感測元件用於健康照護的應用及其進程

國立台北科技大學 電子所

李仁貴特聘教授

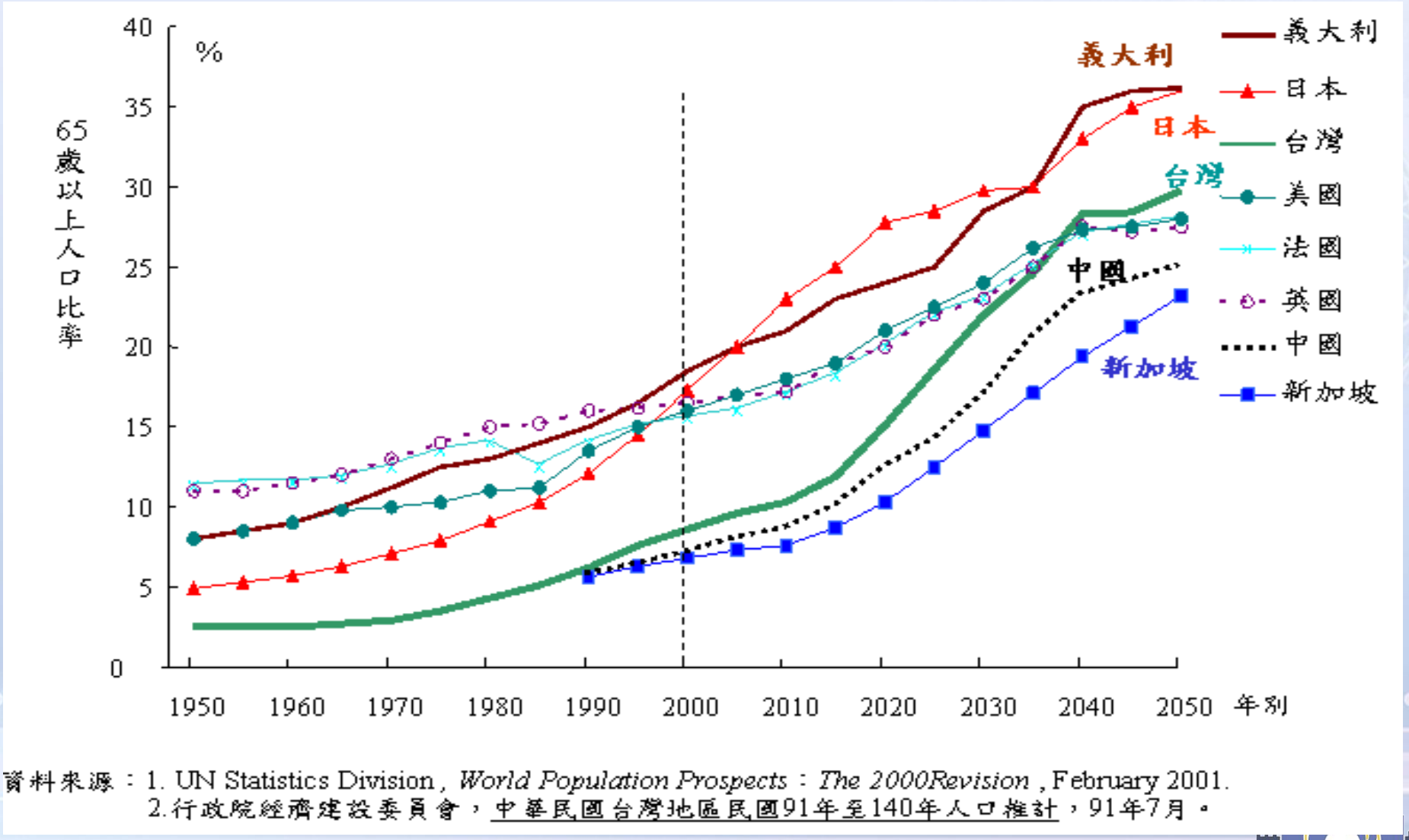
evans@ntut.edu.tw

2015.10.20

Outline

- 健康照護簡介
- U化與智能化健康照護
- 生醫資料感測收集技術
- 行動醫療與穿戴式技術發展
- 結論

高齡化社會



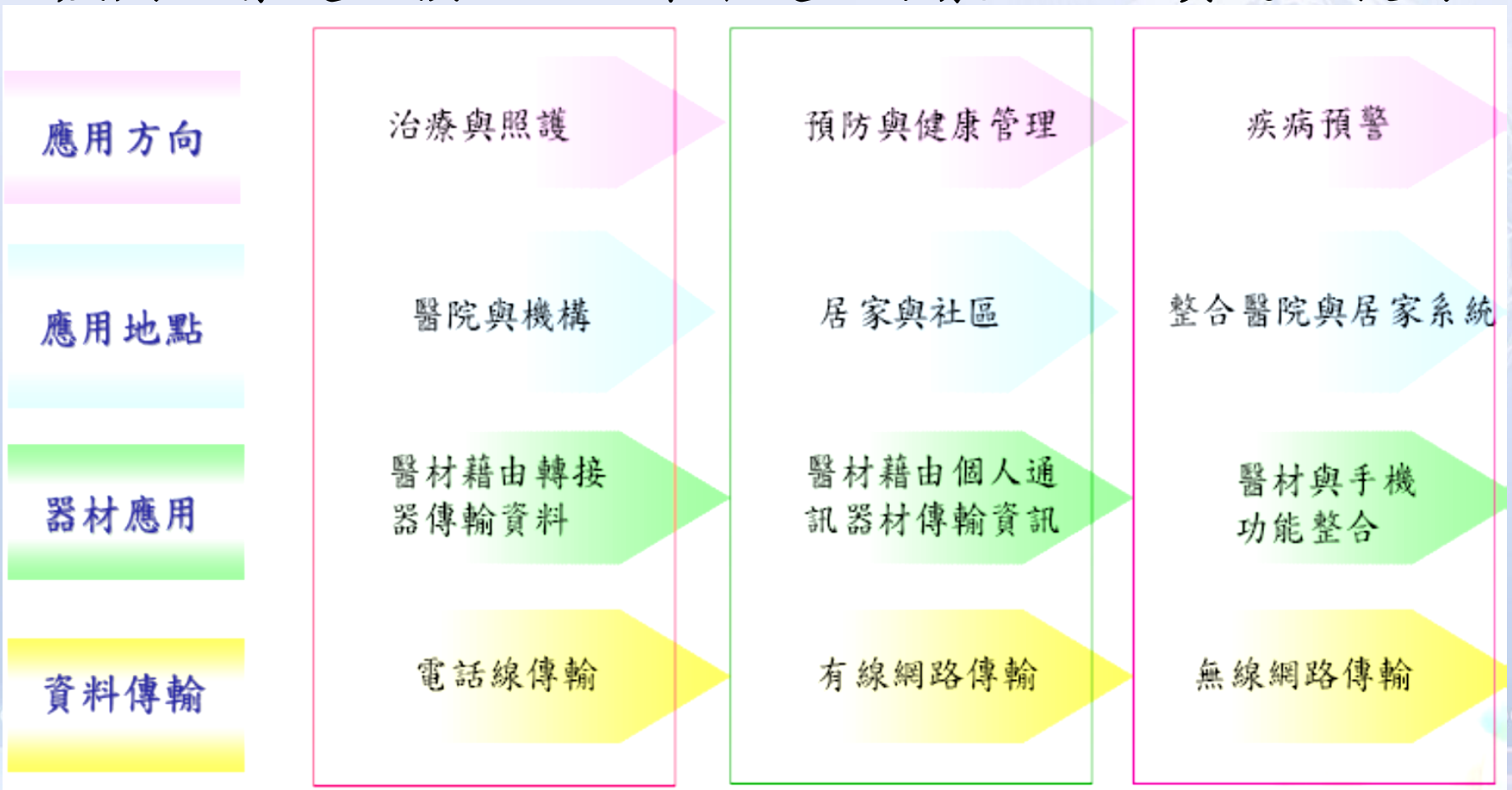
資料來源：1. UN Statistics Division, *World Population Prospects：The 2000Revision*, February 2001.
2.行政院經濟建設委員會，中華民國台灣地區民國91年至140年人口推計，91年7月。

高齡化人口的醫療照護問題

- **巨大照護需求是家庭的負擔**
  - 醫療支援:慢性疾病的併發症，殘疾，絕症
  - 心理輔助:獨居老人及與社會少接觸者
  - 緊急照護:緊急事件處理
- **不斷增加的醫療費用**
  - 在台灣，10%的老人使用整體健康照顧開支的25%以及40%的緊急醫療。

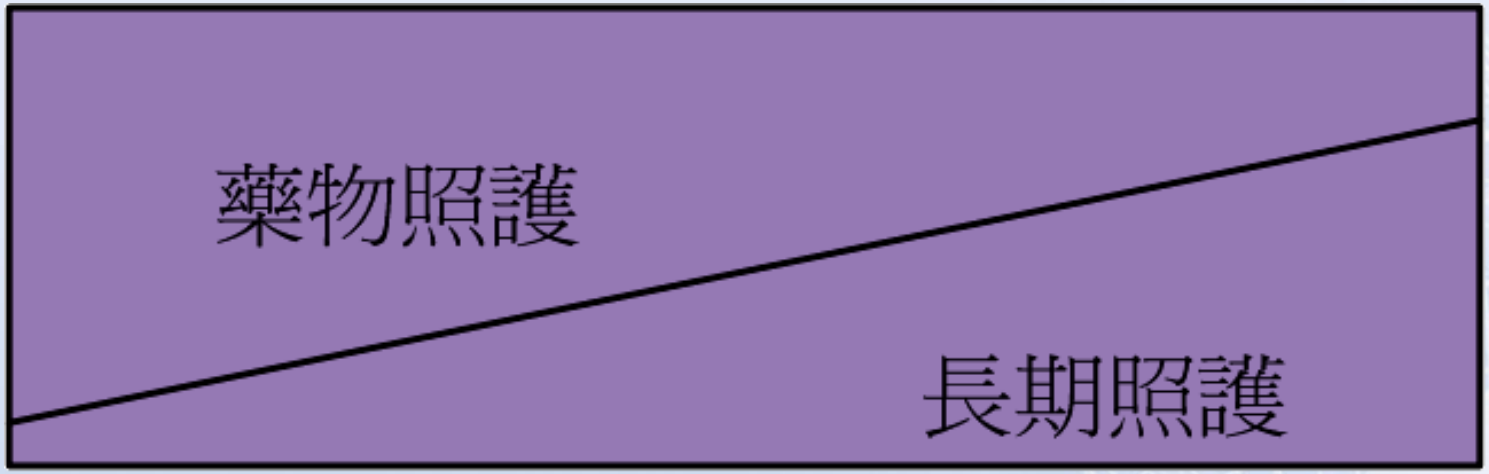
健康照護管理的演進

由疾病治療走向預防；由集中走向分散；結合資通訊技術



資料來源：工研院IEK

醫療照護的持續性



緊急照護

急性照護

慢性照護

長期照護

門診、急診

遠程會診

遙控監視

持續性照護

看護照護

居家照護

醫院

家庭

家庭

疾病型態慢性化

慢性病困擾全球

死亡率高:
- 21世紀人類的癌症
- 2005年有60%的死亡緣於慢性病 (WHO)
- 十大死因佔7項

醫療成本高:
- *美國約佔75%*、不處理慢性病的問題，將無法解決日益高漲之醫療成本。 (Centers for Disease Control, 2006)
- *台灣則約佔60%*

慢性病問題

慢性病管理

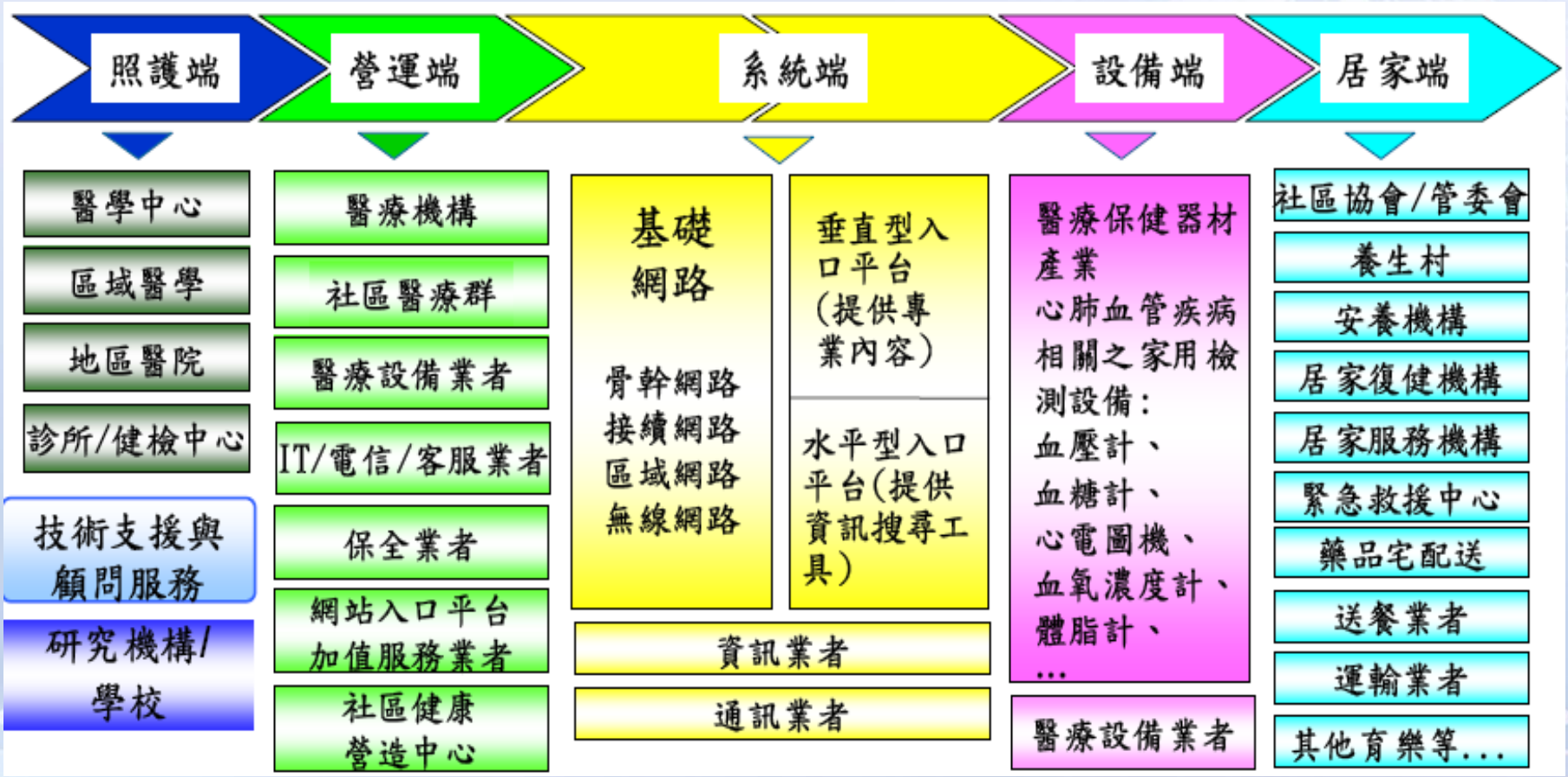
- 美國率先於廿世紀80年代經營慢性病管理產業，並持續增長。
- 日本已意識到慢性疾病管理產業之價值，而自前(94)年開始試行推展。
- 新加坡近年來也努力跟進。
- 我國現階段亦尚未出現明確整合型之產業，但長遠而言，值得由法人與業界共同推廣。

- 慢性病主要*病因*多*能掌握*，如能消除了這些危險因素，至少80%的心臟病、中風和二型糖尿病，40%以上的癌症都是可以避免的。（WHO）

- 我國已進入高齡化社會，慢性病之負擔將有增無減
- 此一趨勢造就國內發展「健康照護」之契機

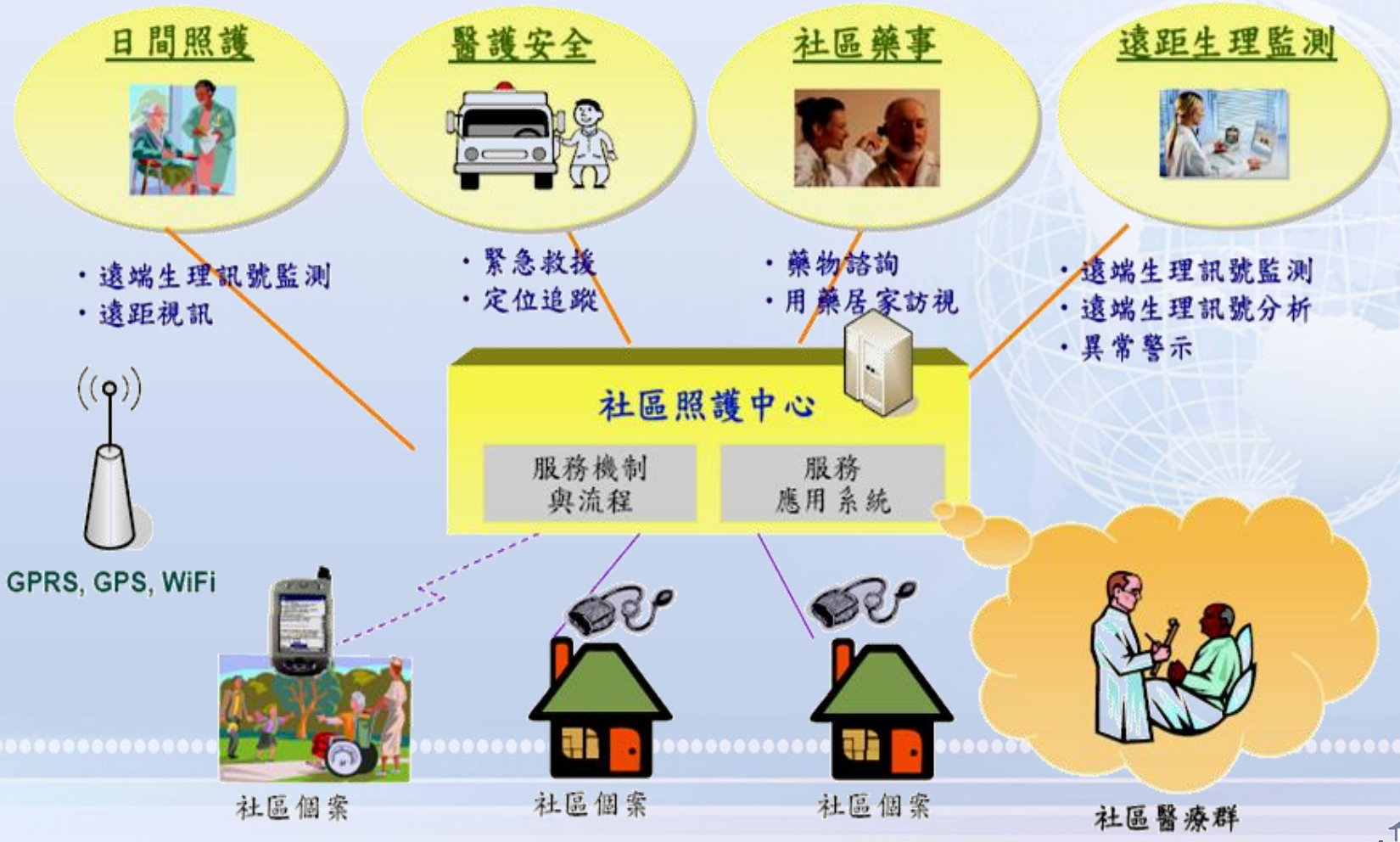
國內健康管理照護系統趨勢

- 未來銀髮新商機



資料來源：經濟部

國內社區式照護服務架構圖



資料來源：洪麗珍,弘光科技大學護研所

國內居家式照護服務架構圖

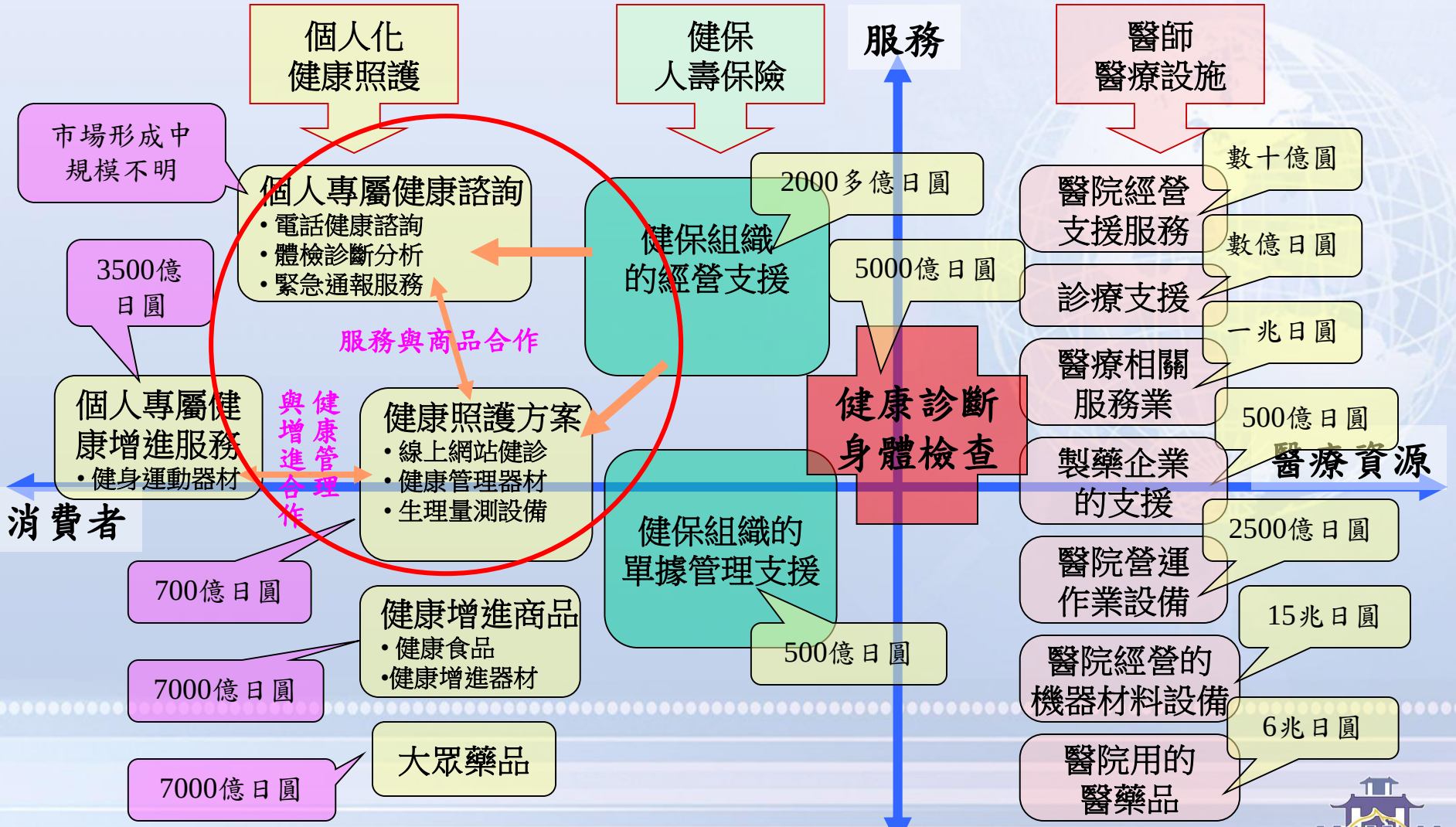
資料來源：洪麗珍,弘光科技大學護研所

國內機構式照護服務架構圖

資料來源：洪麗珍,弘光科技大學護研所

健康照護服務產業的市場構面

(資料來源：日本野村研究所、工研院服科中心)



