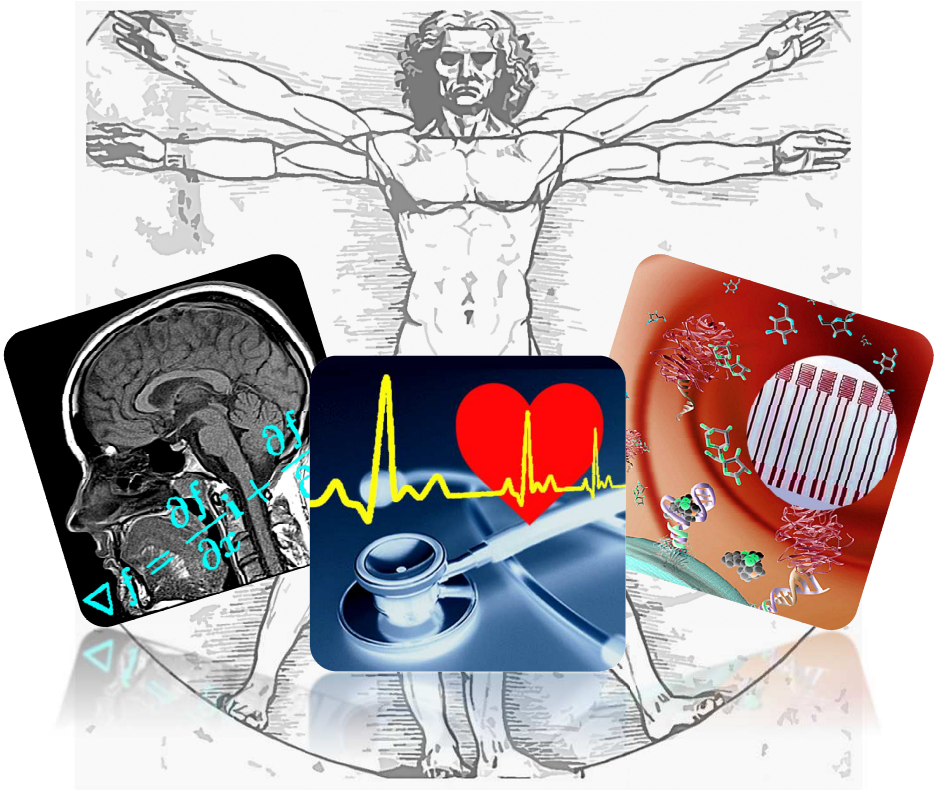
CHULA ENGINEERING
Foundation toward Innovation

Department of Electrical Engineering

ELECTRICAL ENGINEERING
CHULALONGKORN UNIVERSITY

Cluster Bioelectronics (**BIO**)



CUEE Graduate Program 2023

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Smart Medical Devices

Smart Healthcare

Assistive Devices for Disabled & the Elderly

Rehabilitation Devices

Lab-on-a-chip Devices

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BIO & EE Department Members

Professor
Dr. Boonchai Techaumnat
(Kyoto University)

- Bioelectromagnetics
- Particle electromechanics
- Micro-nano engineering
- Lab-on-a-Chip / Microfluidics

Associate Professor
Cherdkul Sopavanit
(Chulalongkorn University)

- Pre-hospital bio-signal based telemedicine
- Biphasic external defibrillator
- Pulse oximeter, EEG, ECG

Associate Professor
Dr. Supatana Auethavekiat
(Tokyo University)

- Medical image processing and recognition
- Image segmentation
- Image classification

Associate Professor
Dr. Chanchana Tangwongsan
(University of Wisconsin-Madison)

- Medical instrumentation
- Biomaterial
- Synthesis of nano particles for various applications

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BIO & EE Department Members

ELECTRICAL ENGINEERING
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Assistant Professor
Dr. Arporn Teeramongkonrasmee
(Chulalongkorn University)

- Medical instrumentation
- Home health monitoring
- ECG, Ballistocardiography (BCG)
- Gas sensors

Assistant Professor
Dr. Apiwat Lek-uthai
(Karlsruhe Institute of Technology)

- Medical signal processing
- ECG, Arrhythmia detection, HRV
- EEG, Seizure detection
- PPG, Cuff-less blood pressure estimation

Lecturer
Dr. Sawit Na Songkhla
(Tokyo Institute of Technology)

- Medical instrumentation
- Biosensors
- Odor sensing system

Assistant Professor / BME Program
Dr. Pakpum Somboon
(Tokyo Institute of Technology)

