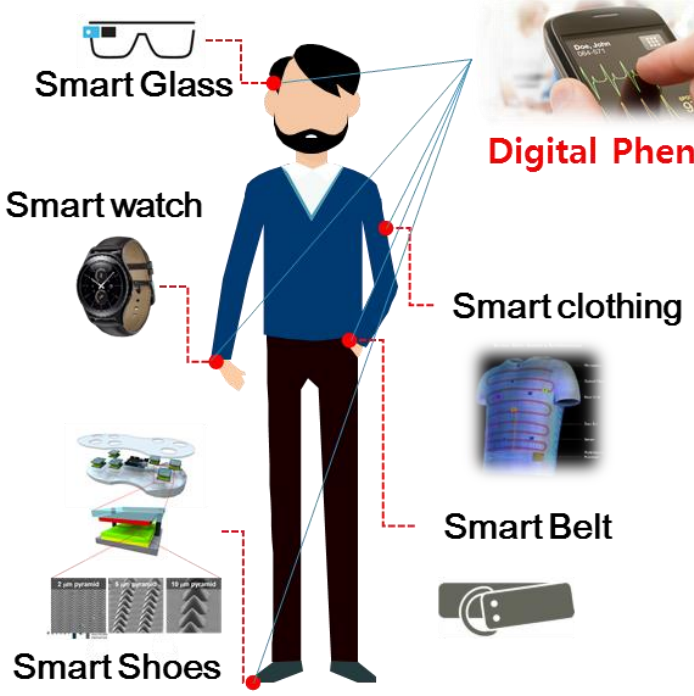
미래세움

성남 고령친화종합체험관

운영기관 을지대학교 산학협력단

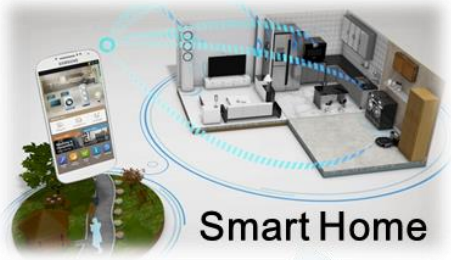
Future Plans

Daily Tracking of Bio signal & Lifelog

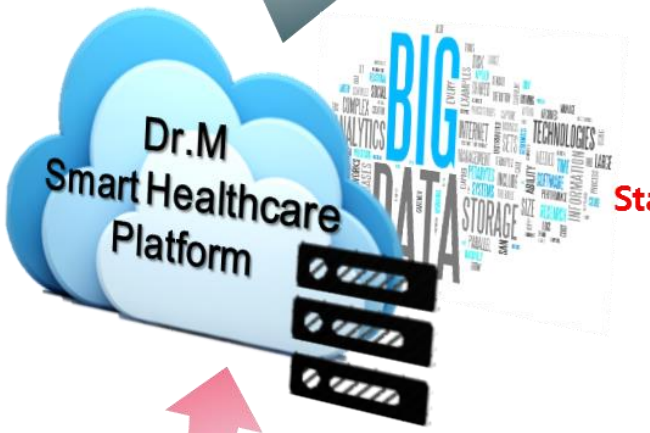


Digital Phenotype

Wearable Device



Smart home & IoT Device



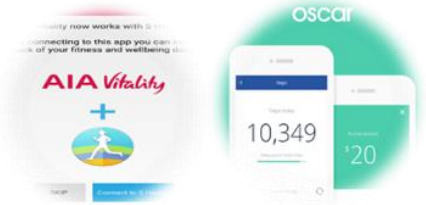
Hospital information system + Genetic information

Open API: Standard Database & Platform

Personal Healthcare service

Entertainment

Diagnosis, Prevention of Diseases



Finance & Insurance Service

Thanks for attention!!

Contact Us & More Information

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