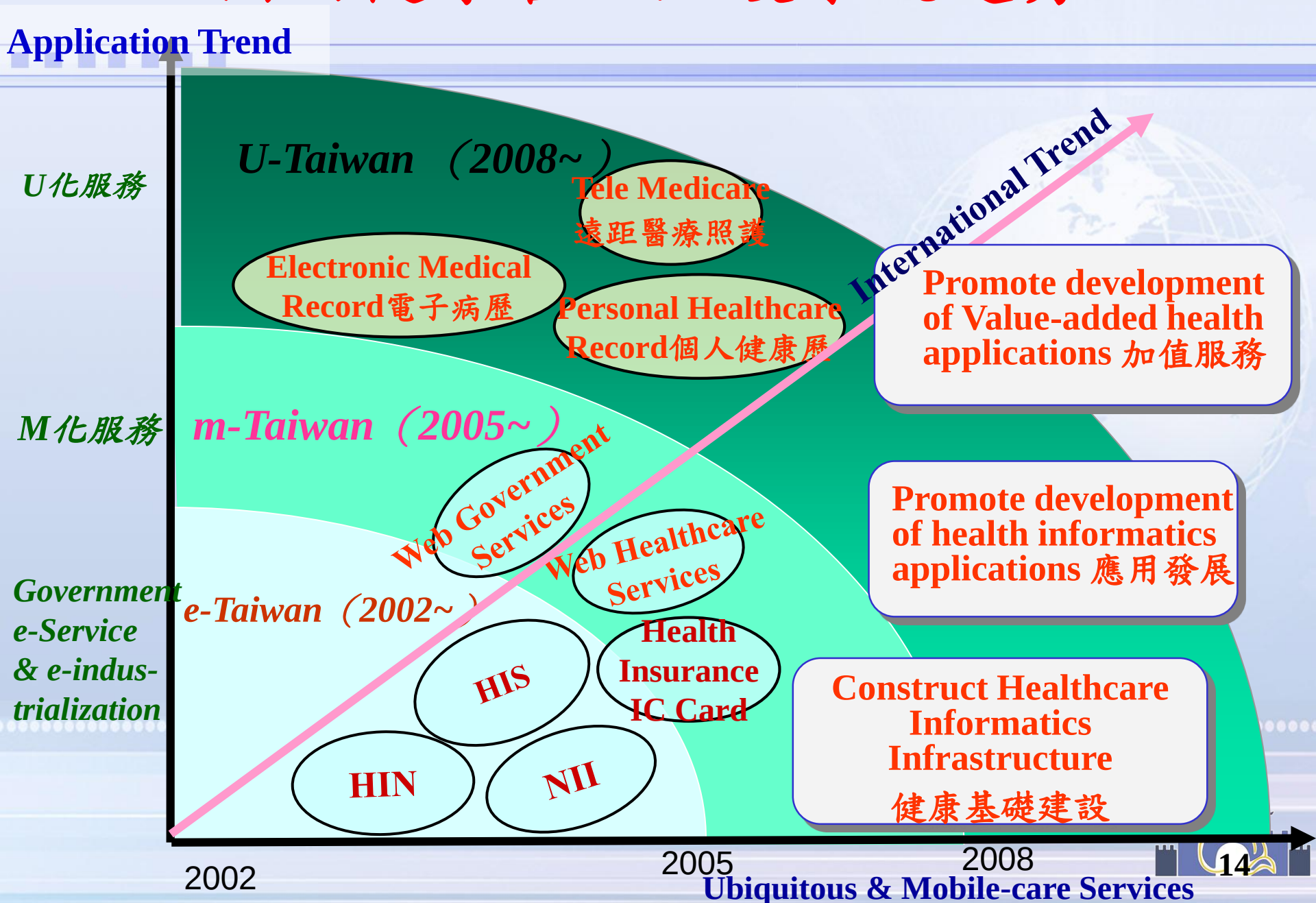
TAIPEI TECH 國立臺北科技大學
National Taipei University of Technology

誠,樸,精,勤

無所不在（U化）與智能化健康照護

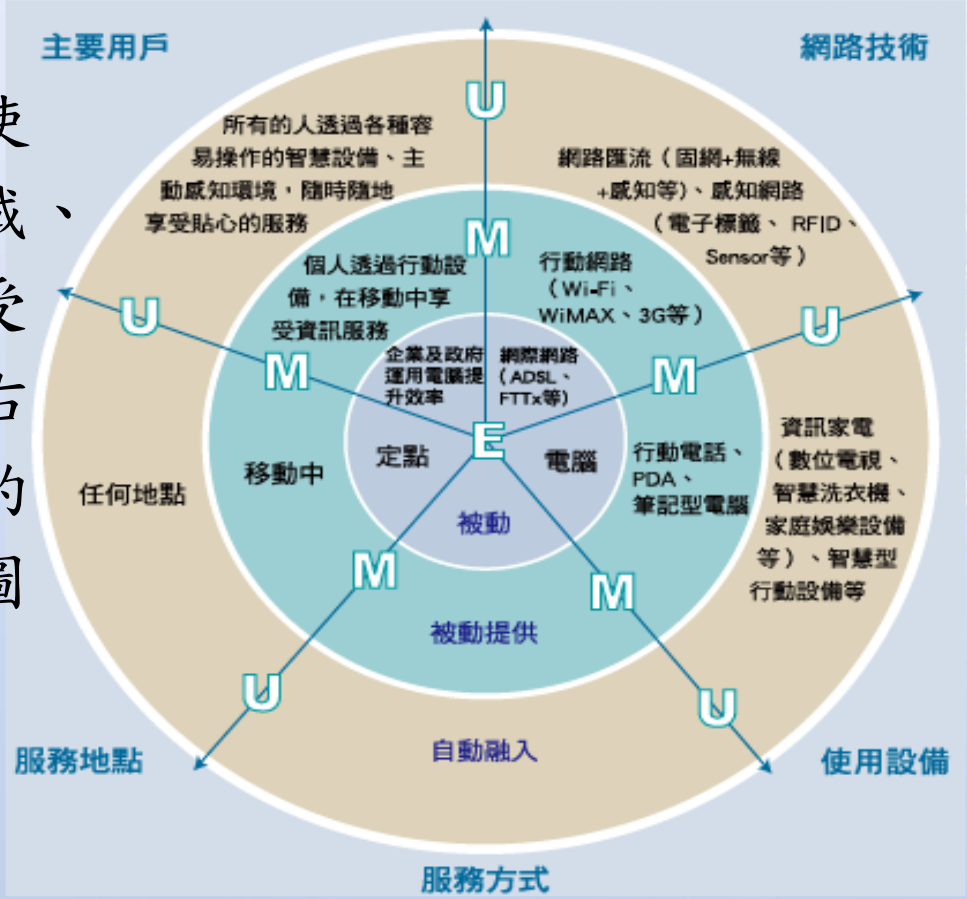
Ubiquitous & Mobile-care Services

國內健康管理照護系統趨勢



國內U化發展現狀

以「**使用者**」的觀點出發，使民眾能不受教育、經濟、區域、身心等因素的限制，都能享受「**隨手可得的U化服務**」，如右圖所示，從E化、M化到U化的科技化服務特性示意圖



資料來源：行政院NICI小組

U化健康照護特性

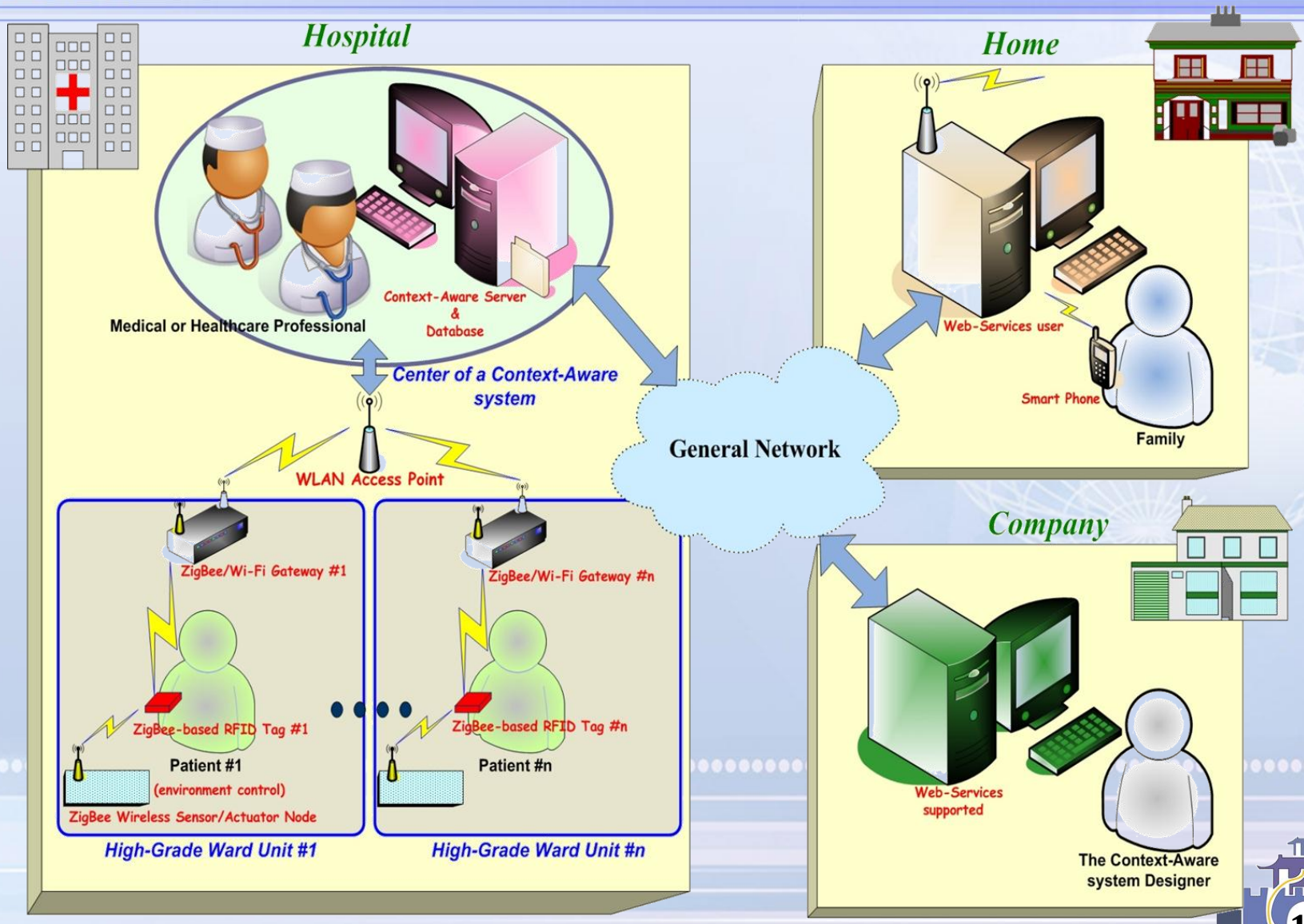
- 從”恢復健康”到”保持健康”
- 全面性的個人化與行動化照護
- 整合居家保健設施的使用
- 持續、適當且有效的提高生活品質
- 可在任何時間、任何地點對任何人提供照護及保全的服務

爲什麼發展U化照護系統

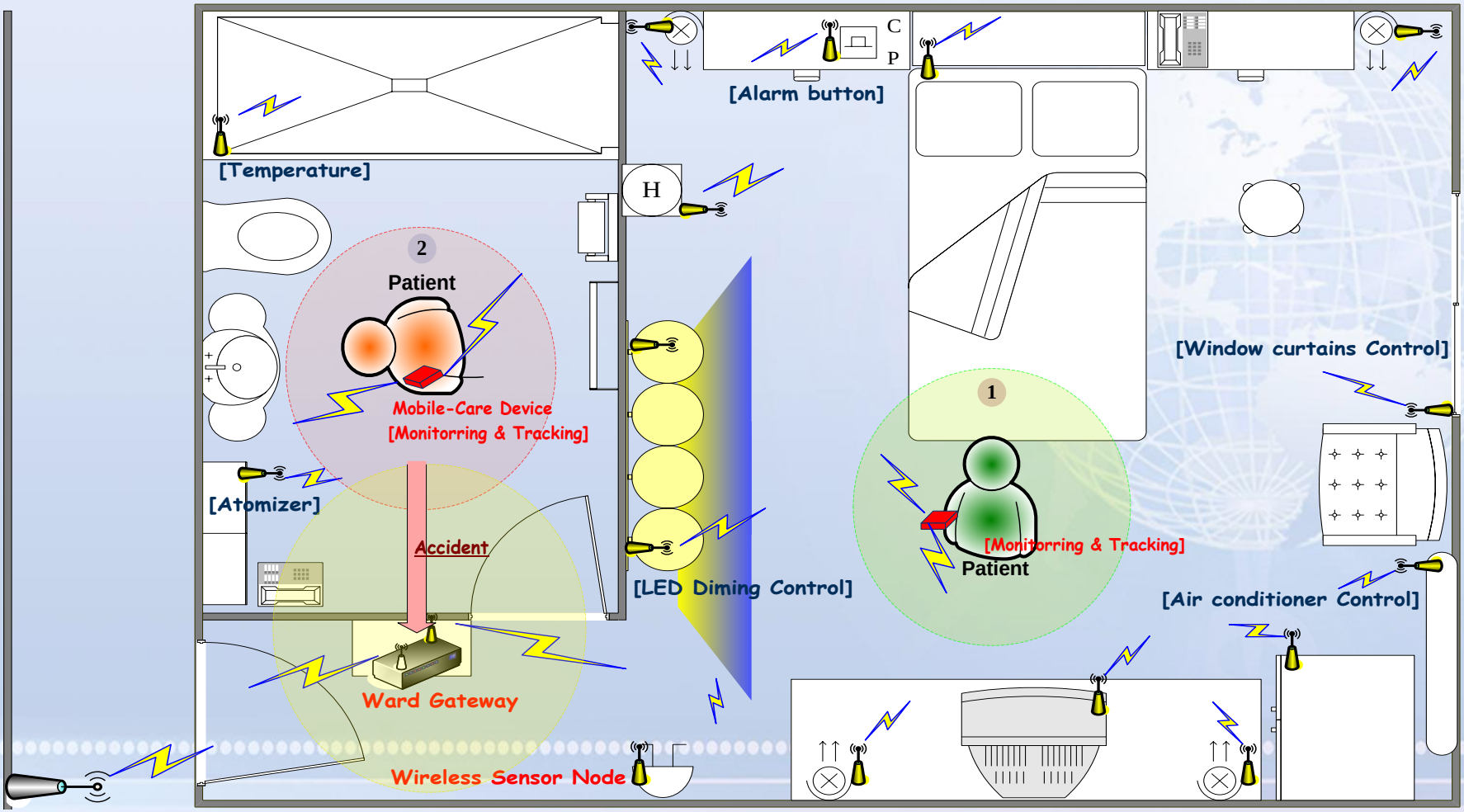
- **高齡化、少子化的社會**
  - 慢性病的影響-失能的主因、醫療費用增加、照顧人力問題。
  - 傳統健康照護轉變為預防方式(Preventive)：個人化疾病管理。
- **資訊化社會不可避免的潮流**
  - 確保病人在住院照護與社區居家照護間安全和有效的轉移。
  - 高品質照護僅在當介入措施被應用在對的病人(right patient)及對的時間(right time)才能被達成。
  - 整合資訊科技，以遠距的方式來建構無所不在(Ubiquitous)的創新照護模式 。
- **落實出院計劃機制的重要性**
  - 世界衛生組織報告：因落實出院準備服務降低醫院老人再住院率大約20%。

資料來源：洪麗珍,弘光科技大學護研所

U化優質病房情境感知系統



U化優質病房照護系統情境描述



產品發展趨勢之一

多參數整合

❖多功能合一

➢Alere公司：監測體重與心律不整症狀的單一監測儀器DayLink

➢Viterion公司：Viterion 100與Viterion 500遠距監測醫材

❖混搭組合式醫材

➢HomMed；Sentry與Genesis組合式監測器。

➢iMetrikus公司：開發萬用連線工具MetrikLink連結各式醫材。

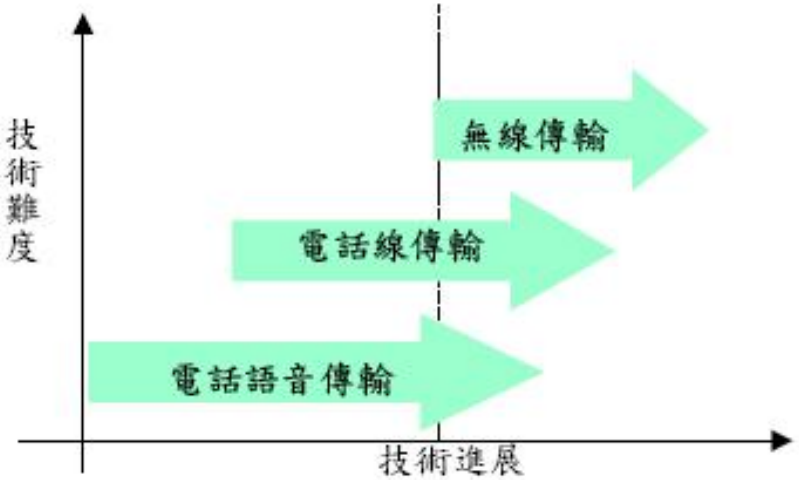
參數測量	充血性心臟病	糖尿病	氣喘/慢性阻塞性肺病
體重	○	○	
血壓	○	○	
心律	○		
體溫	○		
血糖		○	
血氧飽和度			○
肺功能			○

資料來源：Medtech Insight ；工研院IEK-ITIS計畫(2005/03)

產品發展趨勢之二

無線傳輸

➢Polymap Wireless公司：開發藍芽傳輸Polytel system ，可與醫材整合應用。



➢Nonin Medical公司：開發新款的腕式無線血氧濃度計。

➢A&D Medical公司：推出具藍芽傳輸功能的無線血壓監測器與體重計。

➢GMP Companies：推出具藍芽傳輸功能的LifeSync ECG無線心電圖系統

資料來源：各公司網站；工研院IEK-ITIS計畫(2005/03)

產品發展趨勢之三

創新設計

➢I-Wear是使用微機電系統(microsystem technology)或奈米機電系統將偵測器的大小縮到奈米級、內織在衣服裡，使其仍具有監視病人血壓、心跳、心音等身體狀況的功能，也可以提供醫療人員病人身體生化訊號的監控。




❖Vivometrics公司：開發LifeShirt，使用內嵌於衣物上的偵測器，偵測心律、血壓、呼吸頻率等資料，並將這些資料以遠距傳輸方式傳送給醫師。

資料來源：Vivometrics；工研院IEK-ITIS計畫(2005/03)