- Medical instrumentation
- Biosensors
- Electronic nose

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Courses

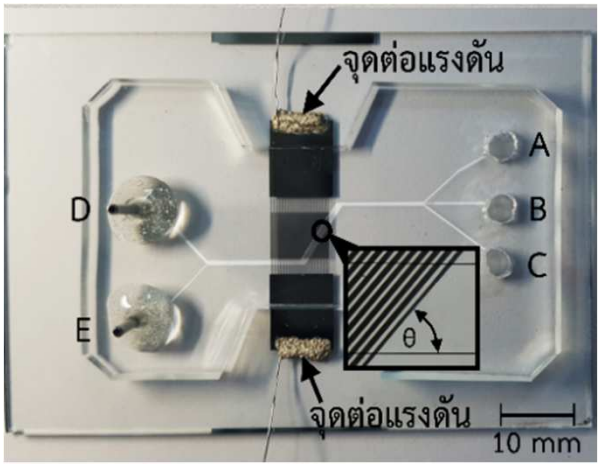
- 2102506 Finite Element Analysis for Electrical Engineers [BTA, PJP]
- 2102585 Biomaterial Science [CTS]
- 2102587 Sensor Technology and Applications [ATM]
- 2102611 Medical Instrumentation [CTS, ALT]
- 2102668 Biosensor [SNK]

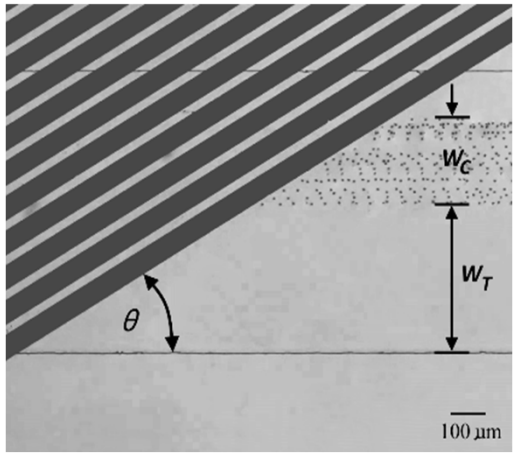
BIO Research Highlights

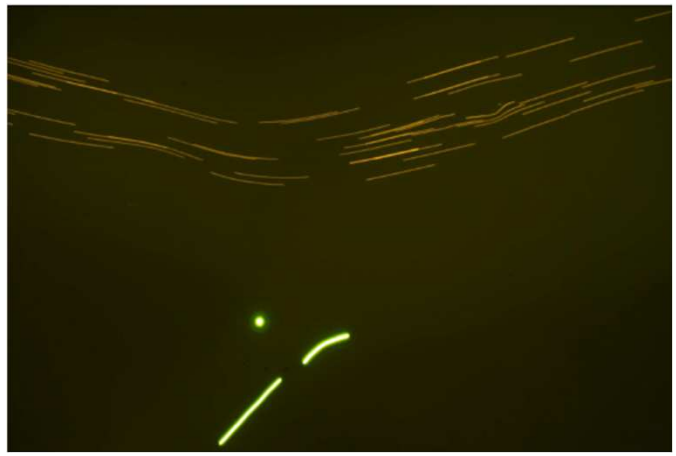
Biomedical Engineering Fundamentals	• Lab-on-a-Chip biomedical sample preparation • Electrical impedance spectroscopy
Biomedical Instrumentation	• Multiparameter vital sign monitor; Wireless ECG monitor • Walking stimulation device for Parkinson patient
Biosensors	• On-chip malaria detection • Glucose sensor; Nitric oxide sensor, Total viable count (TVC) sensor • Electronic nose
Medical Signal & Image Processing	• ECG analysis; Cardiac arrhythmia detection • EEG analysis; Seizure detection • Medical image classification, segmentation, etc.