產品發展趨勢之四

介面簡單

與現有入口網站合作增加曝光度，也可以除去使用者需另外下載軟體所造成的不便與排斥。

可將數據予以圖表化，供給醫護人員和使用者參考，得知疾病發展進程，已在早期疾病發生徵兆時提出警告。

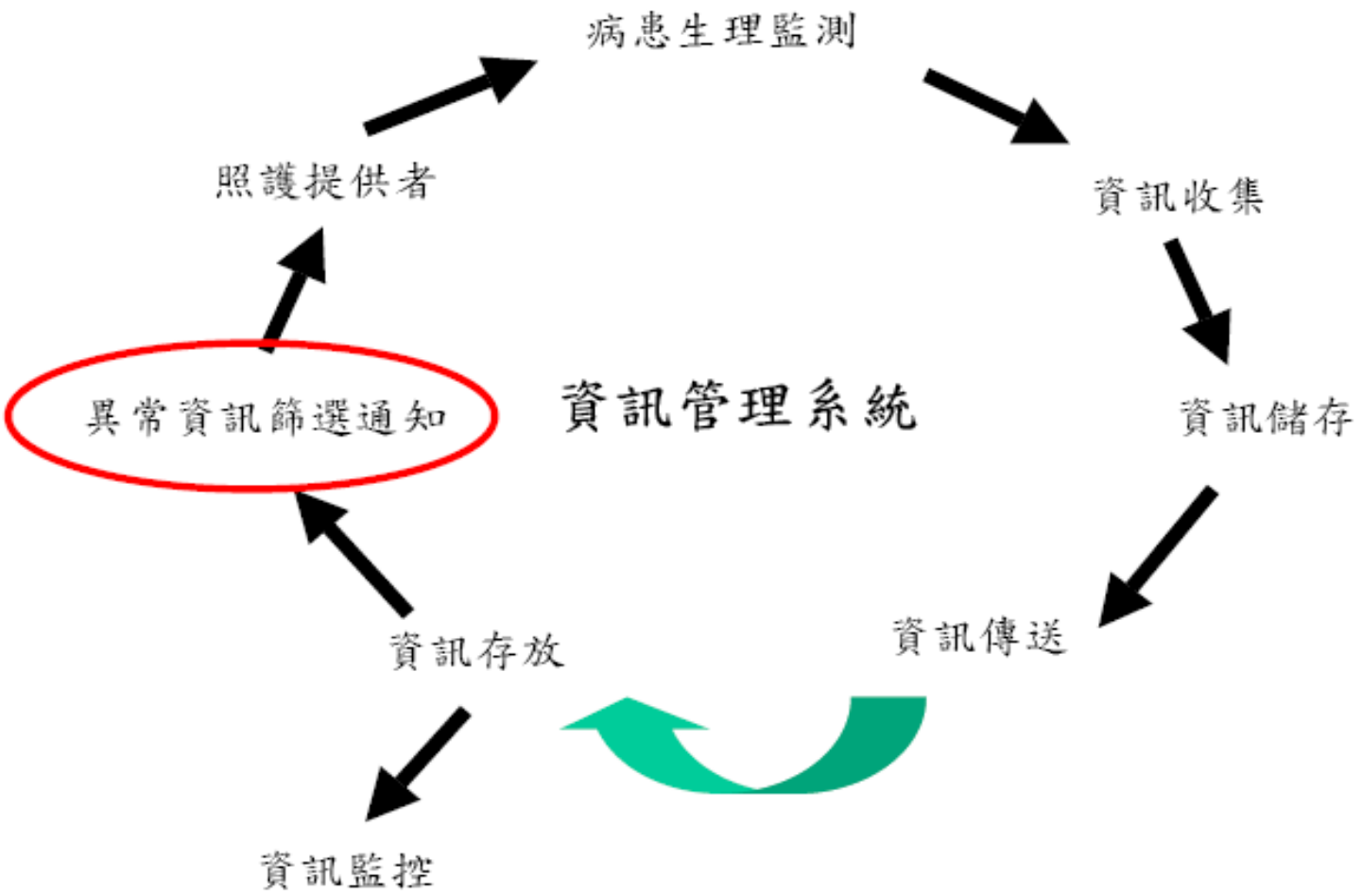
具客製化功能，可依個人需要設定照護方式，並具智慧型警告功能，當病人無反應或生理狀況異常時，會自動提醒照護提供者與患者。

與疾病管理系統結合，要求使用者回答設定的生活問題，可使照護提供者所得資訊完整。並可與飲食、服藥等生活形態監測連結，達到最佳管理功能。

資料來源：工研院IEK-ITIS計畫(2005/03)

產品發展趨勢之五

人工智慧



資料來源：工研院IEK-ITIS計畫(2005/03)

TAIPEI TECH 國立臺北科技大學
National Taipei University of Technology

誠,樸,精,勤

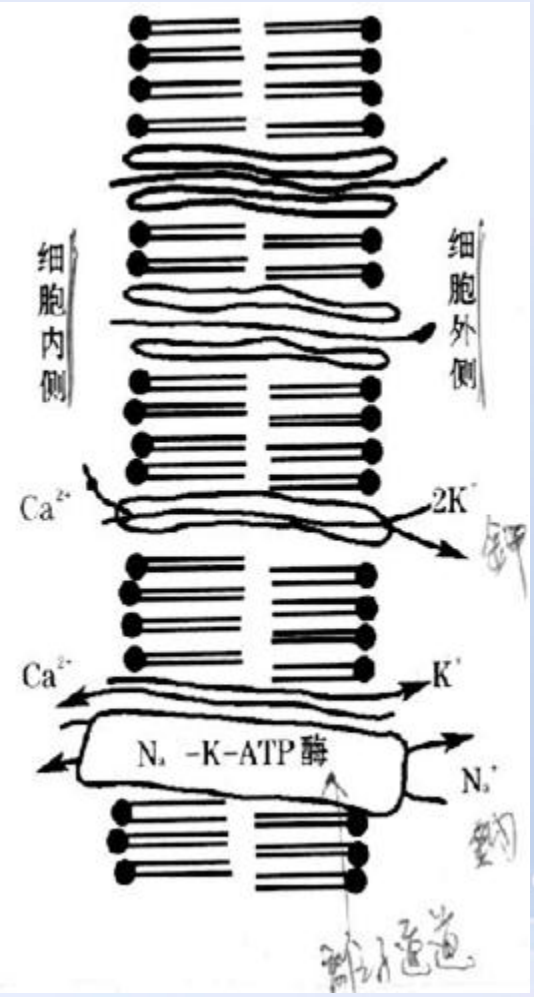
生理資料感測蒐集技術

Ubiquitous & Mobile-care Services

常用生醫電生理訊號

机体参数	频带(Hz)	电压	阻抗
脑电(EEG)	0.5 ~ 70	10 μV ~ 300 μV	10 ~ 50 kΩ
肌电(EMG)	10 ~ 2000	10 μV ~ 15 mV	1 ~ 10 kΩ
心电(ECG)	0.1 ~ 200	100 μV ~ 2 mV	1 ~ 30 kΩ
视网膜电(ERG)	0 ~ 200	50 μV ~ 1 mV	几十 kΩ
眼震电(ENG)	0 ~ 60	50 μV ~ 1 mV	1 ~ 30 kΩ
眼电(EOG)	0 ~ 60	50 μV ~ 1 mV	1 ~ 30 kΩ
皮电阻(GSR)	0.03 ~ 10	100 μV ~ 5 mV	1 ~ 30 kΩ
细胞活动电	0 ~ 3000	数毫伏	20 MΩ

細胞膜離子通道與靜止膜電位



		乌贼巨大轴突	蛙缝匠肌	哺乳动物骨骼肌
细胞内浓度（克分子浓度）	Na^+	65.0	13.0	12.0
	K^+	344.0	138.0	155.0
	Cl^-	80.0	3.0	3.8
细胞外浓度（克分子浓度）	Na^+	460.0	110.0	145.0
	K^+	10.0	2.5	4.0
	Cl^-	540.0	90.0	120.0
平衡电位（以膜外为零）（mV）	E_{Na}	+49	+55	+65
	E_K	−89	−105	−95
	E_{cl}	−48	−86	−90
实测静息电位(mV)		−77	−99	−90

細胞膜電位計算法

(b). Resting Potential Goldman Equation

$$\frac{RT}{F}\log_{10}\left[\frac{P_K[K]_o + P_{Na}[Na]_o + P_{Cl}[Cl]_i}{P_K[K]_i + P_{Na}[Na]_i + P_{Cl}[Cl]_o}\right]$$

離子	Inside	outside
K^+	155	4
Na^+	12	145
Cl^-	4	120

於室溫 20°C 時, 骨骼肌的 $\frac{RT}{F} \doteq 0.0581$

代入

$$0.0581\log_{10}\left[\frac{2*10^{-6}*4 + 2*10^{-8}*145 + 4*10^{-6}*4}{2*10^{-6}*155 + 2*10^{-8}*12 + 4*10^{-6}*120}\right]$$

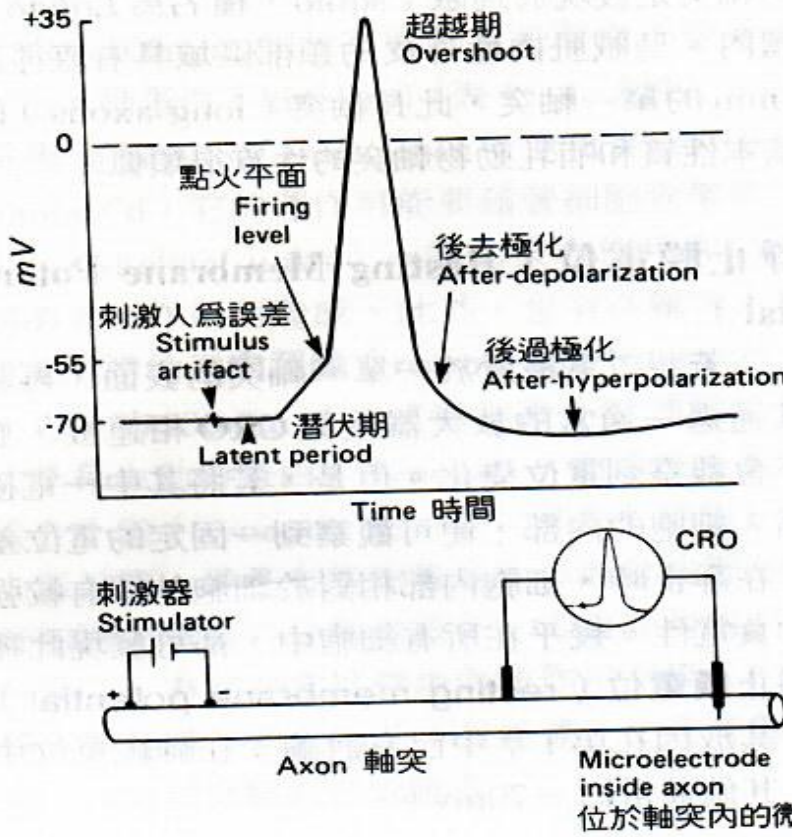
$$\doteq 0.0581\log_{10}\left[\frac{8*10^{-6} + 290*10^{-8} + 16*10^{-6}}{310*10^{-6} + 2*10^{-8} + 480*10^{-6}}\right]$$

$$= 0.0581\log_{10}\left[\frac{24*10^{-6} + 2.9*10^{-6}}{790*10^{-6} + 0.24*10^{-6}}\right]$$

$$= 0.0581\log_{10}\left[\frac{26.9*10^{-6}}{790.24*10^{-6}}\right] = 0.0581\log_{10}[0.034]$$

$$= 0.0581*(-1.47) \doteq -85.4\,mV \#$$

神經纖維動作電位與傳導



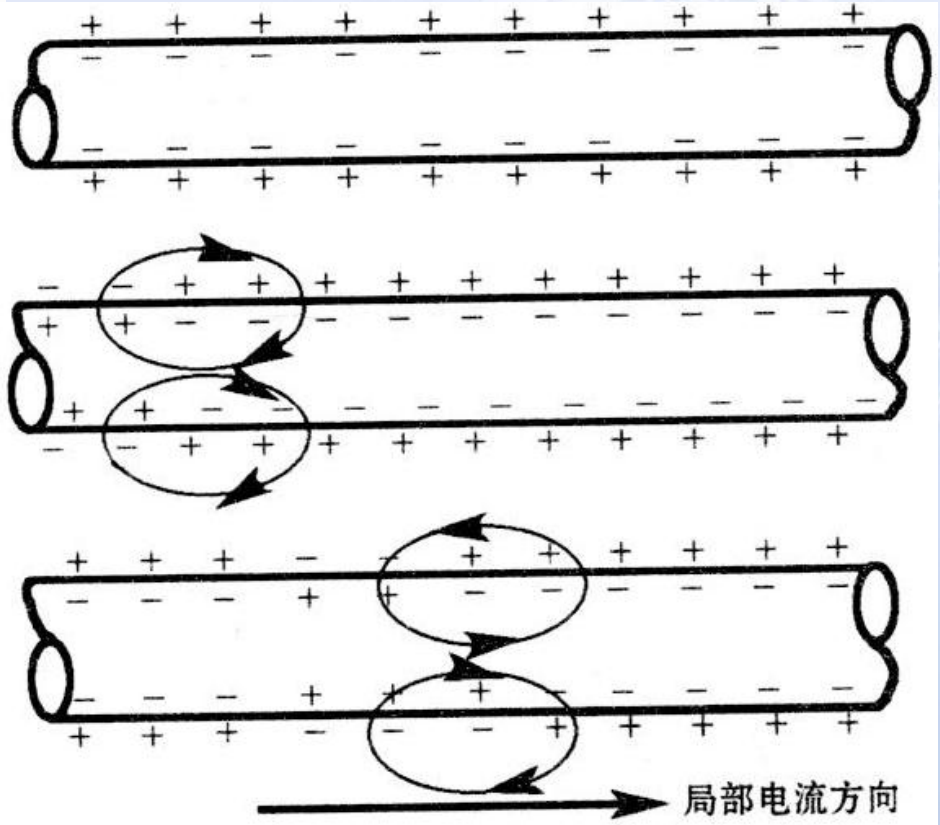


圖 2-6 將一電極置於神經細胞內側，所記錄到此神經單位中的動作電位。

心跳動作電位圖示

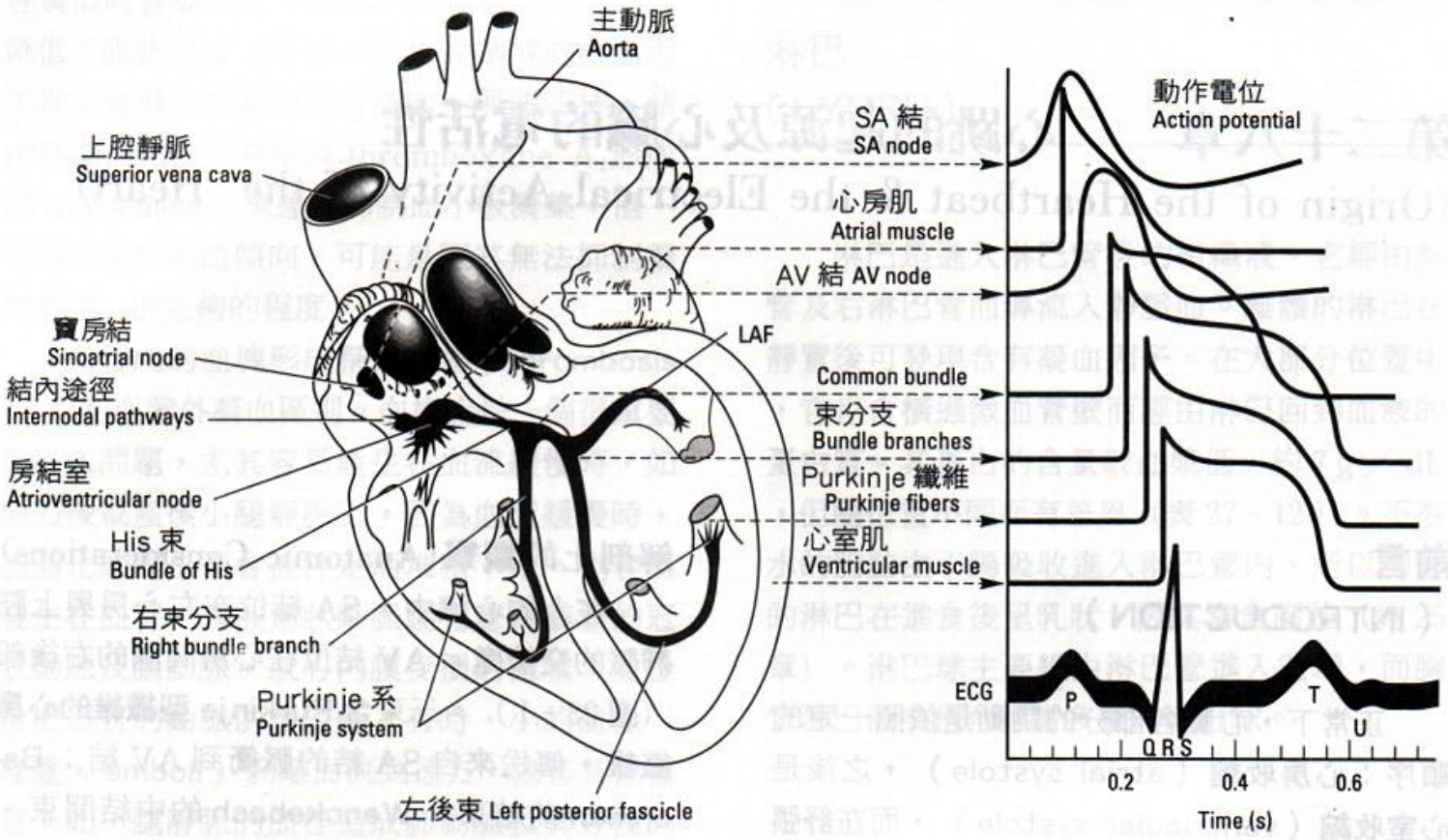
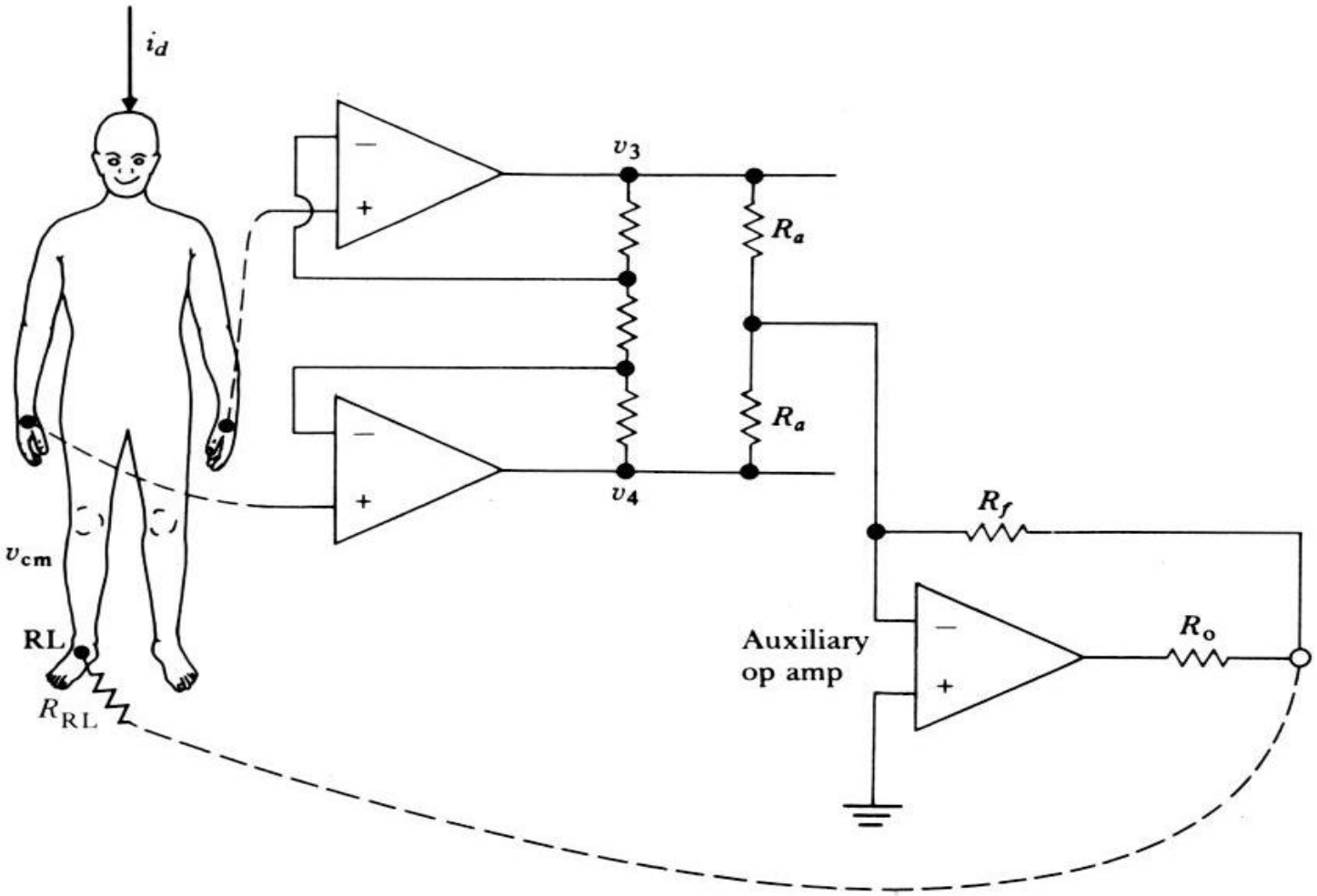
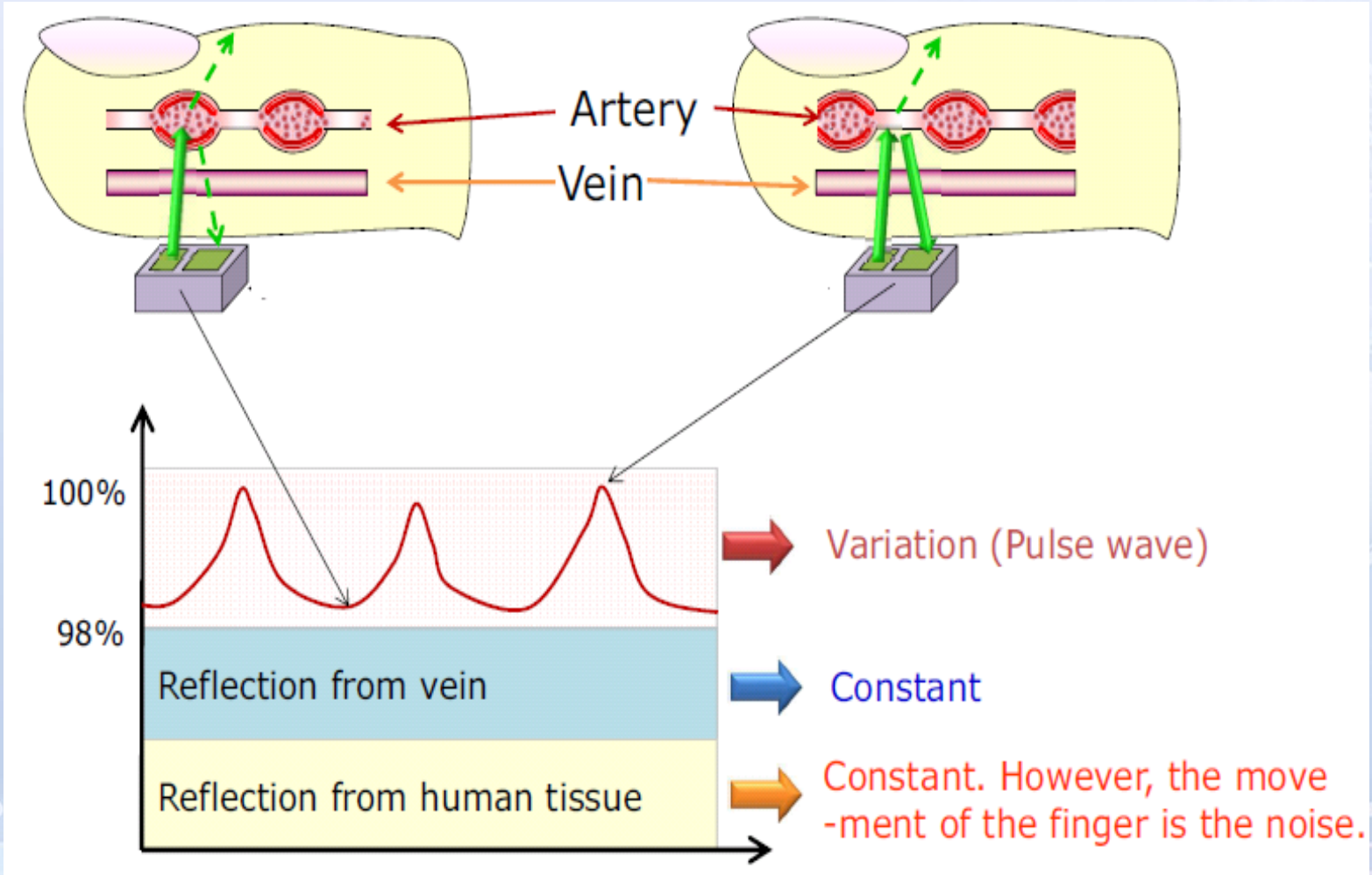