Lab-on-a-Chip Platform for Biomedical Sample Preprocesses

Boonchai Techaumnat





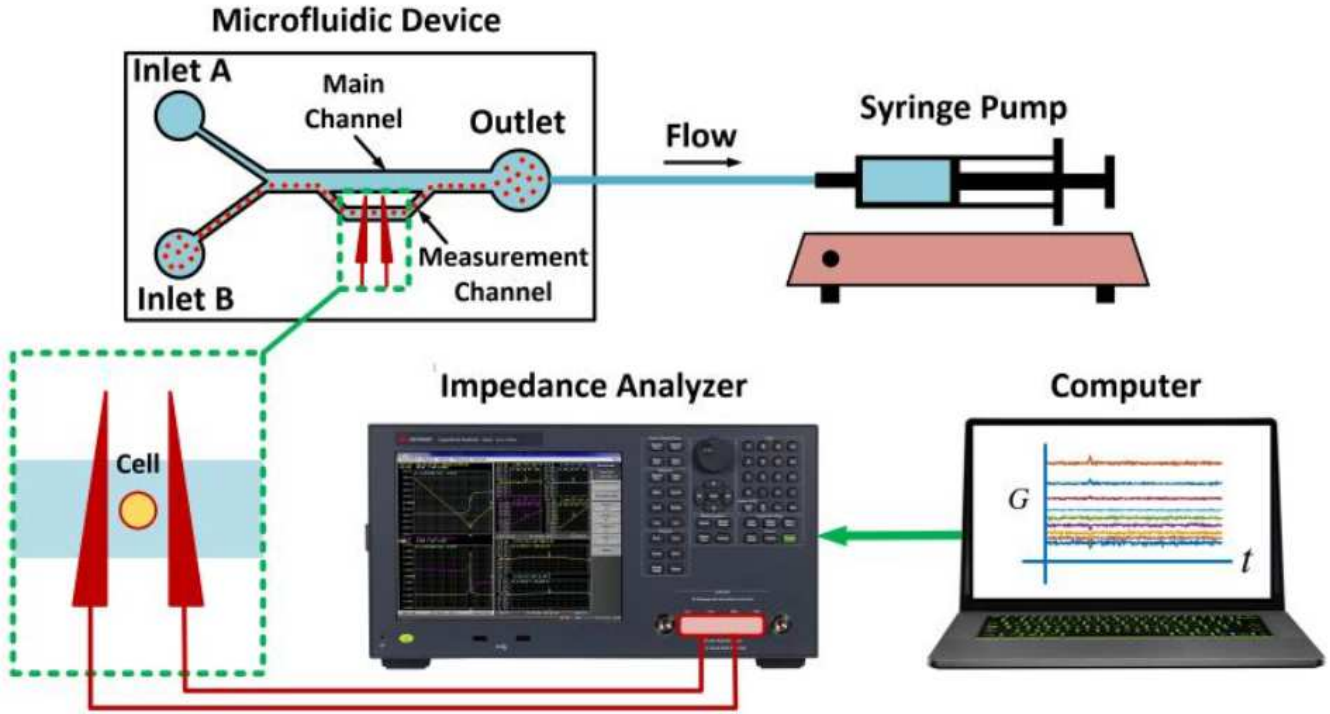


Separation between polystyrene particles and/or red blood cells for target enrichment

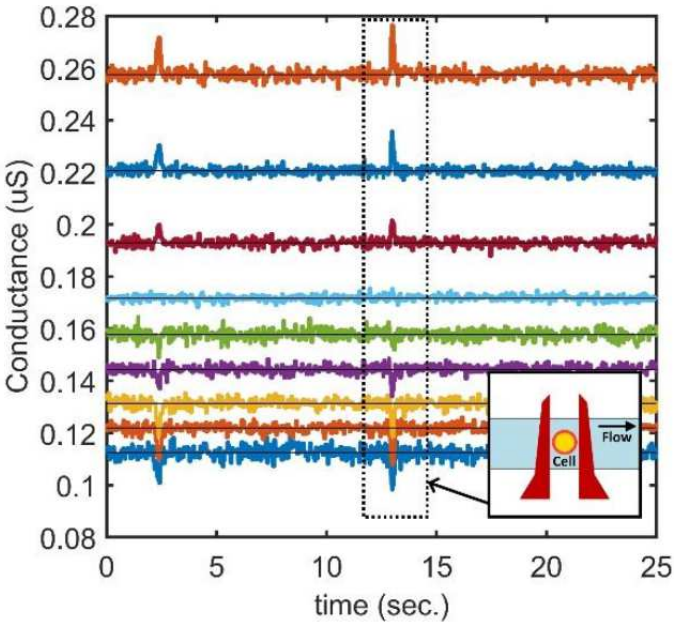
- New methods to pre-concentrate or enrichment target cells/particles in sample can improve the level of detection (LOD) for diagnostics.
- Using lab-on-a-chip or micro total analysis system, we can reduce sample volumes needed for diagnostic, and enhance the sensitivity of detection.

Electrical Impedance Spectroscopy (EIS) of Cells

Boonchai Techaumnat



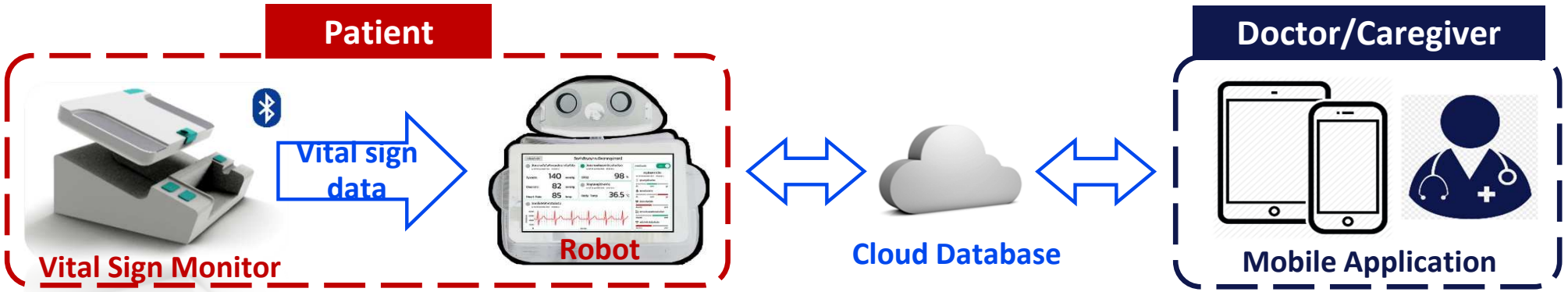
Impedance at various frequencies provide footprints to analyze cell processes or abnormalities