圖 28-1 心的傳導系統。SA結及AV結，傳導系統的其他部分，及心房與心室肌肉等的典型穿膜動作電位，沿著細胞外記錄到的電活性相關圖表示出，即心電圖。動作電位與ECG都在相同的時間軸上畫出，但直軸的零點不同。

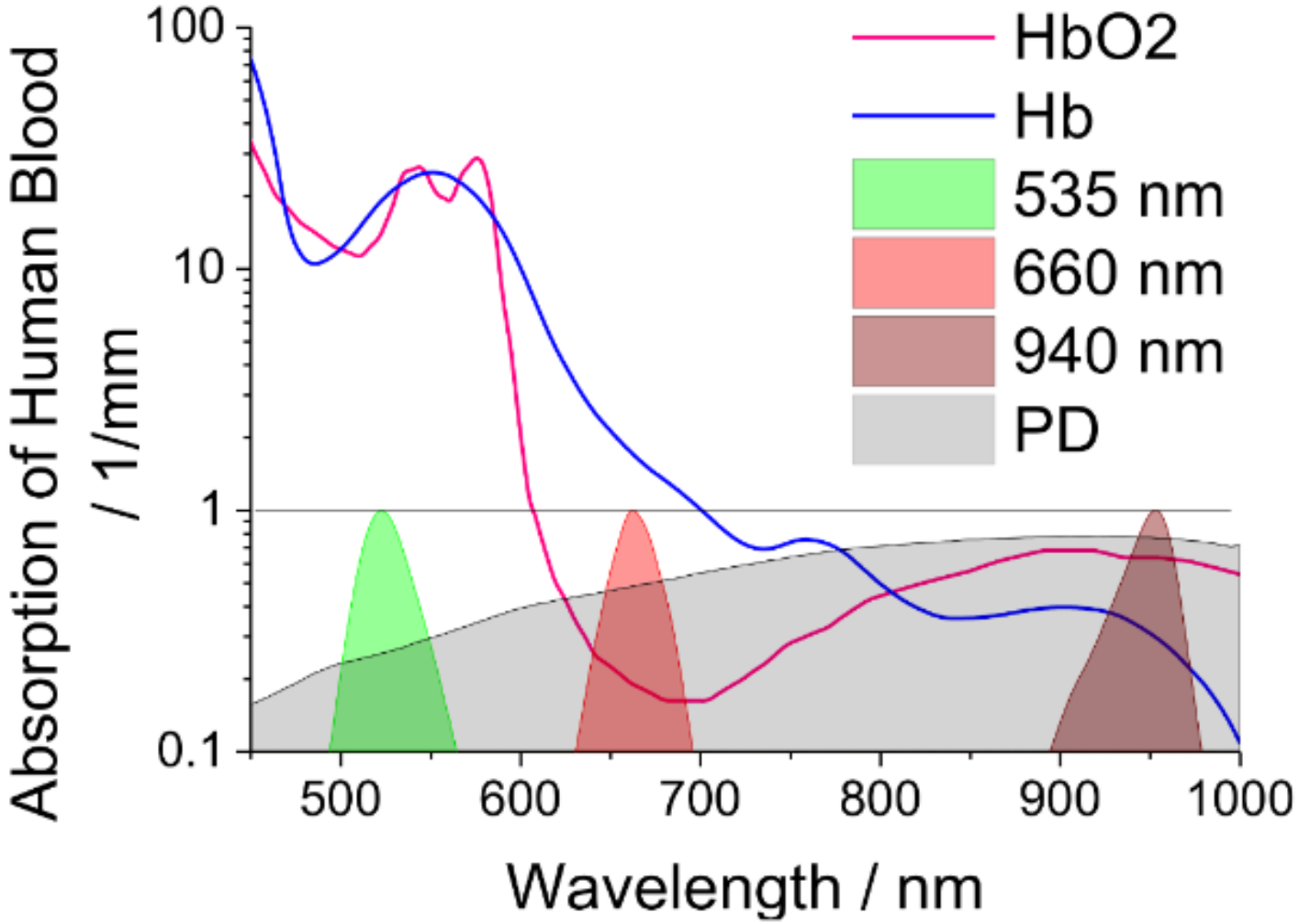
RLD-ECG measurement



PPG for SpO2/Pulse Detection

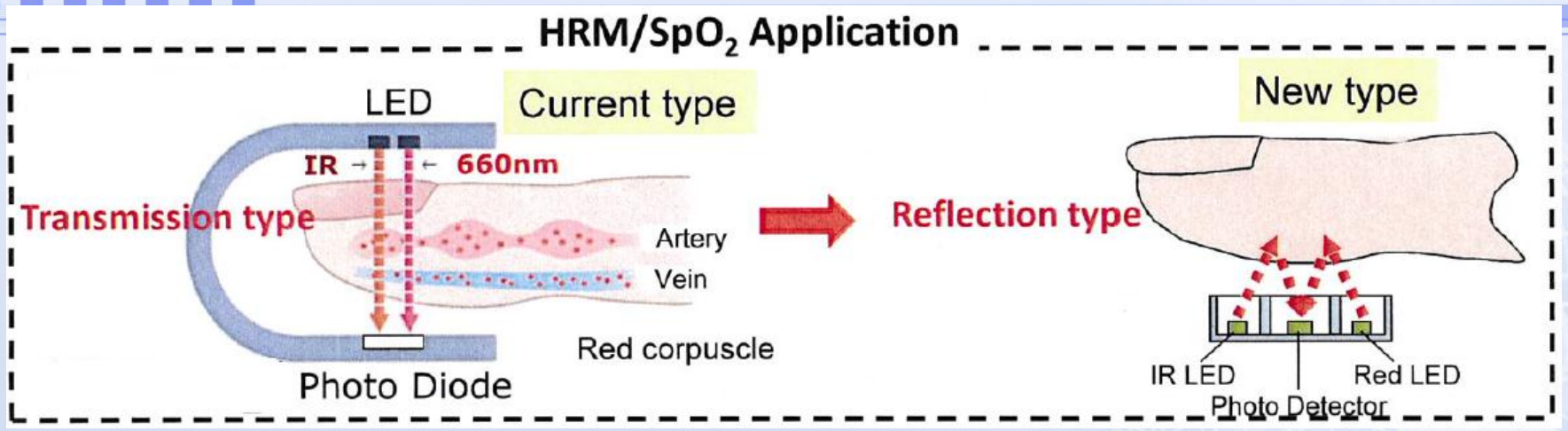


血液對光吸收

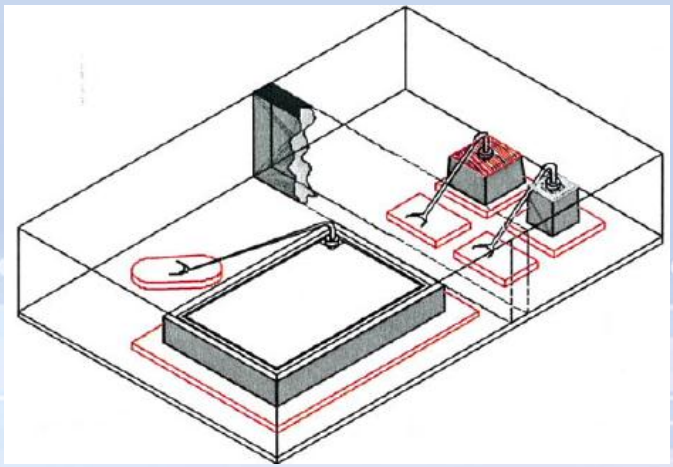

Absorption of Human Blood / 1/mm
100
10
1
0.1
500
600
700
800
900
1000
Wavelength / nm
HbO2
Hb
535 nm
660 nm
940 nm
PD

PPG Sensor

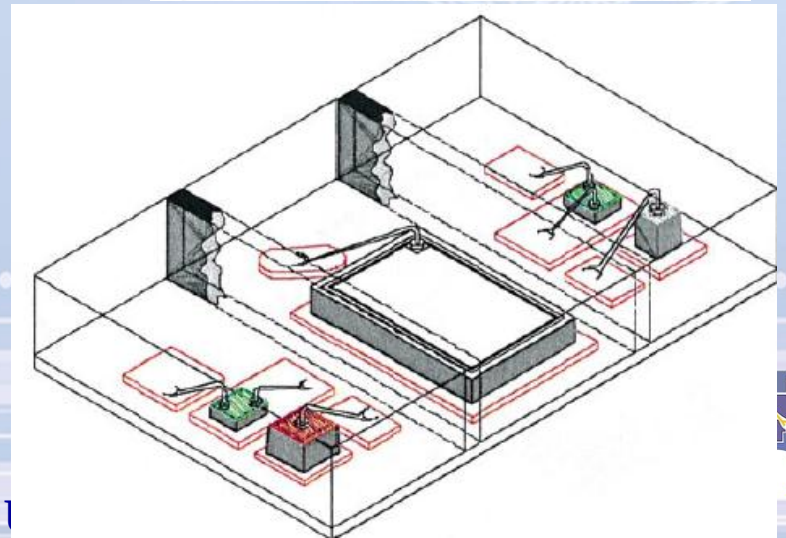
EM Lab.



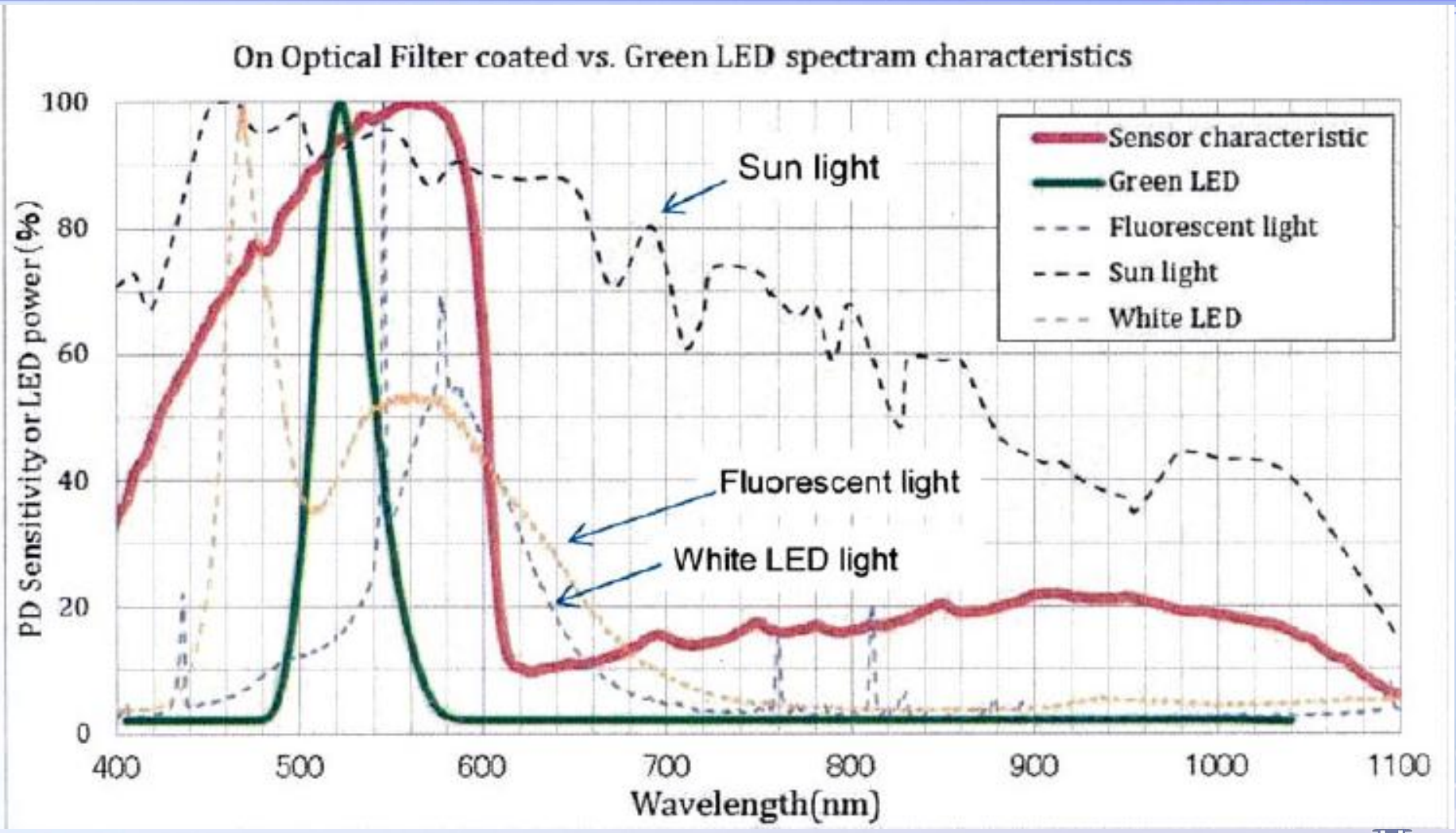
Package Size
2.4×3.75×0.8mm³



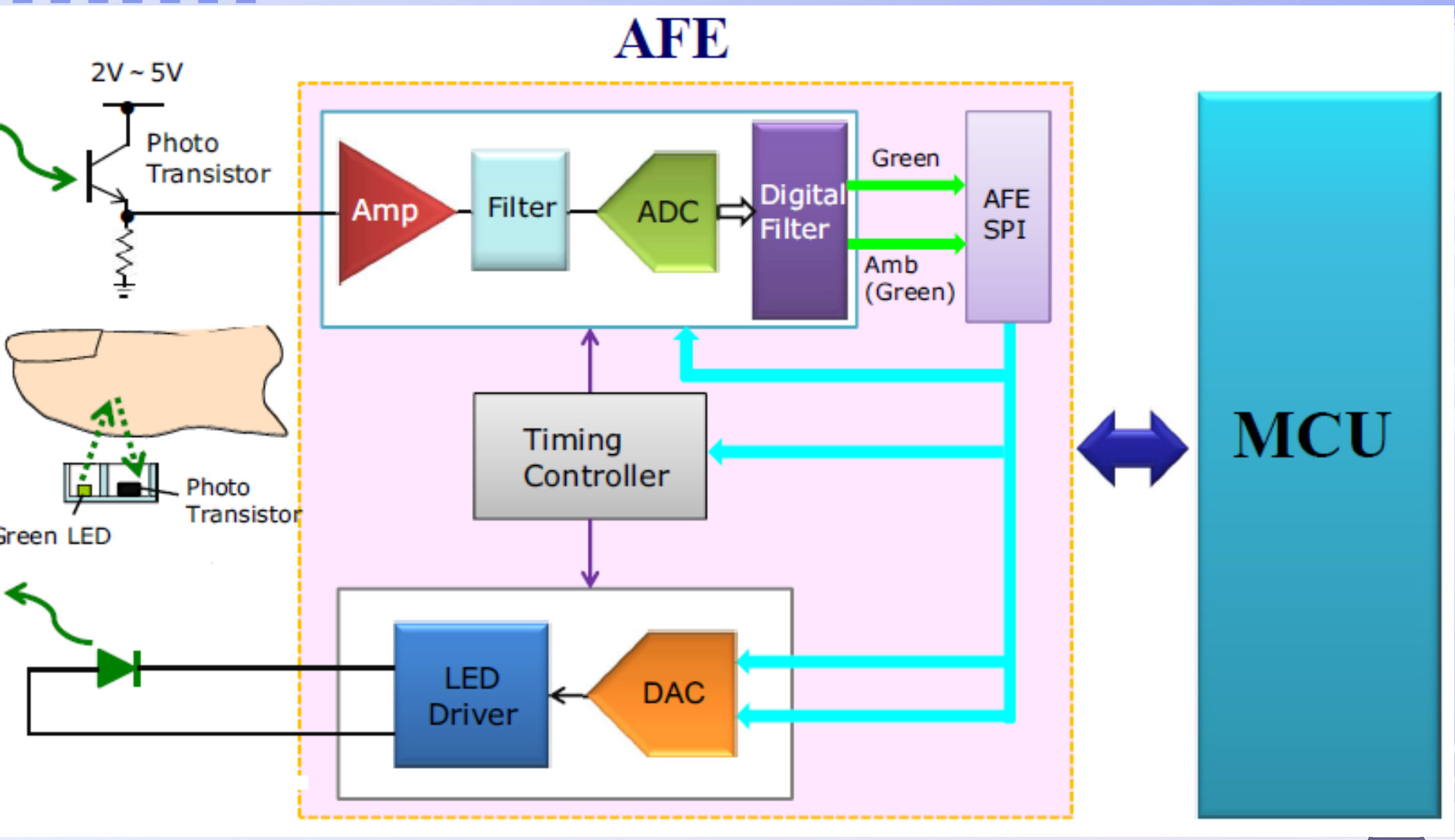
Package Size
2.6×4.8×0.8mm³



Characteristics of Optical Filter



Analog Front-End for PPG Sensor



ECG-Derived Respiration Techniques

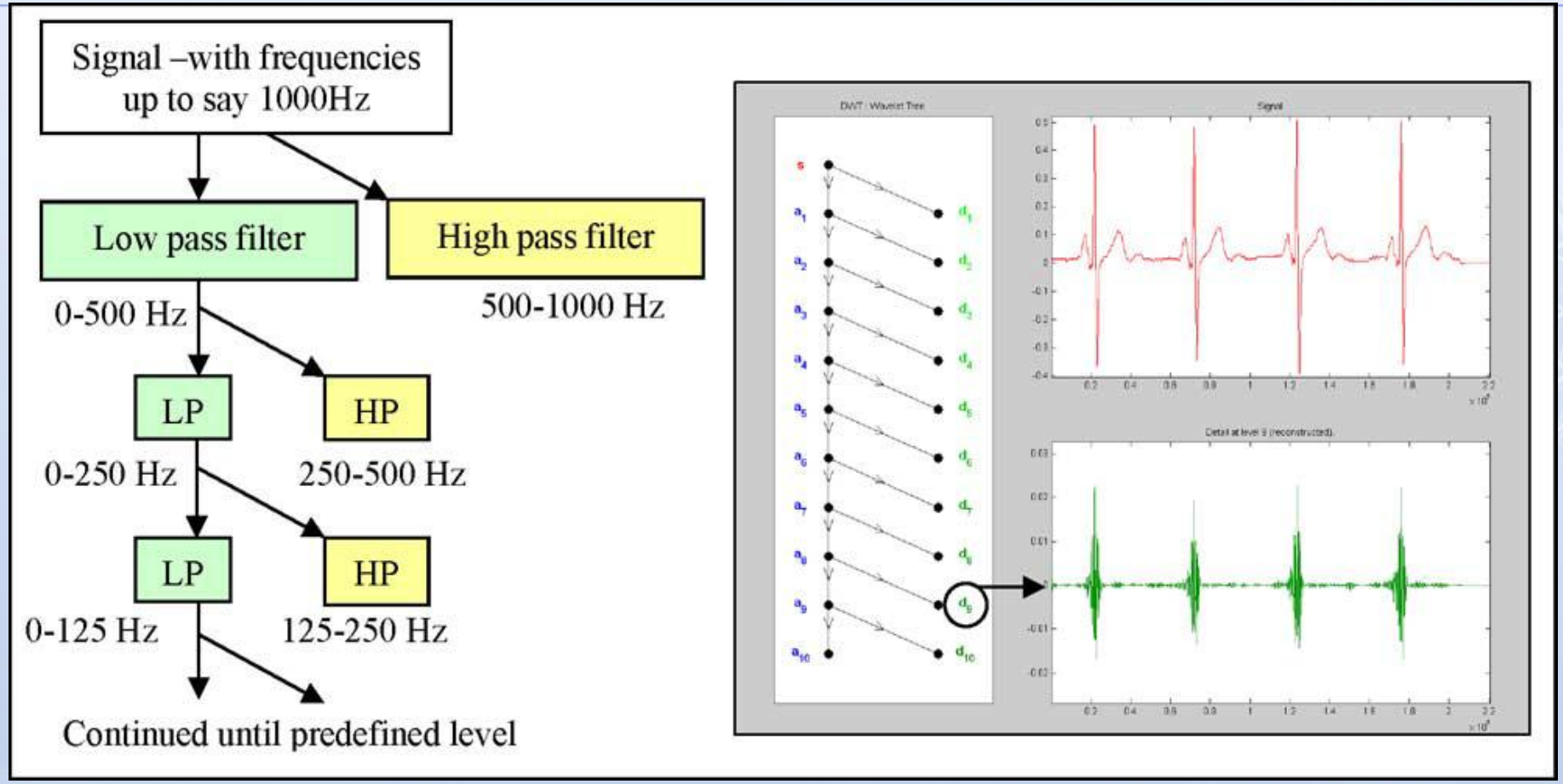


Fig. 1. (Left)Wavelet decomposition refers to representing a signal as different frequency bands. (Right) Wavelet decomposition tree for example ECG signal showing detailed signal, scale 9.