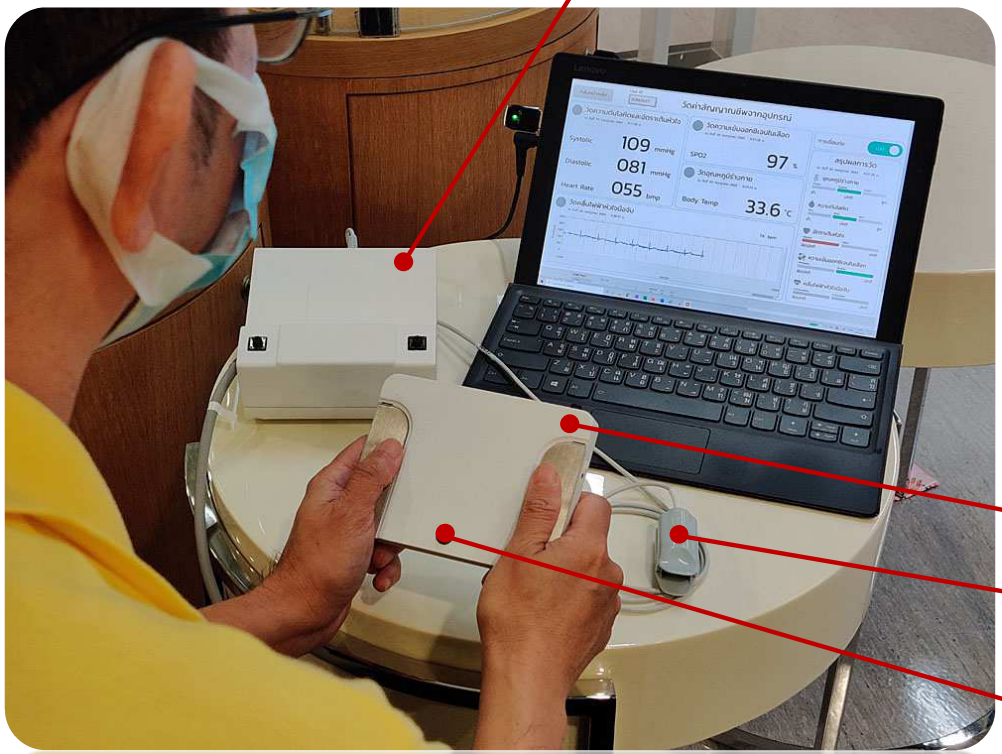


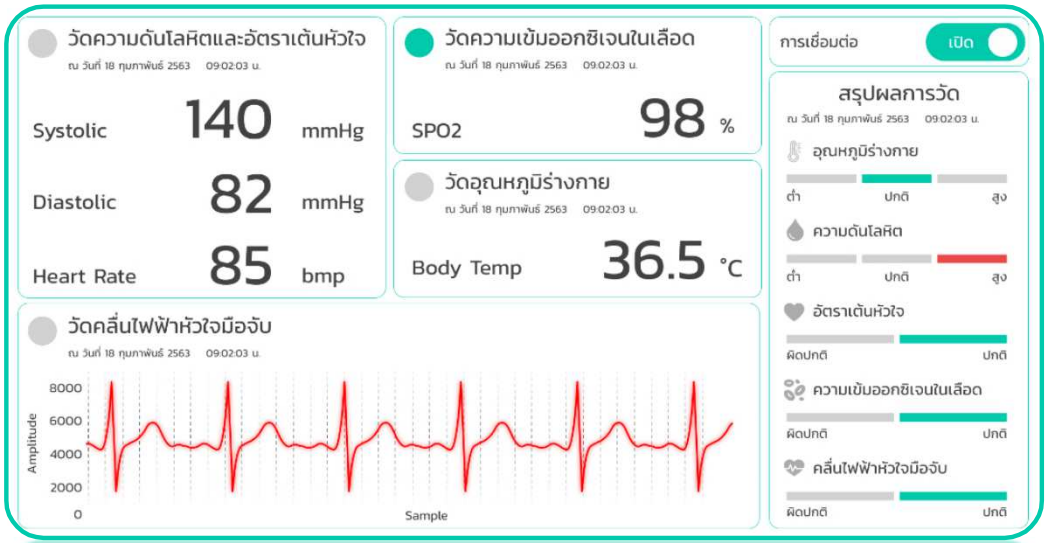
- Microfluidic platform is developed for on chip EIS
- Different EIS characteristics are used to detect infected cells.