Implantable Blood Pressure Monitoring

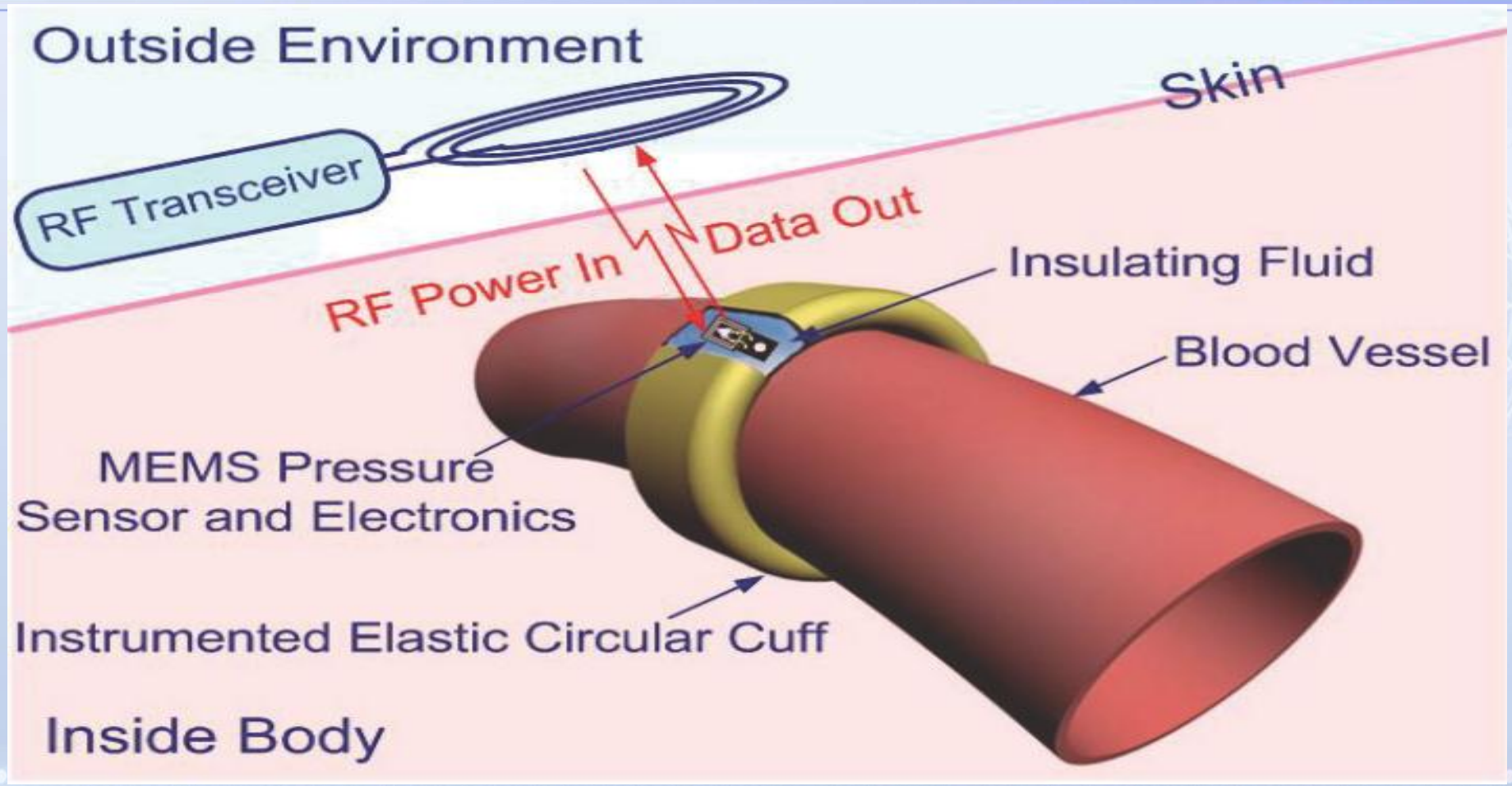


Fig. 1. Wireless less-invasive implantable blood pressure monitoring.

TAIPEI TECH 國立臺北科技大學
National Taipei University of Technology

誠,樸,精,勤

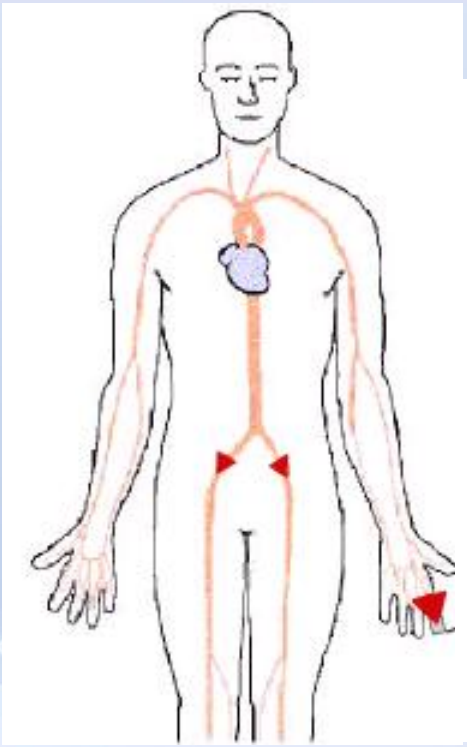
Cuffless Differential Blood Pressure Estimation Using Smart Phones

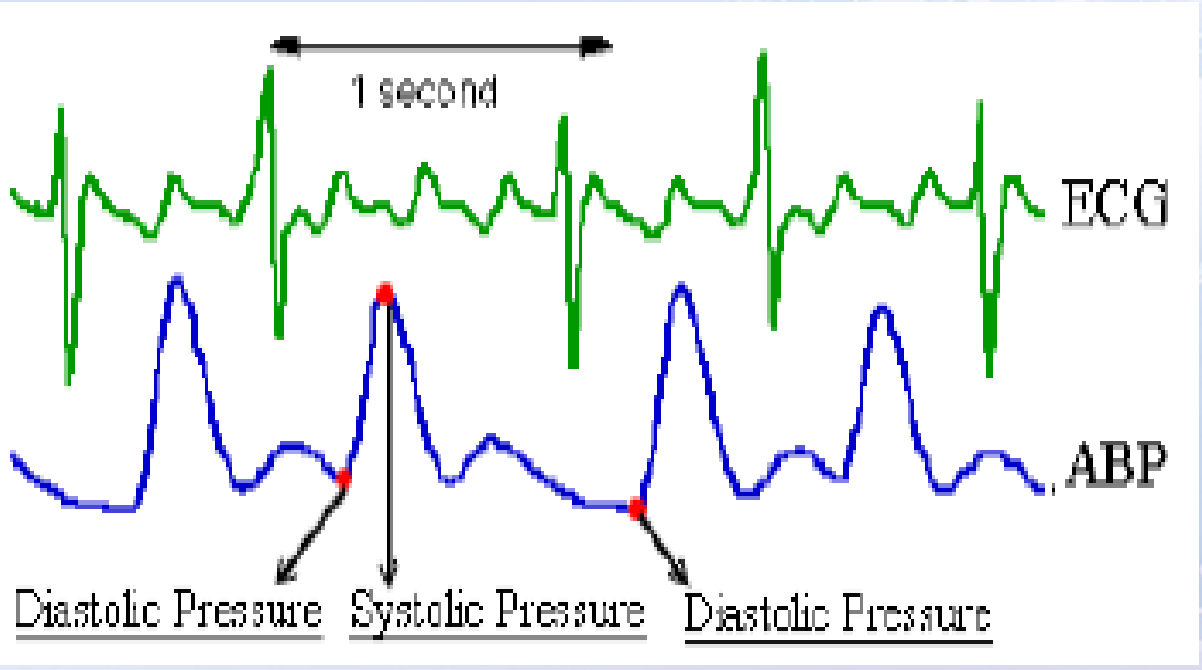
103年5月28日

Ubiquitous & Mobile-care Services

Blood Pressure - Introduction

- 血管中血壓值高低是由心臟的收縮與舒張做變化
- 心臟每次的收縮與舒張視為一次心跳脈搏

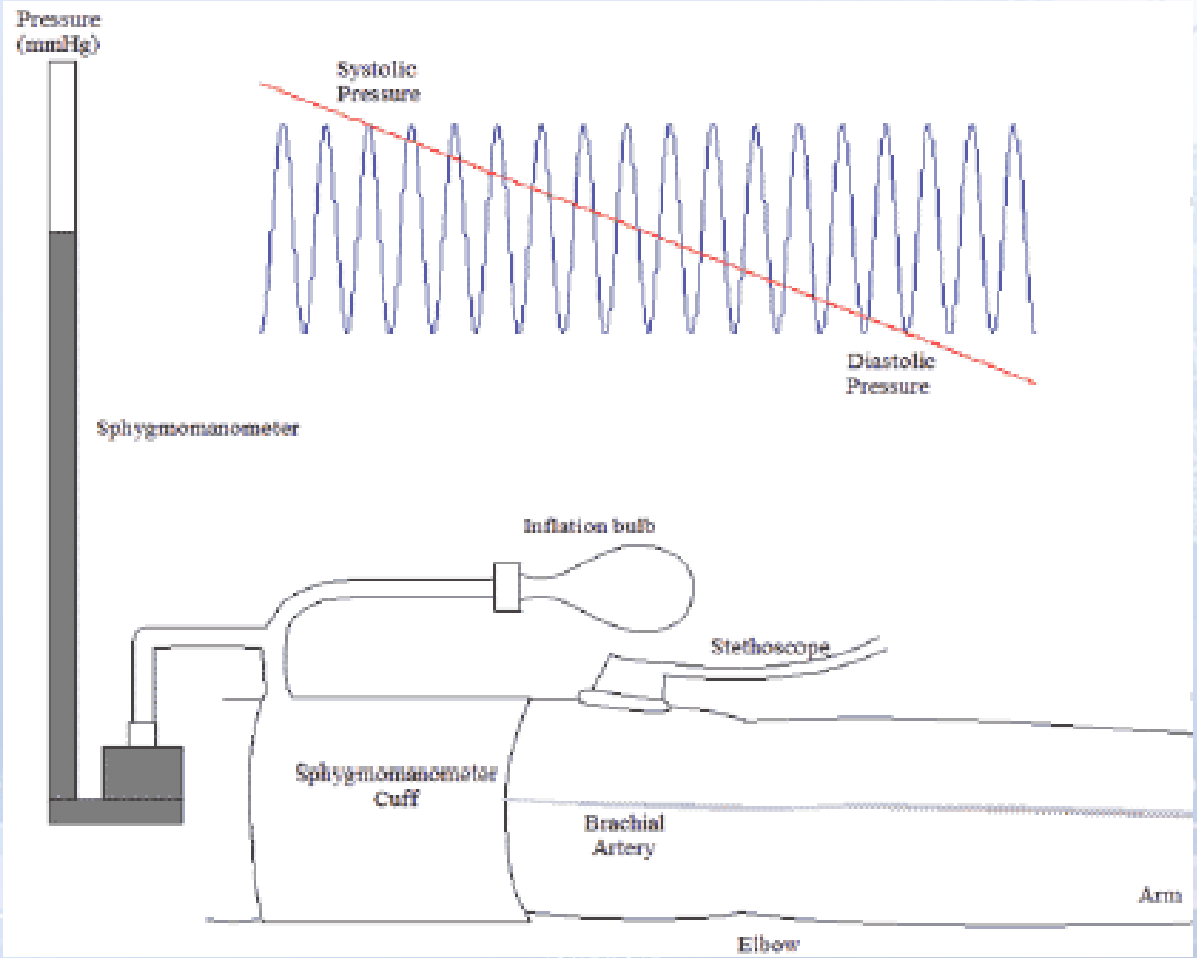




Blood pressure Measurement

EM Lab.

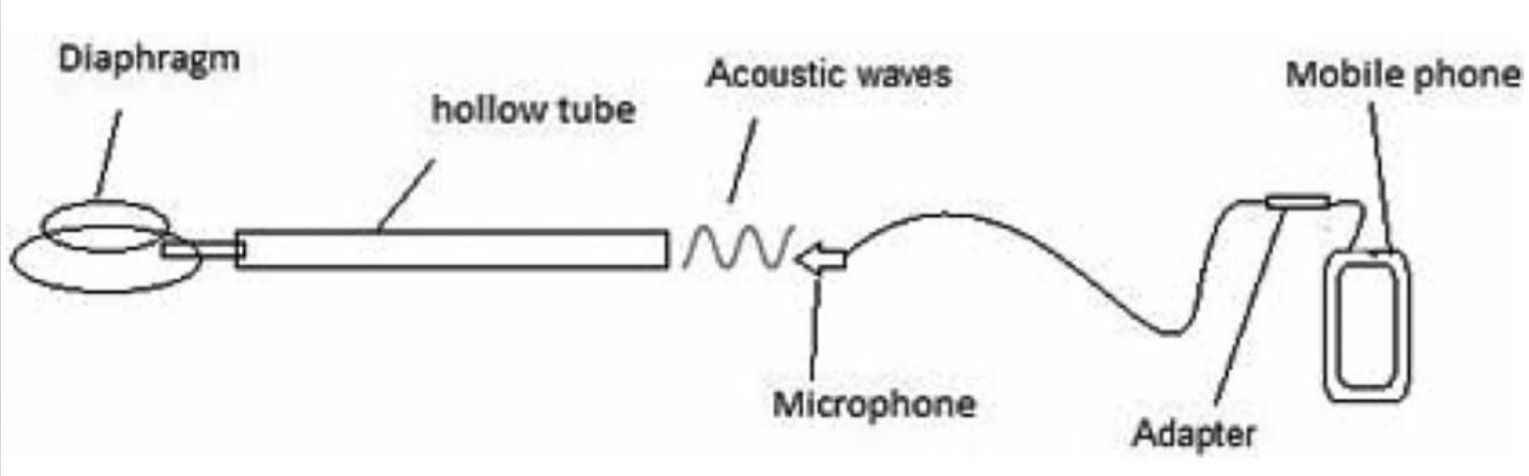
NIBP: Oscillation method (共振法)



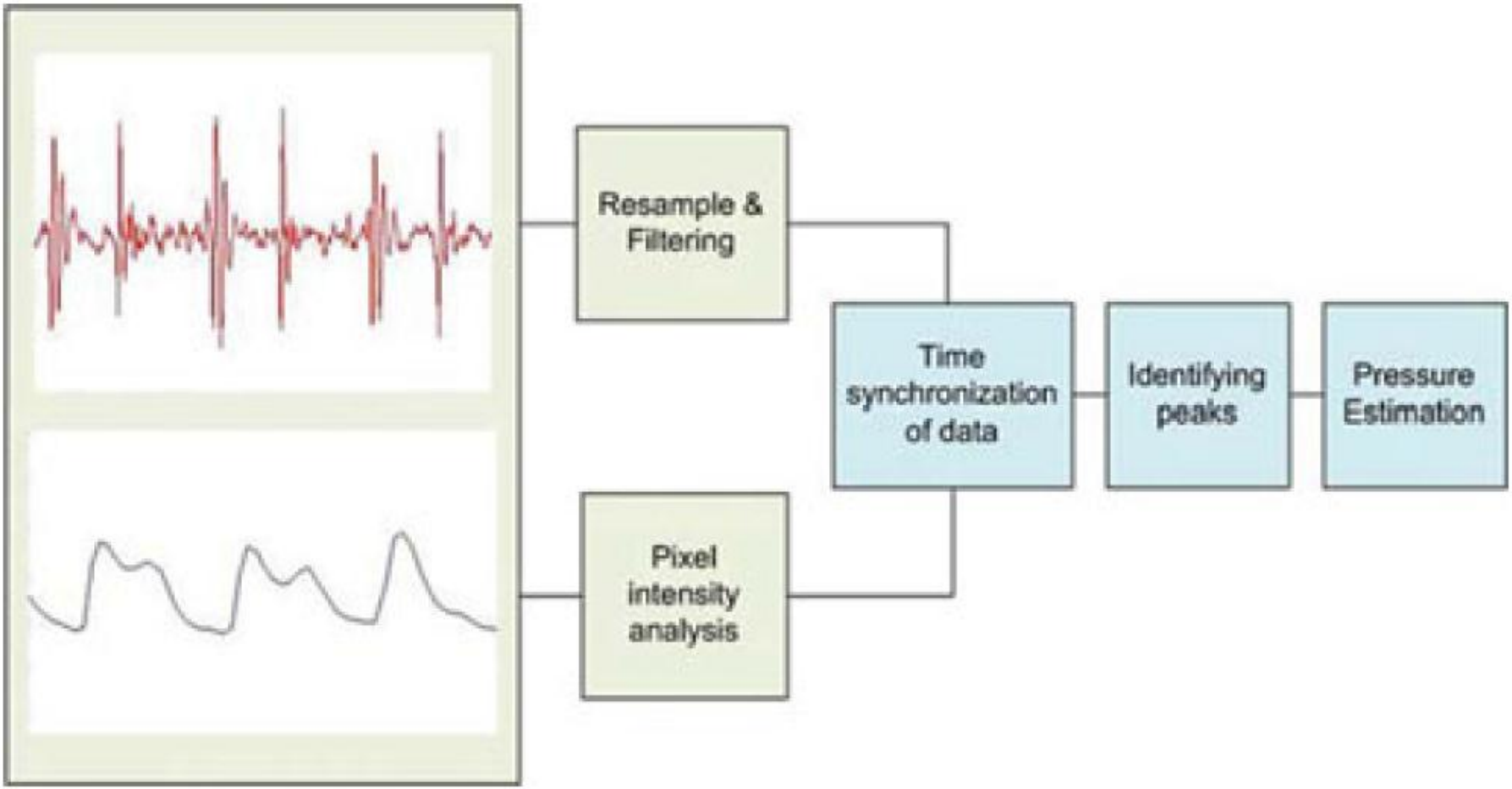
Blood Pressure Measurement by Smartphone

B. Setup of Single Mobile Phone for Blood Pressure Estimation

- **we record heart sounds with a customized external microphone and finger pulse at 24 fps via a video and audio recording application.**
- **The design of the external microphone consists of an acoustic stethoscope diaphragm, hollow tube, 3.5 mm mini-plug condenser microphone with frequency response 50–18,000 Hz and a 3.5-mm microphone adapter for mobile phones.**



Blood pressure estimation



Accuracy of Differential Estimation

TABLE IV
EFFECT OF NOISE AND MOTION ARTIFACTS ON BLOOD PRESSURE, UNITS IN MMHG

Subject	Traditional meter		Single mobile							
			Movements				Still			
	P_s	P_d	P_s	Accuracy (%)	P_d	Accuracy (%)	P_s	Accuracy (%)	P_d	Accuracy (%)
1	118	70	114	96.61	69	98.57	116	98.31	69	98.57
2	116	60	114	98.28	60	100	117	99.15	61	98.36
3	130	85	133	97.74	87	97.70	128	98.46	84	98.82
4	121	68	124	97.58	70	97.14	121	100	71	95.77
5	98	57	101	97.03	54	94.74	101	97.03	58	98.28

TAIPEI TECH 國立臺北科技大學 National Taipei University of Technology

誠,樸,精,勤

行動醫療照護與穿戴式技術的發展

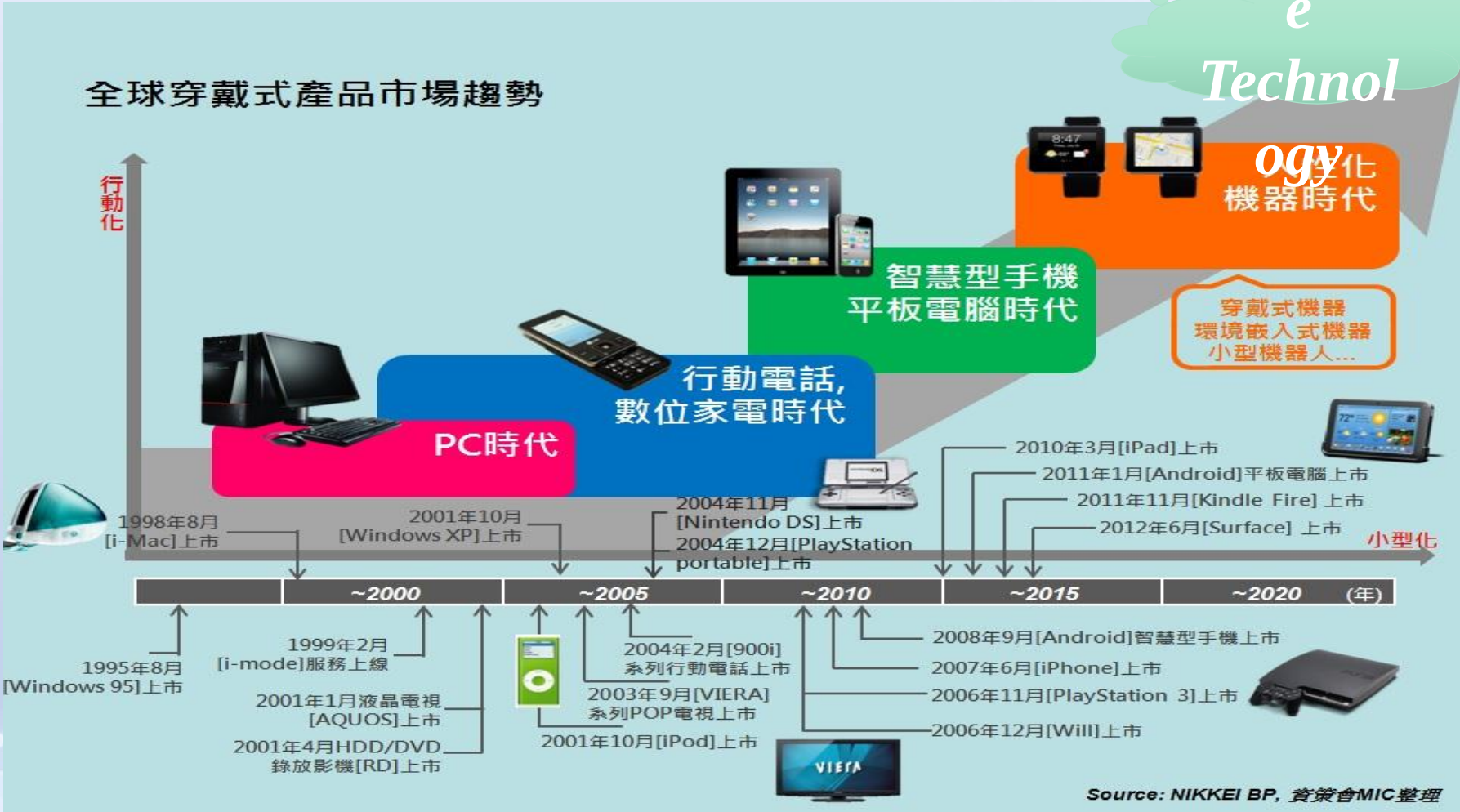
北科大電子系 李仁貴教授
evans@ntut.edu.tw

103年09月24日

Milestone of Consumer Electronics

EM Lab.