Multiparameter Vital Sign Monitor For Home Use

Arporn Teeramongkonrasmee, Pakpum Somboon, Apiwat Lek-uthai





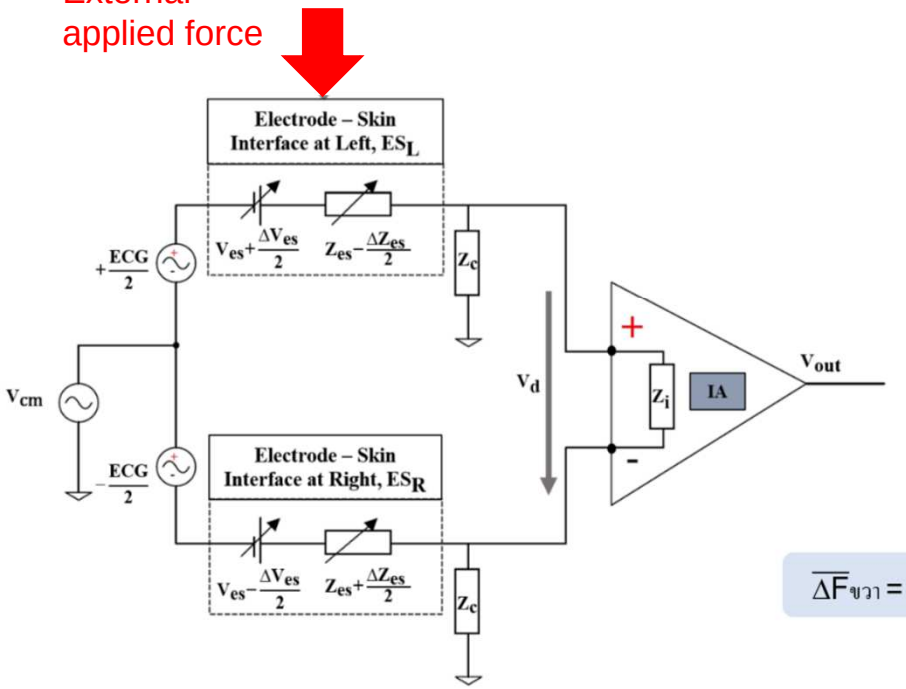


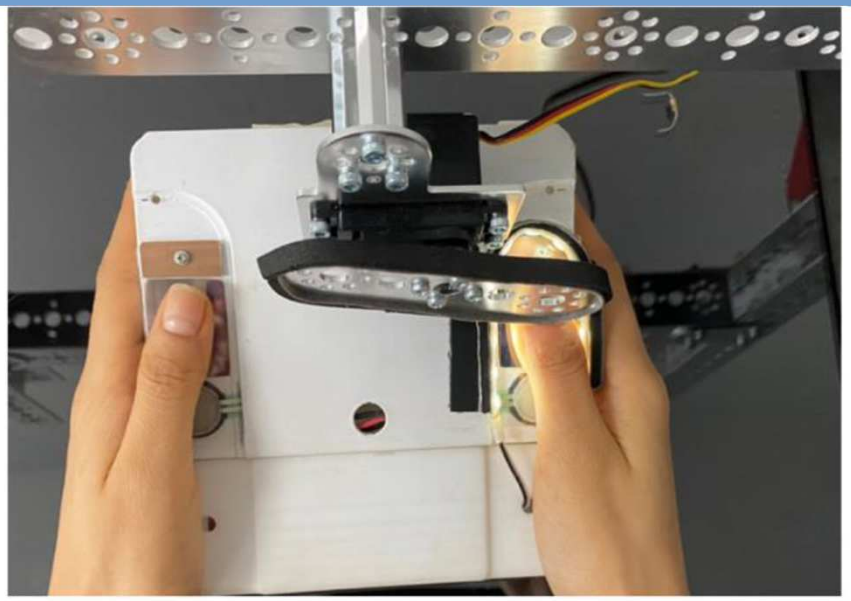
Chulalongkorn Stroke Center
King Chulalongkorn Memorial Hospital

โรงพยาบาลจุฬาลงกรณ์ สภากาชาดไทย

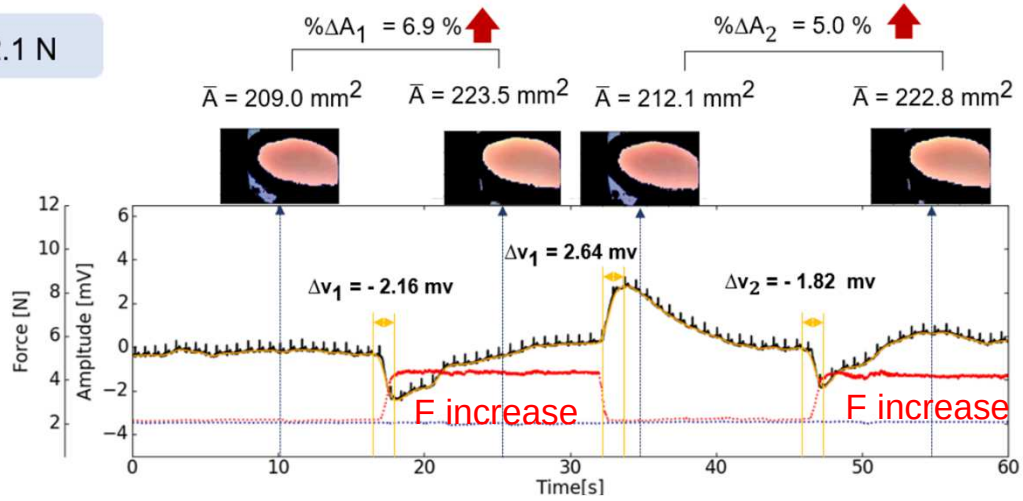
Modelling of ECG Measurement: Baseline Shift