Wearable Technology



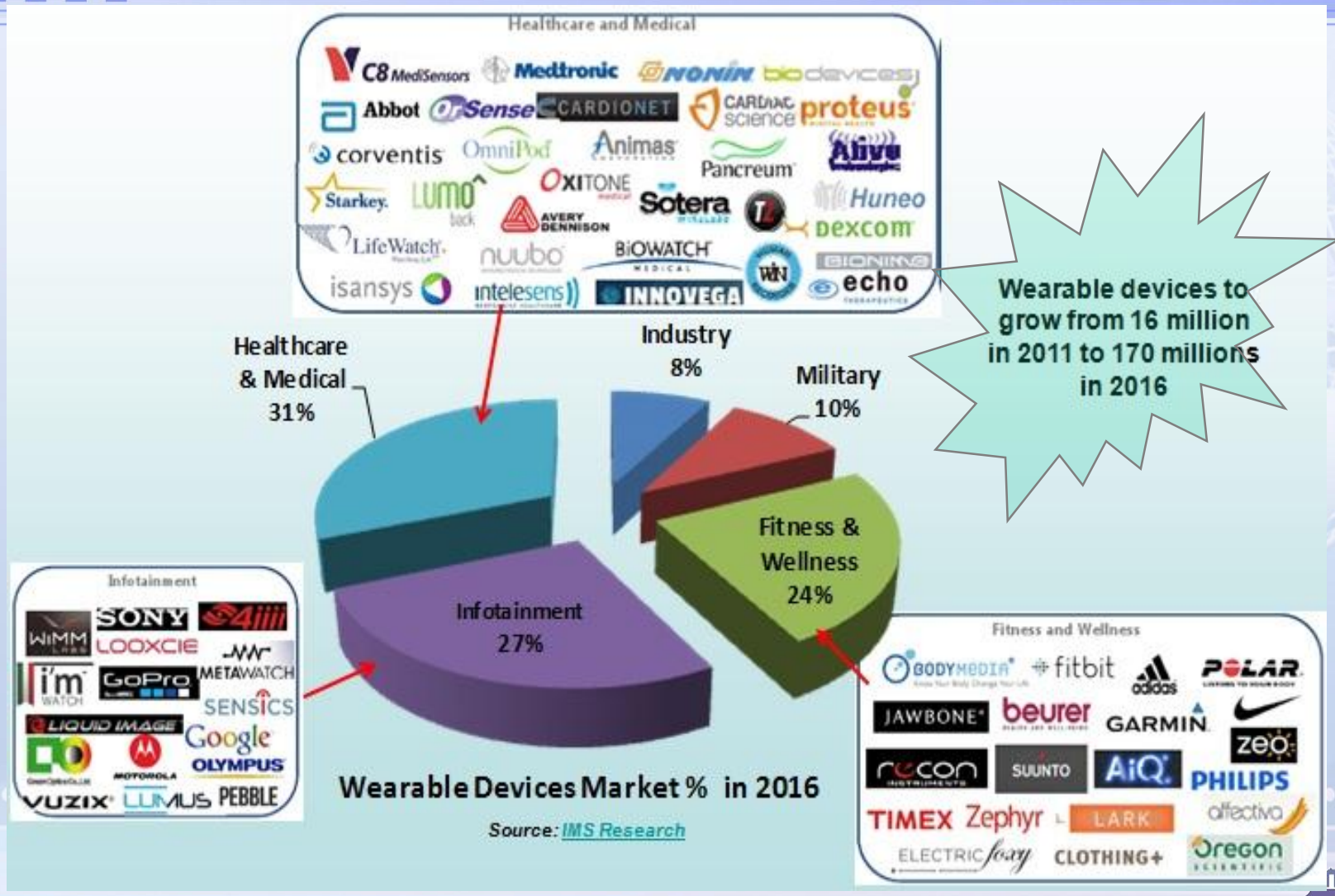
Definition of Wearable Computing

VDC認為可穿戴式的電腦定義須符合以下條件：

1. 具有一個CPU硬體
2. 具有可自行設定功能的軟體裝置
3. 系統可穿戴於使用者身上
4. 具有有線/無線通訊裝置連結穿戴者電腦
5. 穿戴智慧型紡織物具有GPS、RF 或不同目的的感測晶片

VDC: Venture Development Corporation

Wearable Device TAM



Service Model

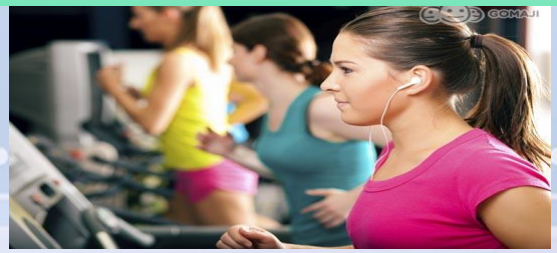
EM Lab.

Cloud & Data Analysis

Application and Service

Data Collection & Gateway

Vital signal measurement

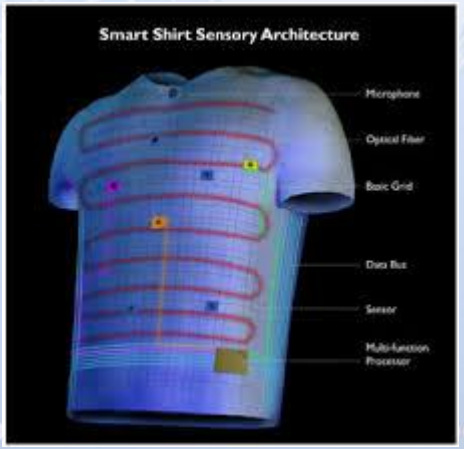


Products in the Market (accessory)

Smart Cloth


SOFT switch


AiQ


Smart Shirt Sensory Architecture
Microphone
Optical Fiber
Basic Grid
Data Bus
Sensor
Multi-function Processor

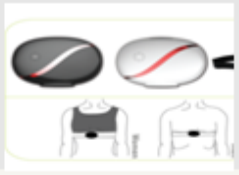
Framework of HealthCare

EM Lab.

Application

I-wear

I-peripheral



Social Network

I-healthcare

健康促進及優質生活應用支援層

智能分析平台 | 雲端運算平台 | 服務支援平台

App加值服務運用

■ Key：支援平台

■ Breakthrough：
與生活形態結
合之應用服務

Service Cloud

Networking

Health data center

Health manage center

2G/3G | Wi-Fi | WiMAX | 4G

Feel-less Devices

■ Key：結合、成熟無
縫式資料傳輸網路

■ Breakthrough：
Miniaturized, 網路位置、
QoS

Sensoring

BAN, NFN

Sensor | MEMS

■ Key：感知量測、擷取、訊號梳理、A/D、傳輸

TAIPEI TECH 國立臺北科技大學
National Taipei University of Technology
誠,樸,精,勤

Experiment– Health-care

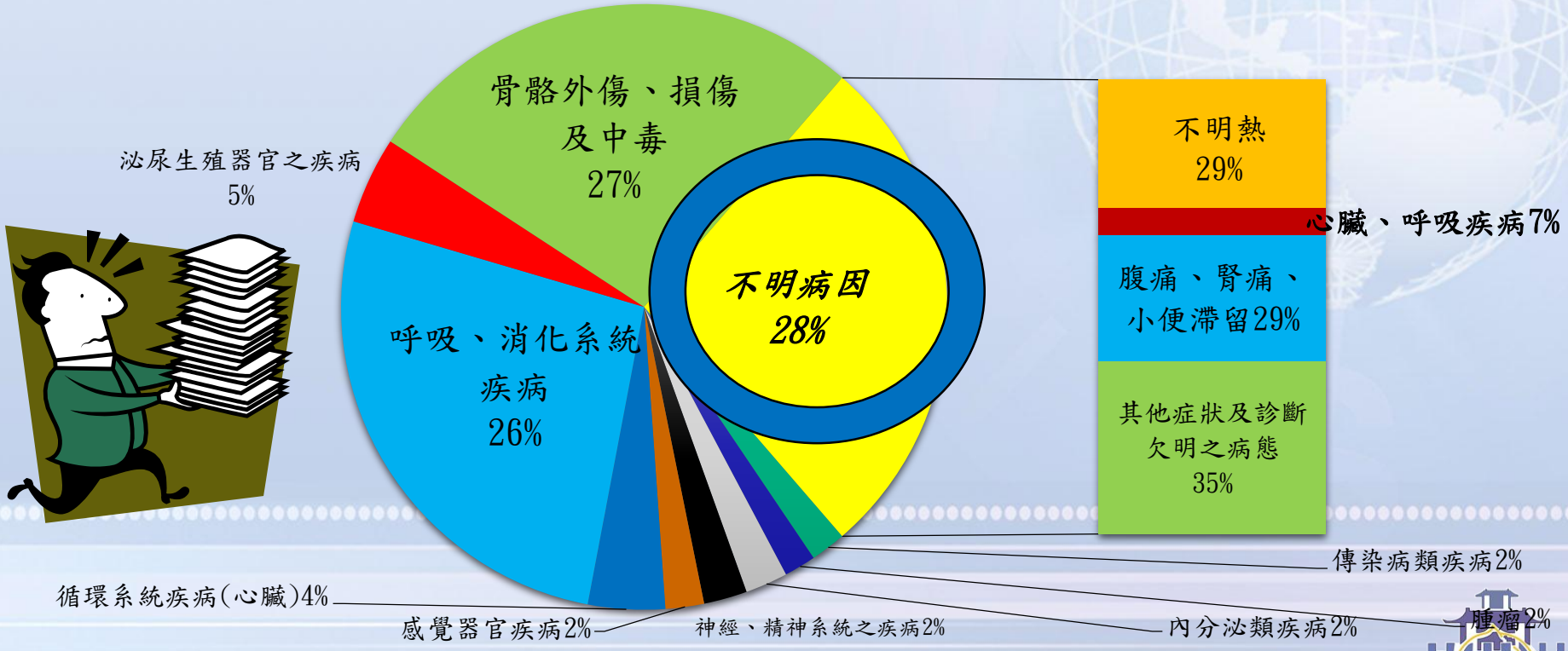
Ubiquitous & Mobile-care Services

Introduction(1/4)

EM Lab.

- Cardiovascular diseases are chronic diseases, physicians may be more difficult to do current diagnosis or seek for medical treatment based on their symptoms[1][2].

民國98年台灣急診就診症狀比例



Introduction(2/4)

CHF(Congestive Heart Failure)

- ✓Occurs when the heart is unable to provide sufficient pump action to maintain blood flow to meet the needs of the body[6][7].

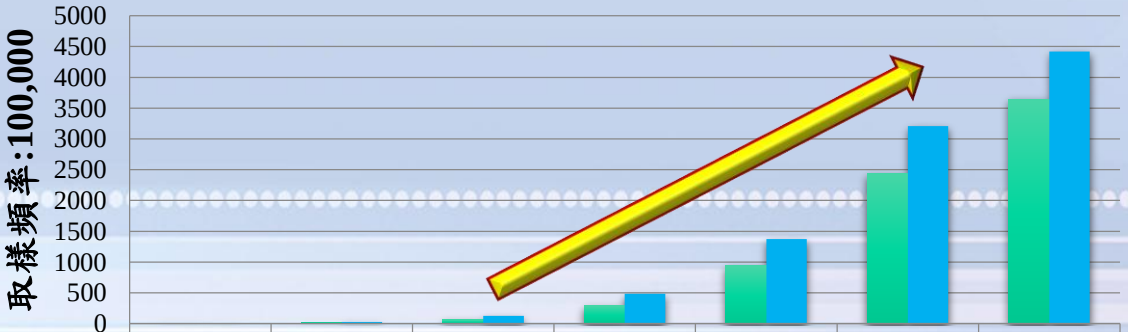
Cause

- ✓Myocardial infarction, Ischemic heart disease, Hypertension, diabete.

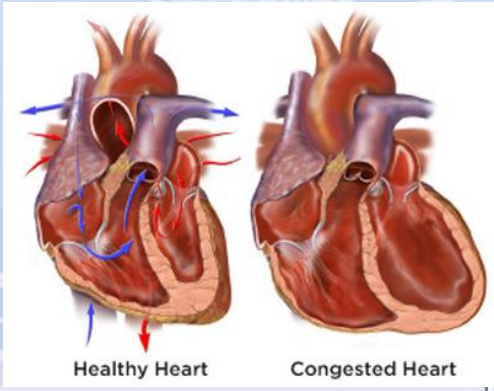
Difficult

- ✓The predominance of causes of heart failure are difficult to analyze due to challenges in diagnosis

臨床心臟衰竭病患與年齡及性別之關聯[8]



	30-39	40-49	50-59	60-69	70-79	80-89	90+
woman	5	15	71	298	939	2436	3644
man	7	29	127	486	1376	3206	4419



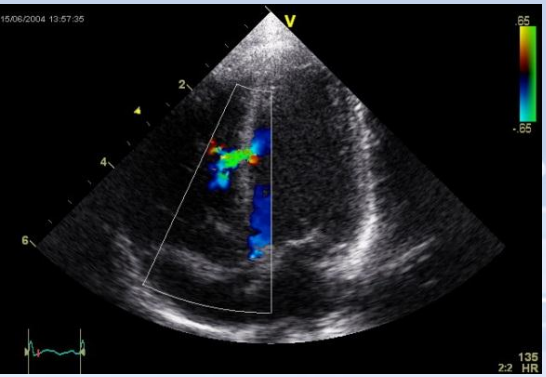
圖片來源:http://medictests.com/congestive-heart-failure/

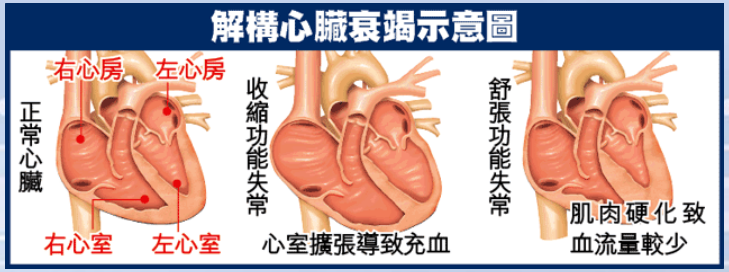
Introduction(3/4)

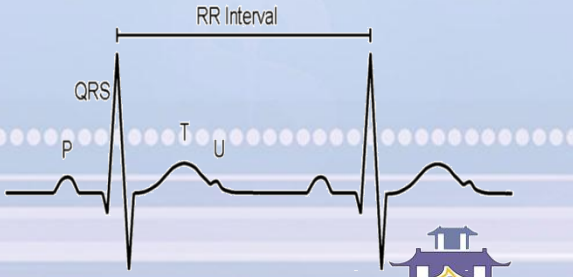
CHF(Congestive Heart Failure)

Diagnosis

- Echocardiography
  - Cardiac echo, sonogram of the heart, ultrasound images of heart structures
  - LVEF（Left Ventricular Ejection Fractions）
- HRV(Heart Rate Variation)[9][10]
  - The variation in the time interval between heartbeats.(R-R intervals)
  - Researches show direct correlation to cardio diseases including CHF







Introduction(4/4)

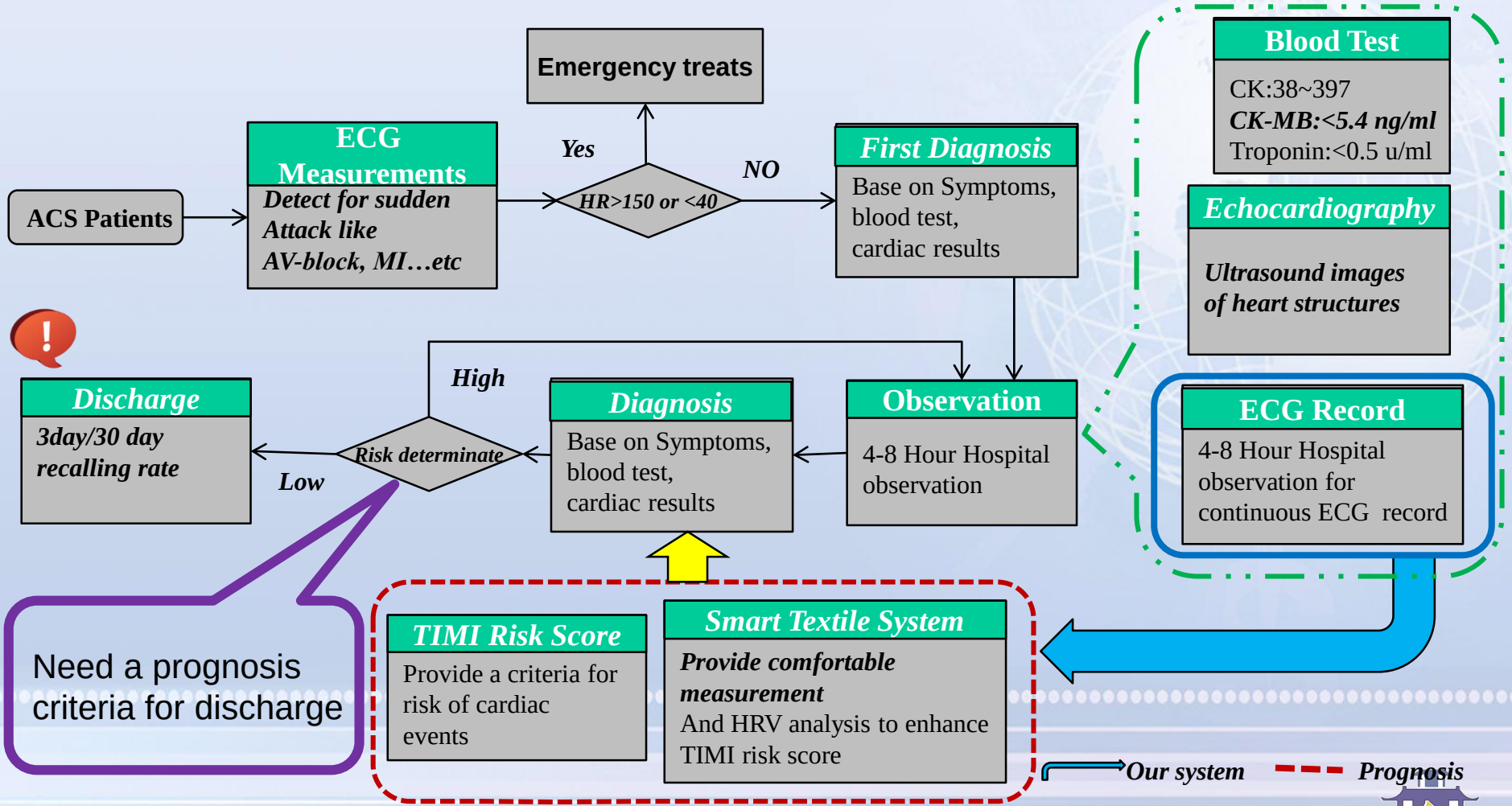
EM Lab.

NYHA places patients to four categories based on symptoms and limited during physical activity.

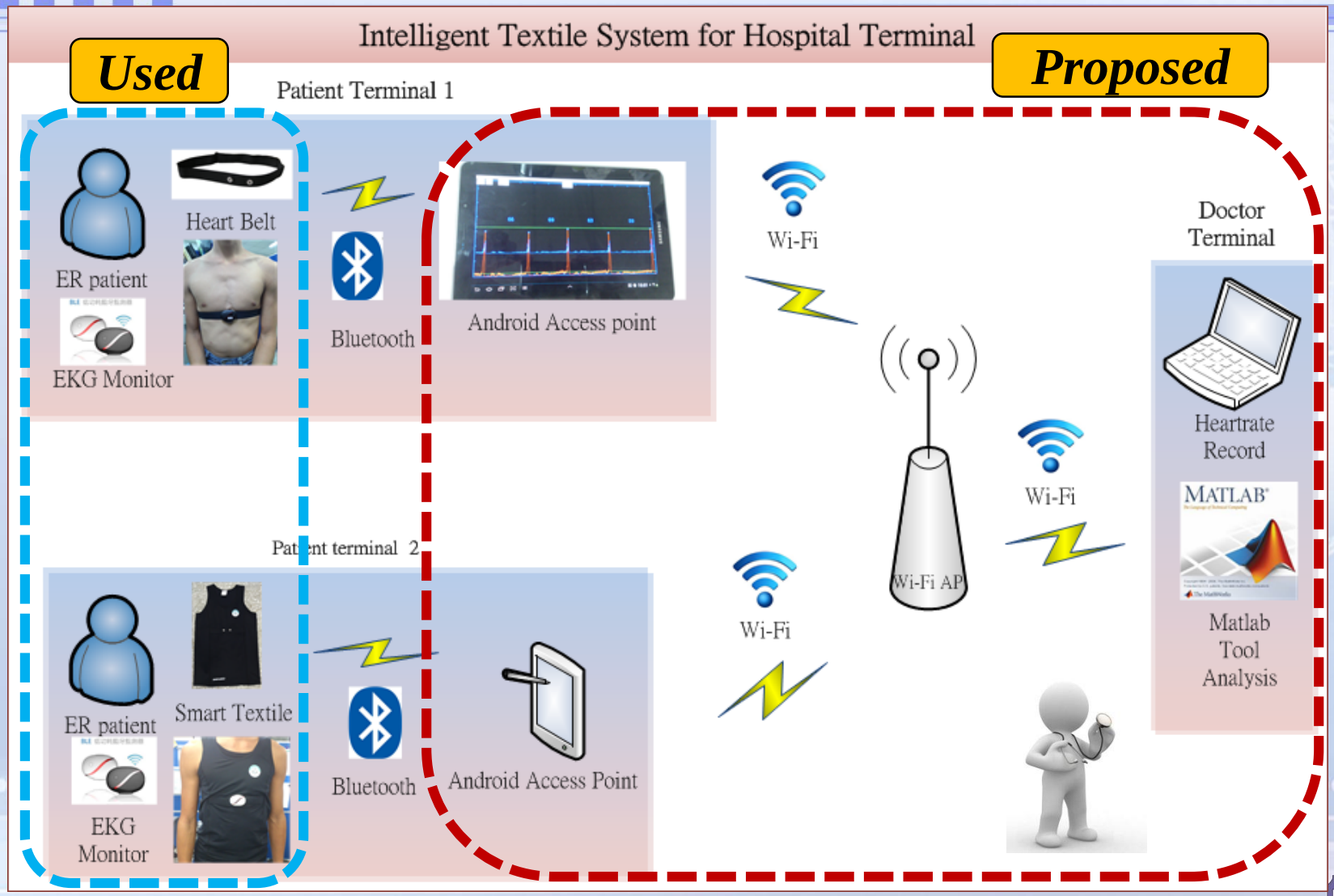
NYHA Heart Failure Classification	
Class	Symptoms
I	No symptoms and no limitation in ordinary physical activity, e.g. shortness of breath when walking, climbing stairs etc.
II	Mild symptoms (mild shortness of breath and/or angina) and slight limitation during ordinary activity.
III	Marked limitation in activity due to symptoms, even during less-than-ordinary activity, e.g. walking short distances (20–100 m). Comfortable only at rest.
IV	Severe limitations. Experiences symptoms even while *at rest*. Mostly bedbound patients.