Arporn Teeramongkonrasmee





$\overline{\Delta F}_{ขวา}$ = 2.1 N



A Simplified model of ECG measurement with Electrode-skin interface

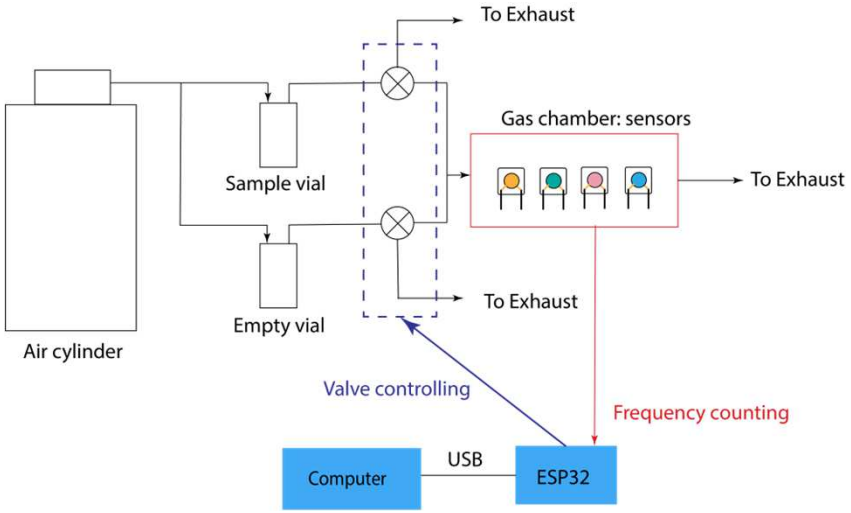
- **To understand how the ECG baseline shift due to the change of electrode/skin interface**

Odor recognition system using QCM sensors

Sawit Na songkhla

QCM = Quartz Crystal Microbalance

Objective: To construct a prototype odor recognition system which can be extended to E-nose application.



Arrays of sensor different coating materials responses differently for each scents. This pattern can be classified by using PCA (Principal component analysis) or k-NN discrimination.

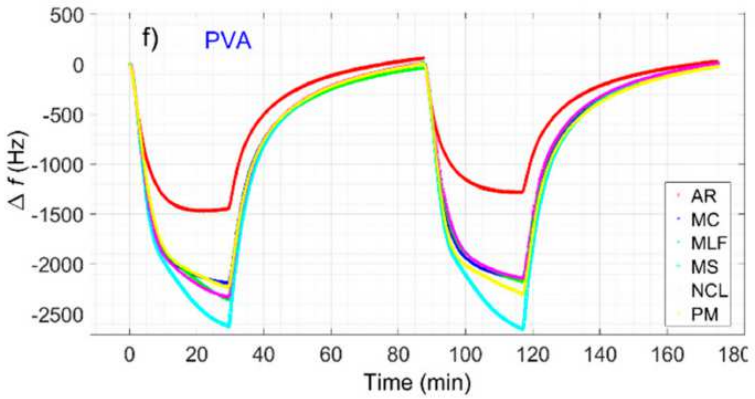
Electronic Nose applications

- fruit ripeness, freshness and food quality assessment.
- Air quality monitoring
- Pathogen or disease detection

Open Access Article

Identification of Mint Scents Using a QCM Based E-Nose

by Salih Okur [1,2,*], Mohammed Sarheed [3], Robert Huber [2], Zejun Zhang [1], Lars Heinke [2], Adnan Kanbar [3], Christof Wöll [1], Peter Nick [3] and Uli Lemmer [2,4]



AR: Korean Mint
MC: Curly Mint
MLF: Horse Mint
MS: Spear Mint
NCL: Catnip
PM: Pepper Mint

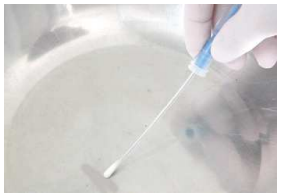
Resonant frequency shift of sensor with PVA (Poly vinyl alcohol) expose to various mint

Okur, Salih and Mohammed Sarheed, et.al. 2021. "Identification of Mint Scents Using a QCM Based E-Nose" *Chemosensors* 9, no. 2: 31

Total viable bacterial counts for food processing facility

Sawit Na songkhla

Objective: To estimate Total viable bacterial counts (TVC) from oxygen consumption by electrochemical sensor.



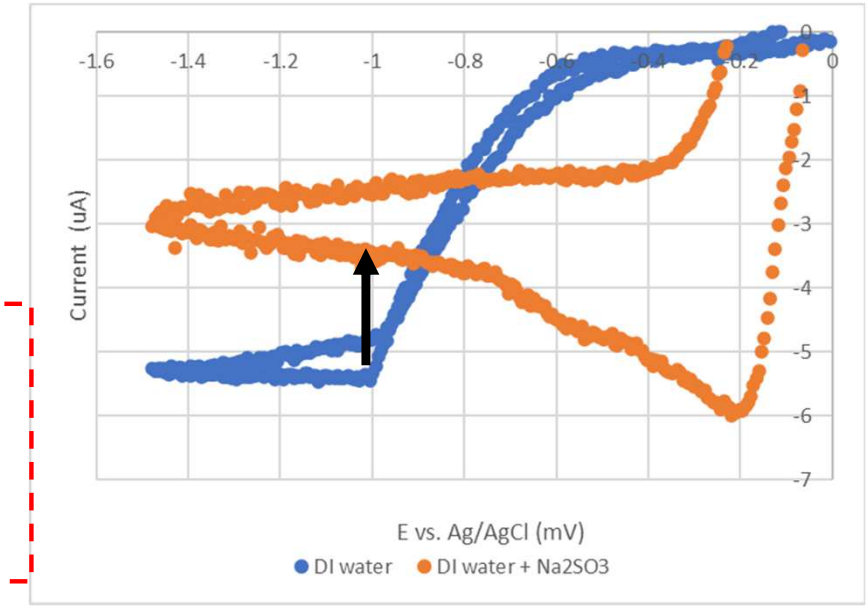
Swab the preparation surface

Screen printed electrode

AD5940: Electrochemical Front End

10 – 30 min.

Peak at -1 V can estimate bacteria in sample



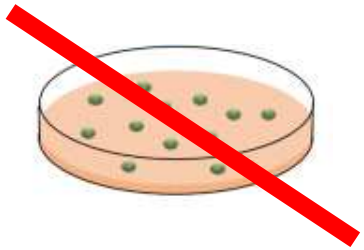
Cyclic voltammograms of oxygen measurement using screen printed carbon electrode. Compare between prior to adding Na_2SO_3 and after adding Na_2SO_3.

Na_2SO_3 captures O2 and causing the reduction reaction at -1 V to decrease.

The electrochemical reduction of oxygen occurring at the electrode surface is as follows

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^- \text{ (working electrode)}$$

$$4OH^- \rightarrow O_2 + 2H_2O + 4e^- \text{ (counter electrode)}$$

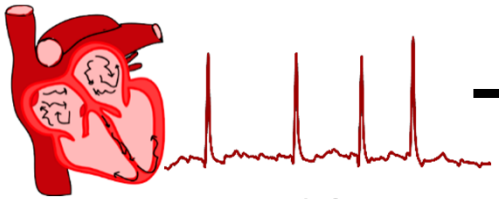


No need of direct colony count

Rhythm-based Classification of Cardiac Arrhythmia using SVM

Tanawan Tearwattanarattikal and Apiwat Lek-uthai

Objective: to develop a high-performance algorithm for automatic atrial fibrillation detection



ECG → QRS Detection → Feature Extraction → Classifi-cation → Atrial Fibrillation (Y/N)