ACS Procedure in ED

- *ACS(Acute Coronary Syndrome) procedure in ED*



System Architecture



Clinical Results

EM Lab.

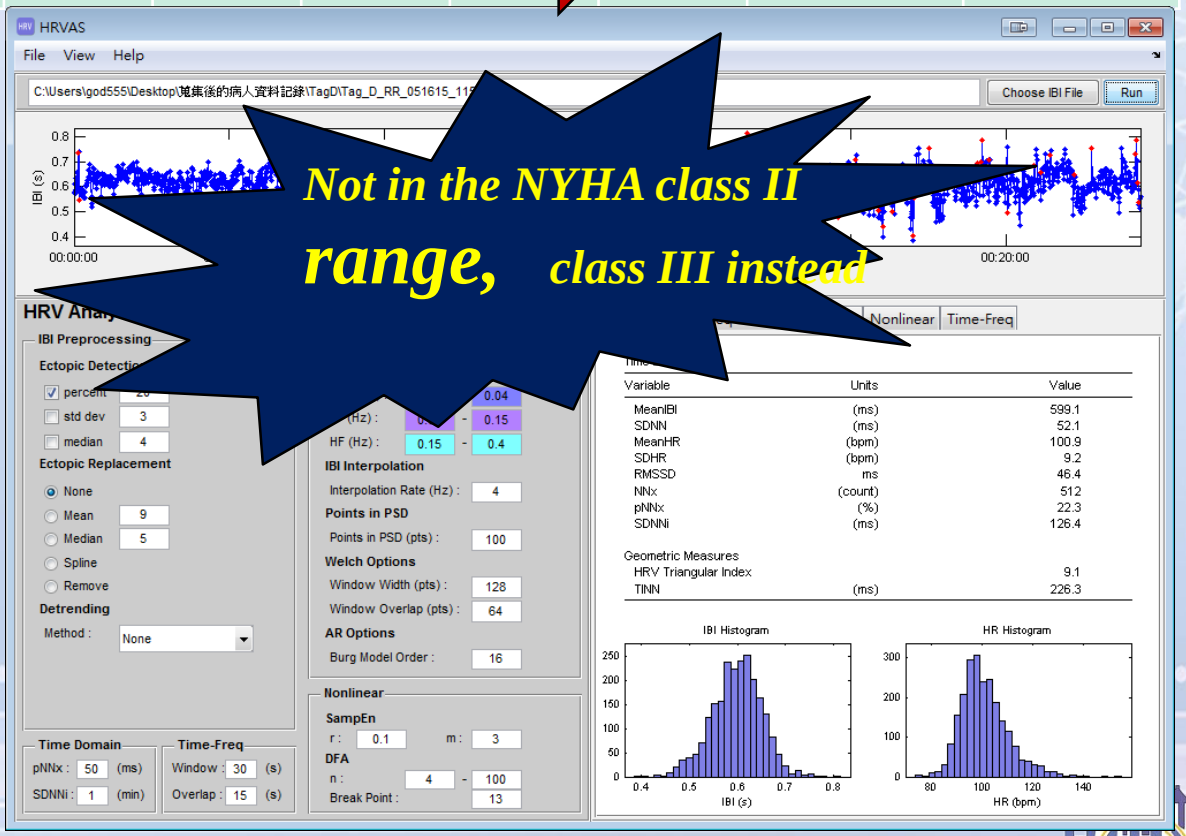
Patient number	NYHA	Gender	Age	入院體溫	入院心跳	入院呼吸	宿疾	主訴	SDNN (ms)	SDANN (ms)	LF (ms^2)
1	II	M	50	36.2	127	18	膽結石	昨天晚上開始胸口痛，背痛	61.4	46.2	330.95
2	II	M	40	36.2	75	18	X	昨天開始胸悶	83.8	79.2	512.73
6	II	F	70	36.3	84	17	X	很容易喘胸痛	79.5	68.8	563.8
8	I	F	54	36.5	98	18	X	凌晨四點開始胸悶、頭痛	77.8	58.9	556.86
13	III	M	81	36.1	95.9	19	糖尿病高血壓	昨晚呼吸困難胸悶、胸痛	49.9	41.2	330.9
15	II	M	39	37.6	64	18	心臟病高血壓	剛開始胸痛	52.1	45.3	317.9
21	I	M	49	36.5	73	17	X	一小時前工作時胸悶	93.4	82.9	724.33
24	II	F	54	36.4	82	18	心律不整	胸悶持續三天	74.1	65.7	501.46

Discussion

Patient 15:	Gender	Age	入院體溫	入院心跳	入院呼吸	宿疾	主訴	SDNN	SDANN	LF
NYHA class II	Male	39	37.6	64	18	HD/HT	剛開始胸痛	52.1	45.3	317.9

Range[17]	NYHA II
SDNN	71.5±18.6
SDANN	63.6±21.7
LF	563±198.6
Range[17]	**NYHA III**
SDNN	53.4±14.1
SDANN	44.8±11
LF	301±101.9

Not in the NYHA class II range, class III instead



TAIPEI TECH 國立臺北科技大學 National Taipei University of Technology

誠,樸,精,勤

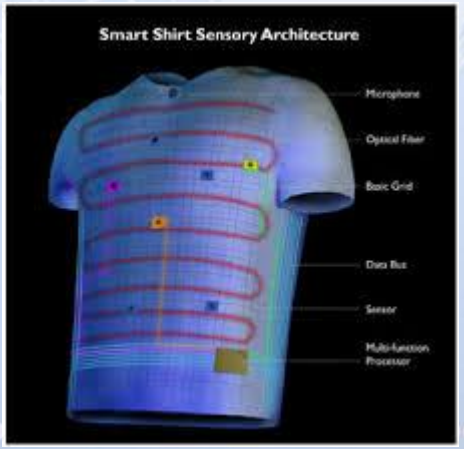
Experiment– Smart Cloth

Ubiquitous & Mobile-care Services

Smart Cloth

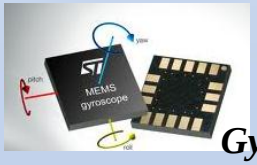

SOFT switch

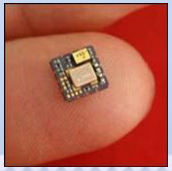

AiQ


Smart Shirt Sensory Architecture
Microphone
Optical Fiber
Basic Grid
Data Bus
Sensor
Multi-function Processor

Cloth as a Platform (CaaP)

EM Lab.





and more…

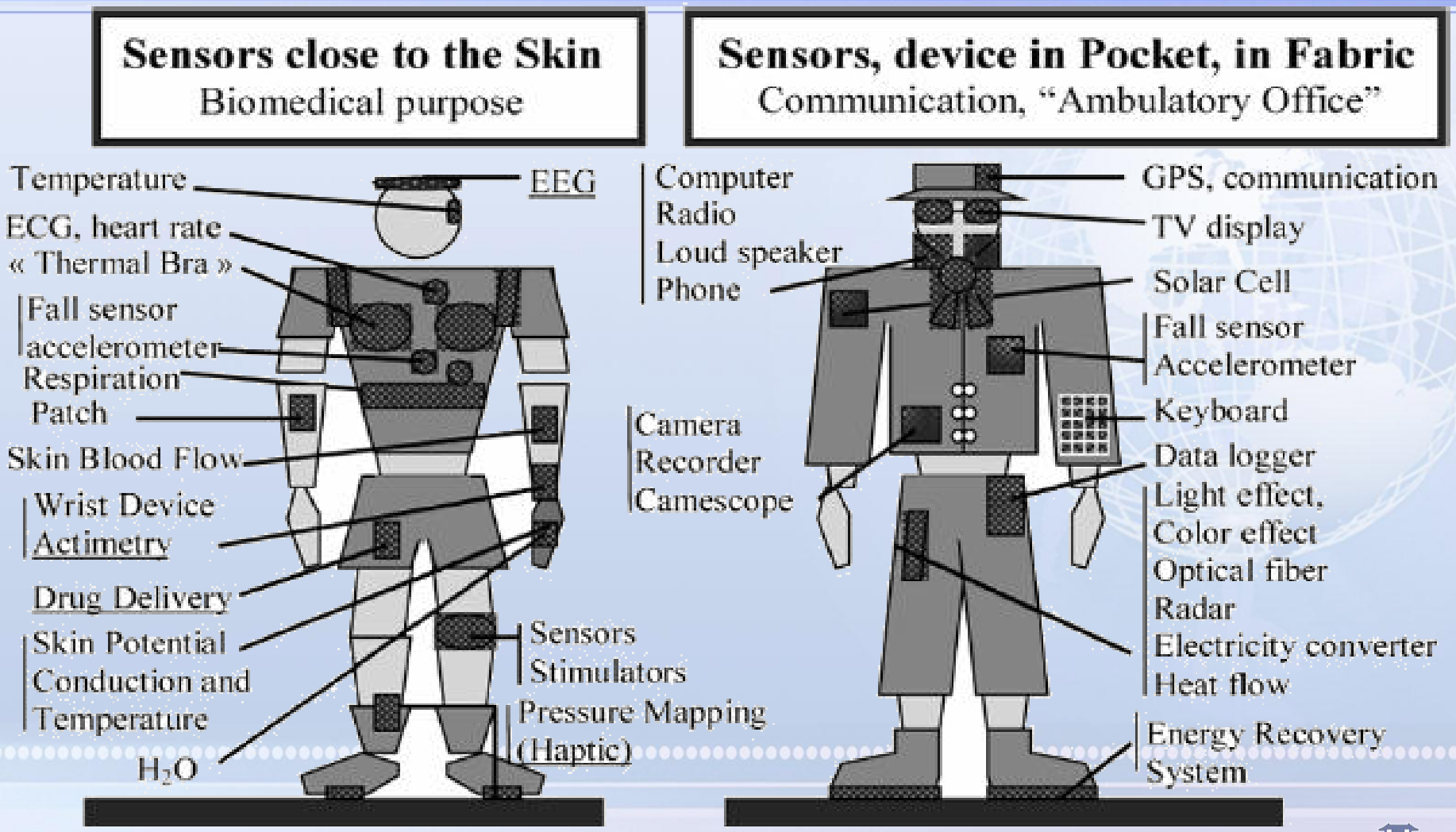
Intelligent wireless electronics

Heating PAD

Ubiquitous & Mobile-care Services

Biomedical Smart Clothes(1/2)

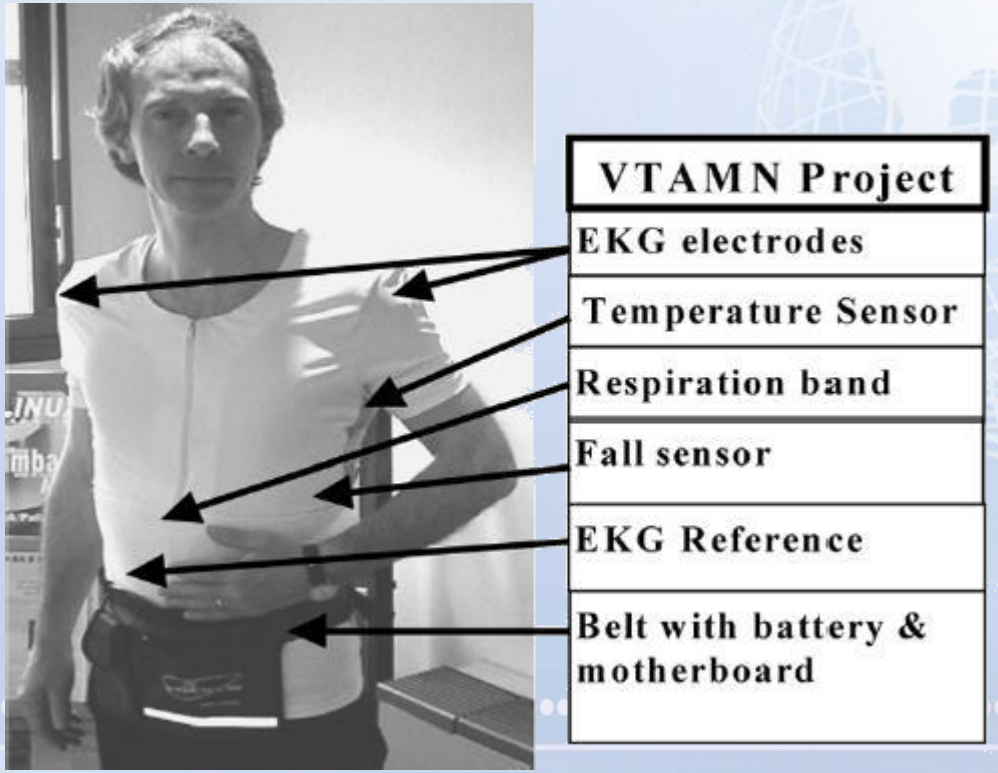
EM Lab.



Two kinds of smart clothes

Biomedical Smart Clothes(2/2)

- **These two main kinds of smart clothing are compatible and complementary**



Life shirt

- **Records parameter as**
  - Electrocardiogram
  - Ribcage respiration
  - Body posture
  - Blood oxygen saturation

Shirt with embedded sensor

WEALTHY's modules

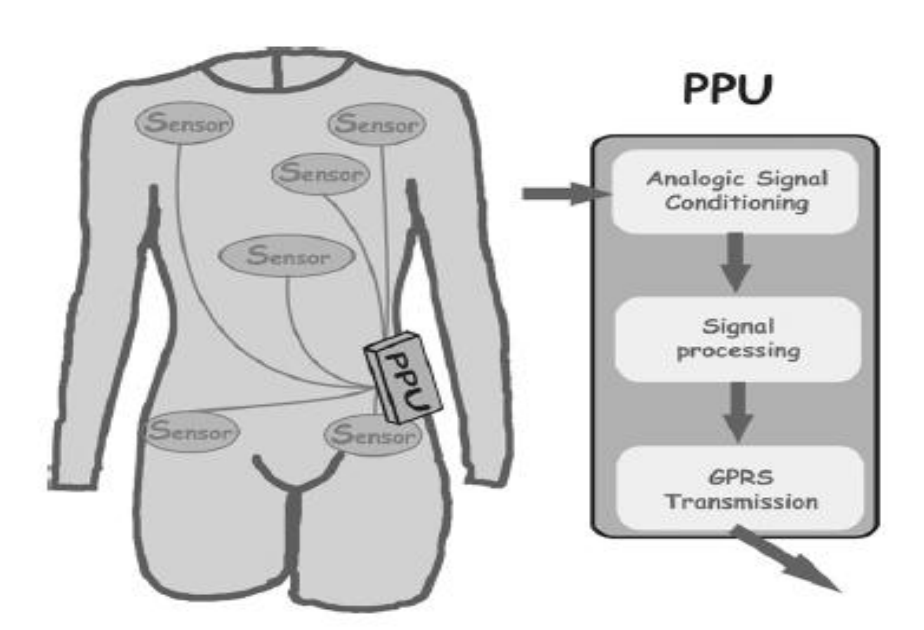
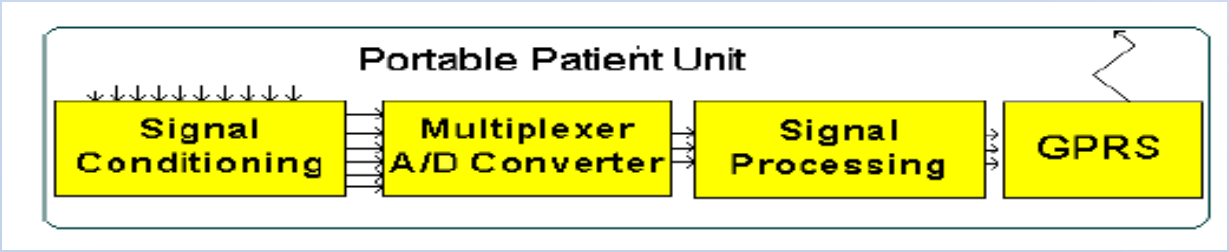


Figure 6: left: old PPU right: new PPU

110mm x 70mm x 25mm
less than 250g



Overview of wearable WEALTHY's modules

Material and Method

- ***Impedance Pneumography***
  - Respiratory activity is the use of the impedance pneumography
  - Inject a high-frequency current (50 kHz, amplitude peak-to-peak 3 mA) and the other ones to capture the voltage variation caused by thoracic impedance change.

Figure 3. Electrodes position for impedance pneumography (prototype B)

Material and Method

- ***Connections***
  - Connections were realized by means of the tubular intarsia technique.

Garment Model and Realization

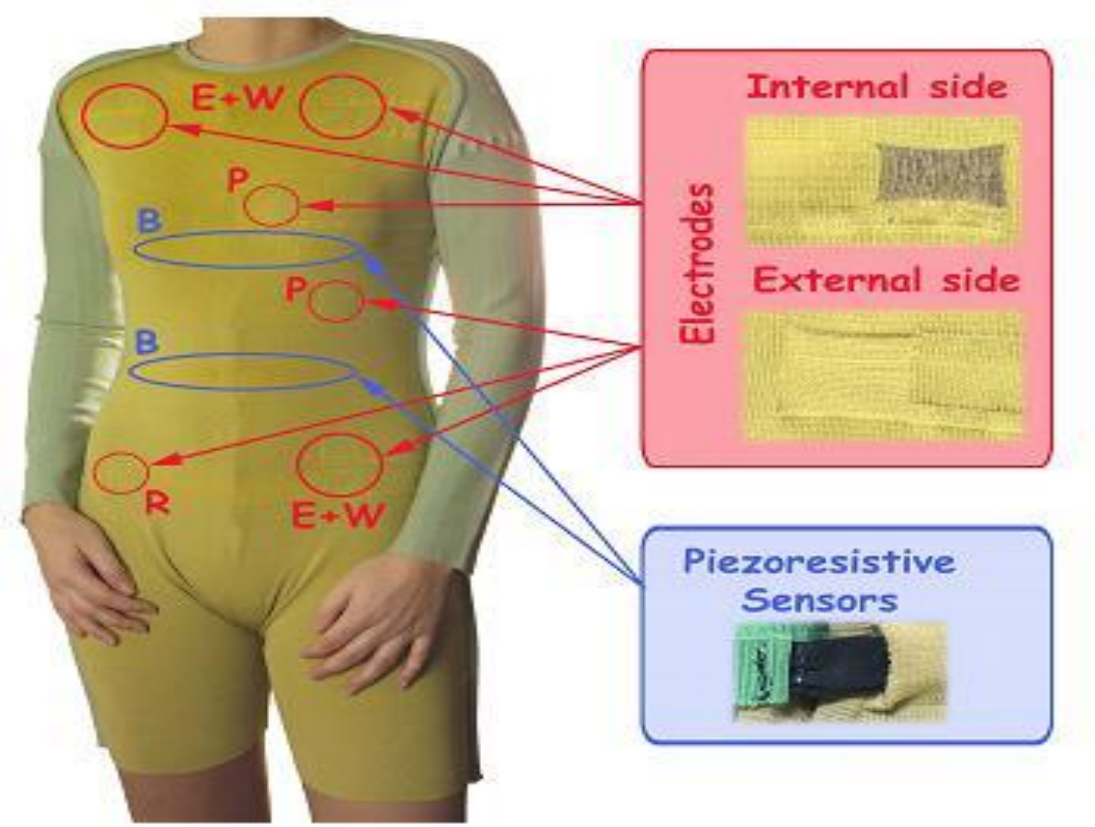


Figure 1. Prototype model, E+W Einthoven and Wilson , R Referee, P Precordial leads, B Breathing sensors. (Prototype A)