Time series of RR-intervals

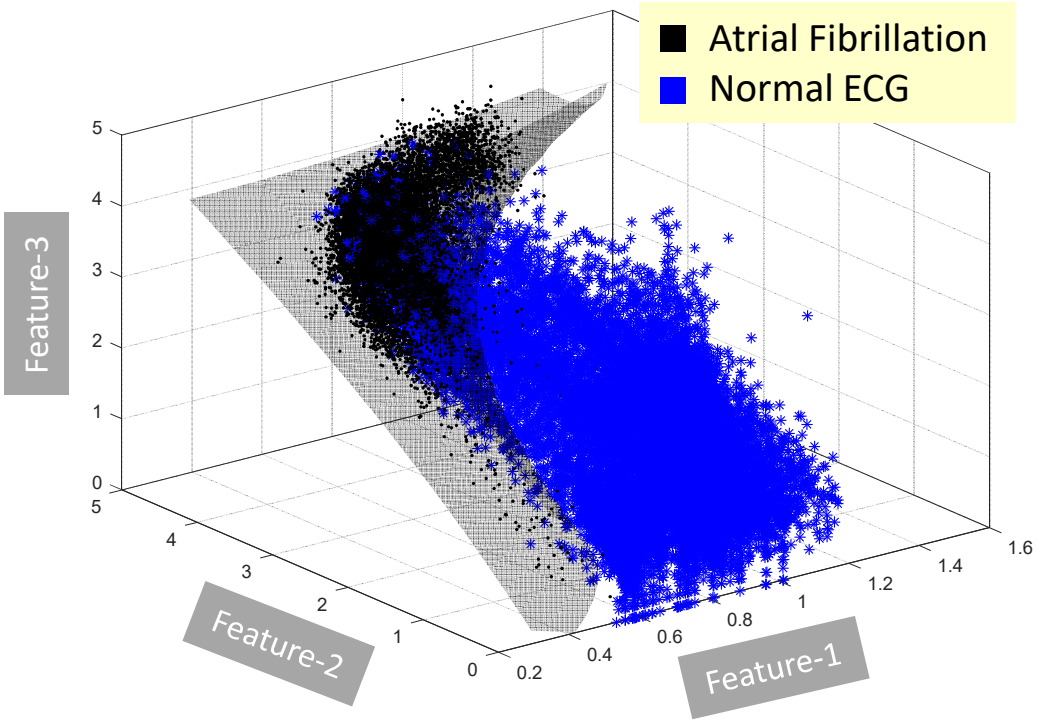
HRV, statistics, entropy,…

Performance on MIT-BIH Arrhythmia Database

QRS detection	Sens	PPV
Pan-Tompkins	99.76%	99.56%
This work	**99.80%**	**99.59%**

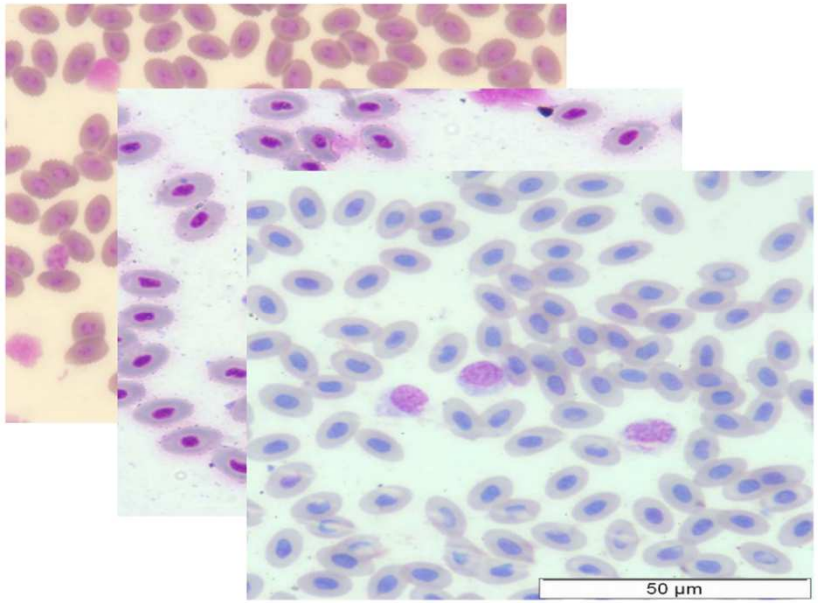
Performance on MIT-BIH Atrial Fibrillation Database

Classifier	Sens	Spec
LDA	98.26%	88.70%
SVM	**98.29%**	**96.46%**



Avian blood analysis

T. Autaiem, Supattana Auethavekiat, V. Sa-ing, K. Nakgoi, N. Prasertsincharoen, P. Arreesrisom

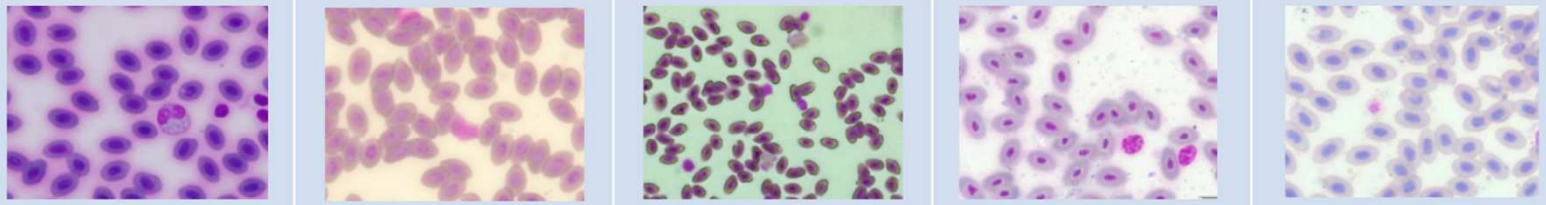


Objective: to count the number of red blood cells and differentiate white blood cells

Difficulties: connected oval cells, different staining, nucleated red blood cells, small sample size

Methods: Iterative multiple thresholding for red blood cell counting and rule based method

%error of red blood cell counting in 5 different staining



1.40	3.77	8.59	4.80	2.15

T. Autaiem, S. Auethavekiat, V. Sa-ing, K. Nakgoi, N. Prasertsincharoen, P. Arreesrisom, "A Novel Iteration Method for Automatic Avian Red Blood Cell Counting," *2019 12th Biomedical Engineering International Conference (BMEiCON)*, Ubon Ratchathani, Thailand, 2019, pp.1-5.