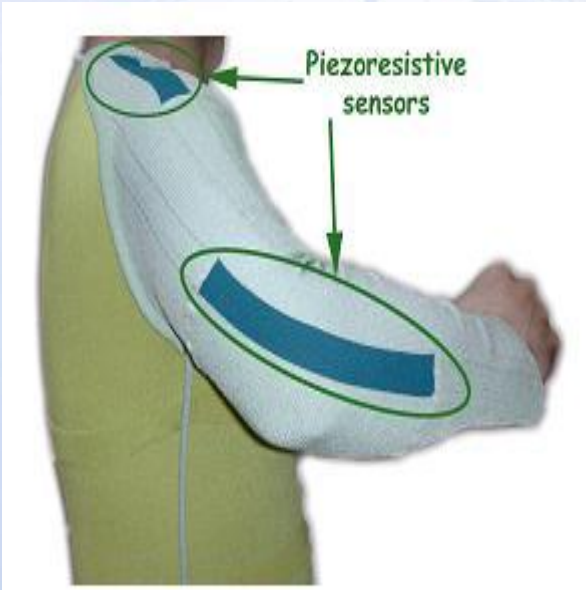
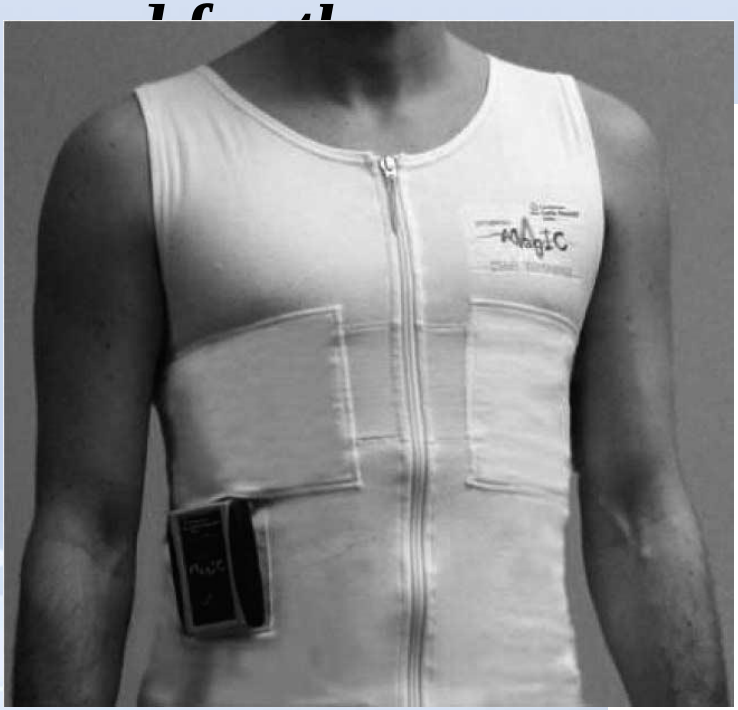


Figure 2. Movement sensors (Prototype A)

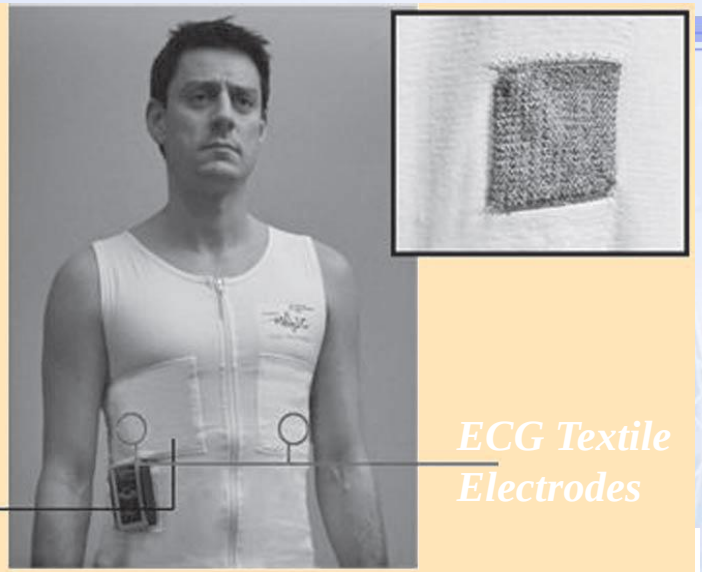
Magic System Description *(cont.)*

EM Lab.

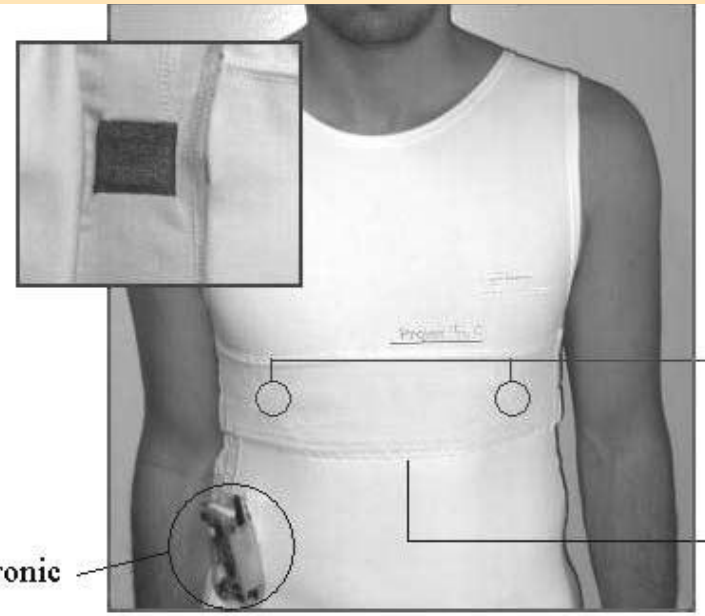
Fig. 1. MagIC system



Textile Transducer for Respiratory Activity



ECG Textile Electrodes



Application

- *We customized an integrated system previously developed in our lab. This system included the MagIC device for the vital signs assessment, a touchscreen computer with a dedicated software for data acquisition, and a UMTS USB dongle for data transmission.*

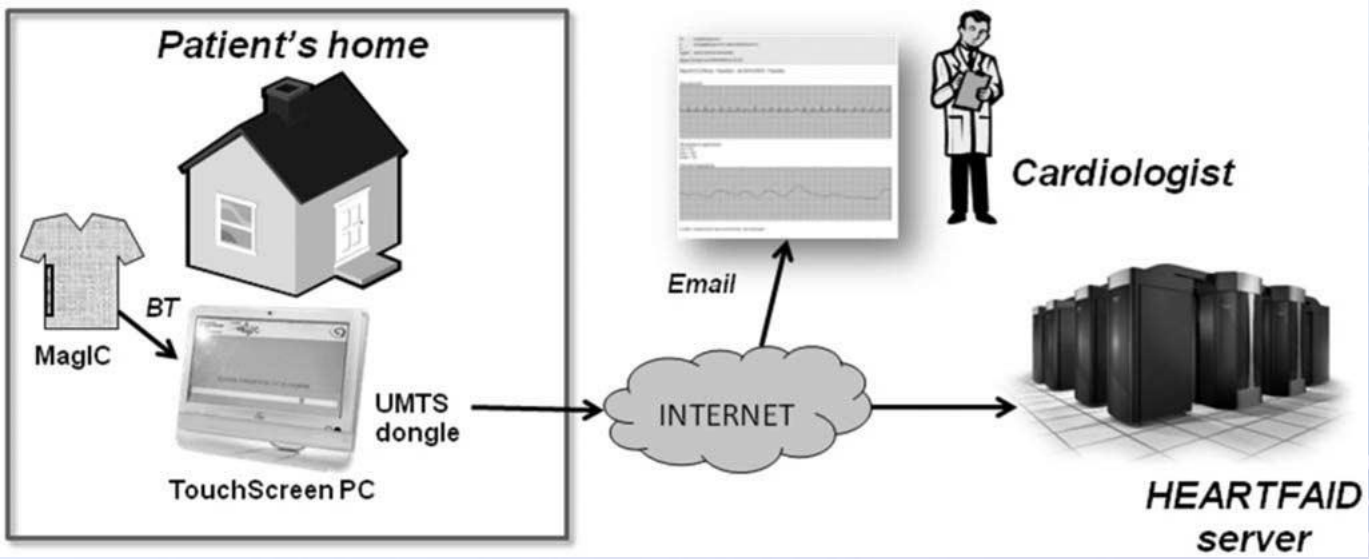
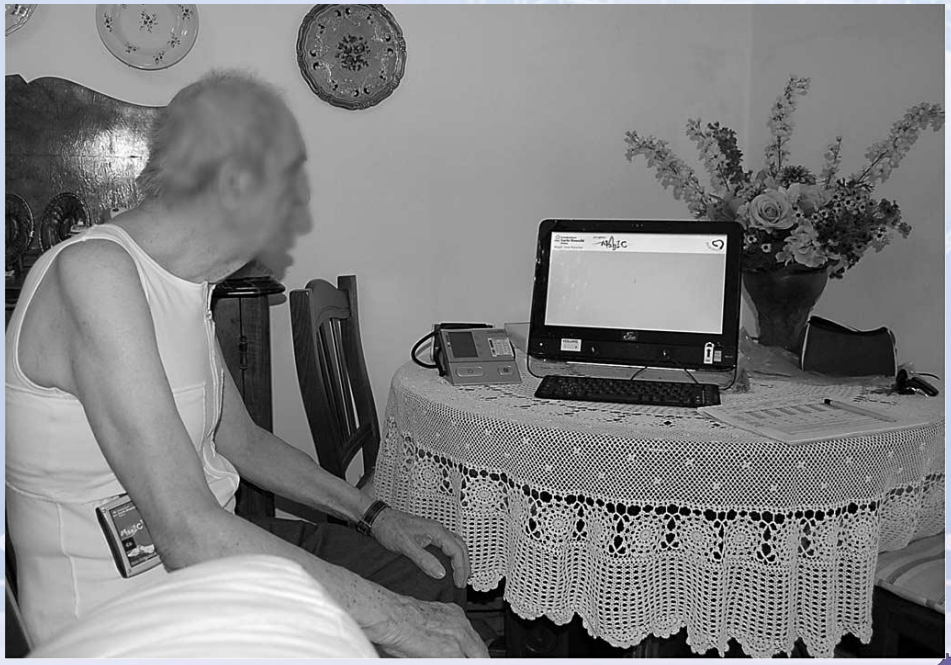


Fig. 2. Overall architecture of the system implemented for the home monitoring of

Application *(cont.)*

- ***Three patients (age: 63, 72, and 82 years), suffering from heart failure and recently discharged from the hospital, were recruited. Patients were asked to perform a telemonitoring session of 3 min every morning for 30 days from their home.***



Introduction (cont.)

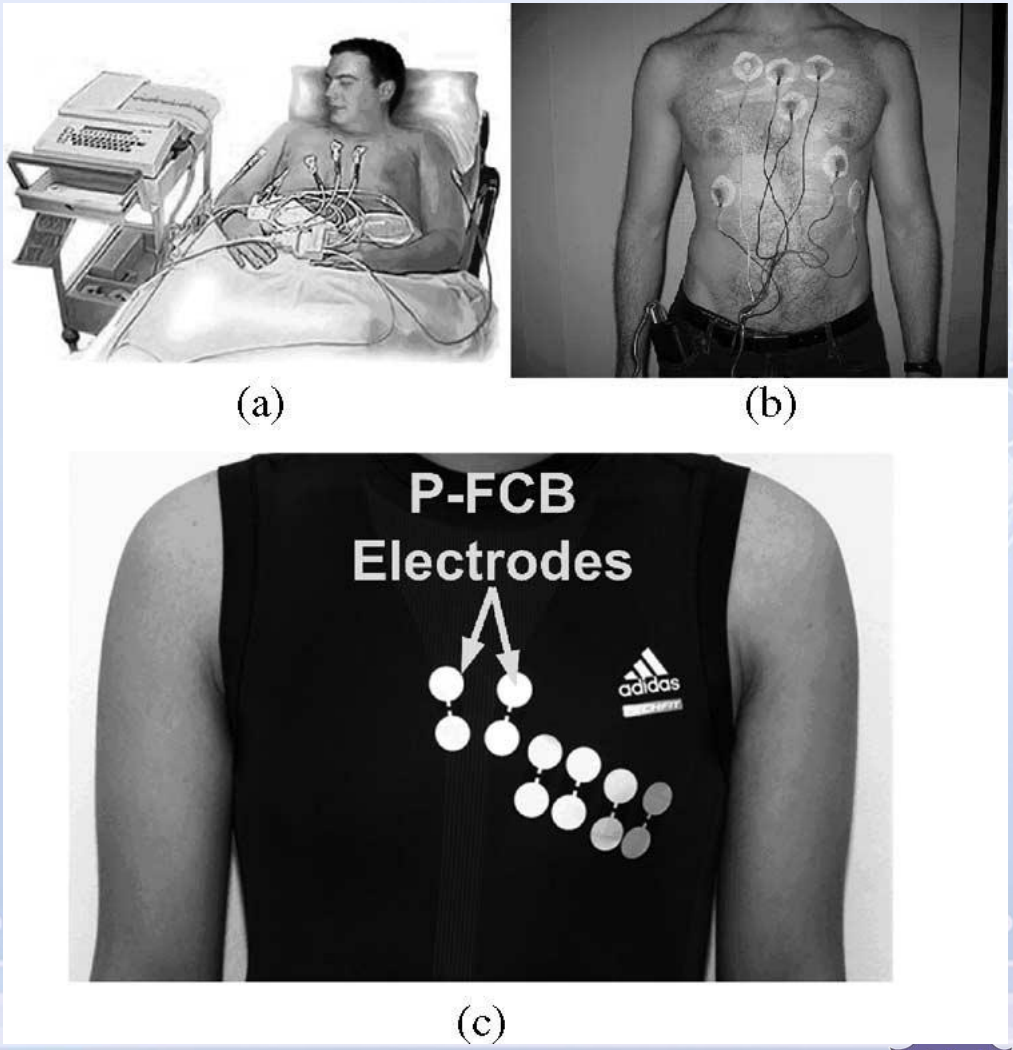


Fig. 1.
(a) Clinical ECG monitoring system.
(b) Conventional Holter monitor system.
(c) Proposed ECG monitoring shirt with P-FCB electrodes.

Systems architecture *(cont.)*

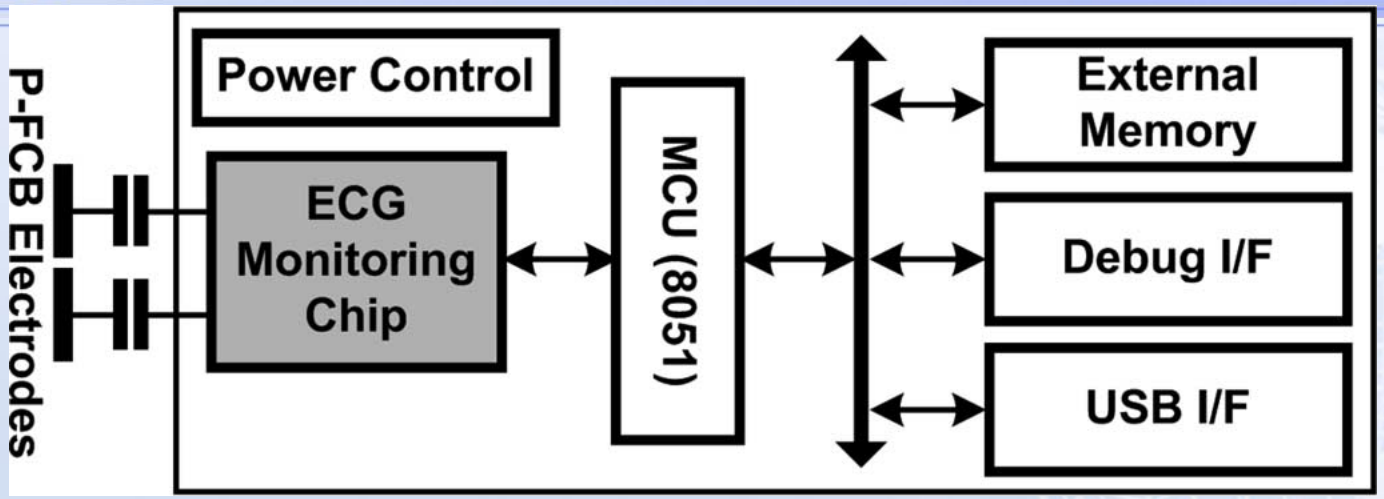


Fig. 2. Block diagram.

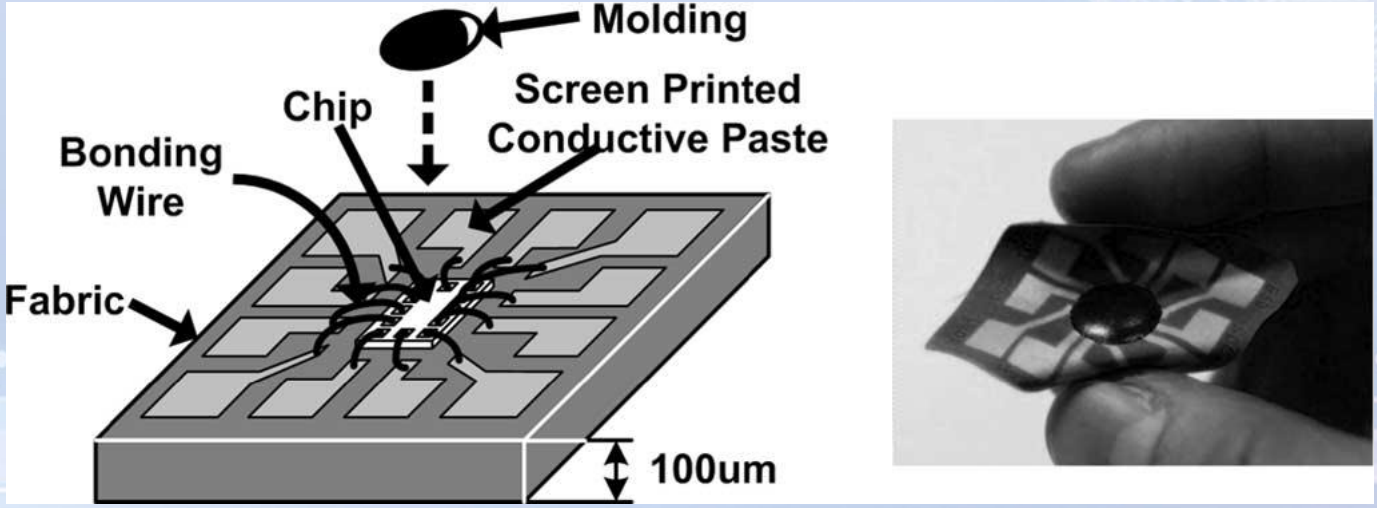


Fig. 3. Wire-bonded chip on fabric.

Implementation and measurement results *(cont.)*

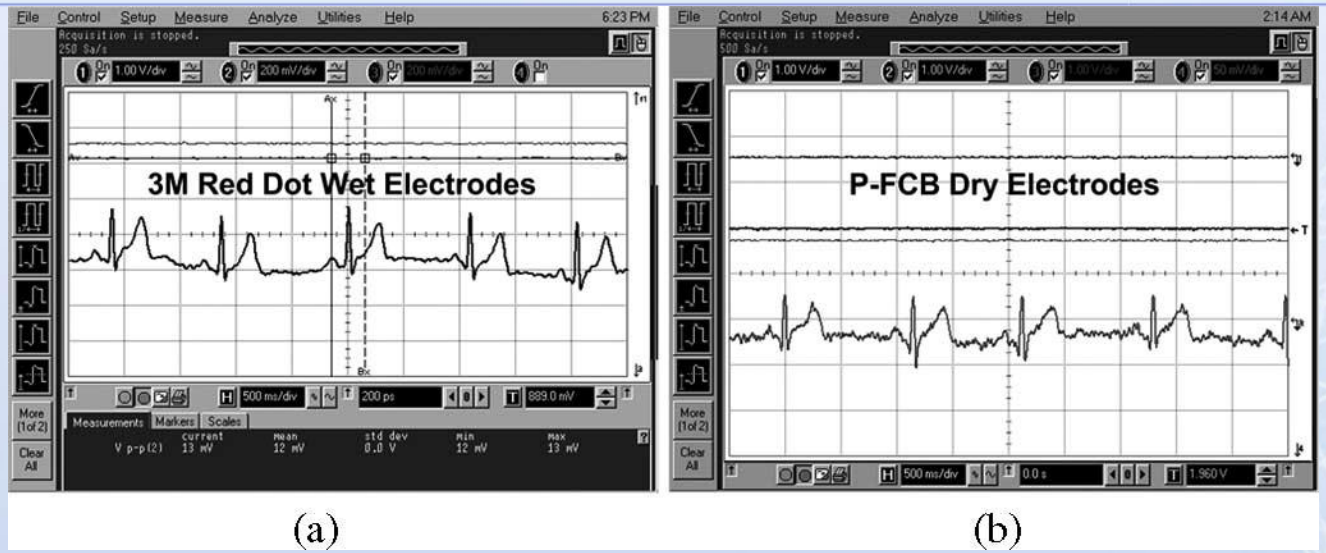


Fig. 13. ECG signal captured by the system. (a)With wet electrodes. (b)With P-FCB electrodes.

Main Function	Continuous ECG Monitoring
Key Features	1) Wearable, Convenience 2) Dry Electrodes for Safety 3) P-FCB Low Cost Manufacturing
Supply	3.6V (½ AA Size)
Power Consumption	3.0mW
Operation Duration	Up to 14 Days of Continuous Operation with ½ AA Battery
Electrode	Differential P-FCB (Dry)

TABLE I
PERFORMANCE SUMMARY

討論

- 手機的出現讓不戴手錶成為一種現象，手錶可能成為特定意義的裝置（紀念、時尚、高貴...）
- 什麼樣的服務或需求，使用者願意再將手錶或手環帶回？（健康、互動、娛樂...）
- 「服務有感、量測無感」的可能性？ (CaaP : Cloth as a Platform)
- 如何提供電量給CaaP 且使用者同意並符合防水及洗滌? (太陽能、皮膚生電、震動生電、能量聚合、行動電源...)
- 系統規格及可量測項目與應用情境？
- 跨領域的思維接受度如何？

結語

- 穿戴式技術需要跨界合作，經驗累積是致勝關鍵。

穿戴式裝置作為Consumer Health的平台已是趨勢。

無感量測及高雜訊下生理訊號偵測是關鍵技術之一。

- CaaP 需要更多材料與電子、醫工及紡織專家共同投入。
- 系統端驗證成功後，仍須晶片商投入資源進行微小化及低功耗設計。
- 平台服務及社群分享與使用者經驗仍是產品熱賣的核心。


企業搖籃一百年
工業推手一世紀
報告完畢 敬請指教