

A.I. in Biomedicine @ CMU



We Invent Smarter A.I.

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**Computational Intelligence Research Lab
&
Director, Biomedical Engineering Institute
Chiang Mai University**

Faculty of Nursing, CMU, December 2019

Outlines

- ▶ Biomedical Engineering -> BMEI, CMU
- ▶ Computational Intelligence / Artificial Intelligence
- ▶ In-house Work (Biomedical Applications) @CMU

What is Biomedical Engineering?

- ▶ “Biomedical engineering integrates physical, chemical, mathematical and computational sciences and **engineering principles** to study **biology, medicine, behavior and health**. It advances fundamental concepts, creates knowledge from the molecular to the organ systems levels and develops innovative biologics, materials, processes, implants, devices and informatics approaches for the prevention, diagnosis and treatment of disease; for patient rehabilitation; and for improving health.”

National Institute of Health (NIH), U.S.A.

What is a Biomedical Engineer?

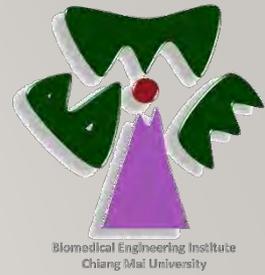
- ▶ "A Biomedical Engineer uses **traditional engineering expertise** to **analyze and solve problems in biology and medicine**, providing an overall enhancement of health care. The biomedical engineer works with other health care professionals including physicians, nurses, therapists and technicians. Biomedical engineers may be called upon in a wide range of capacities: to **design instruments, devices, and software**, to bring together knowledge from many technical sources to develop new procedures, or to conduct research needed to solve clinical problems."



Engineering For Life



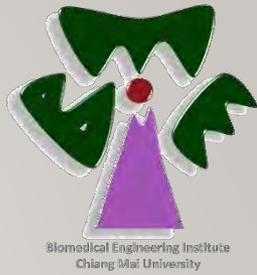
Some Well-established BME Fields



- ▶ Bioinstrumentation
- ▶ Biomaterials
- ▶ Biomechanics
- ▶ Cellular, tissue and genetic engineering
- ▶ Clinical engineering
- ▶ Medical imaging
- ▶ Bioinformatics
- ▶ Biophotonics
- ▶ Orthopaedic bioengineering
- ▶ Rehabilitation engineering
- ▶ Systems physiology

▶ Etc.

Biomedical Engineering Institute Chiang Mai University (since 2006)



Biomedical Engineering Institute
Chiang Mai University

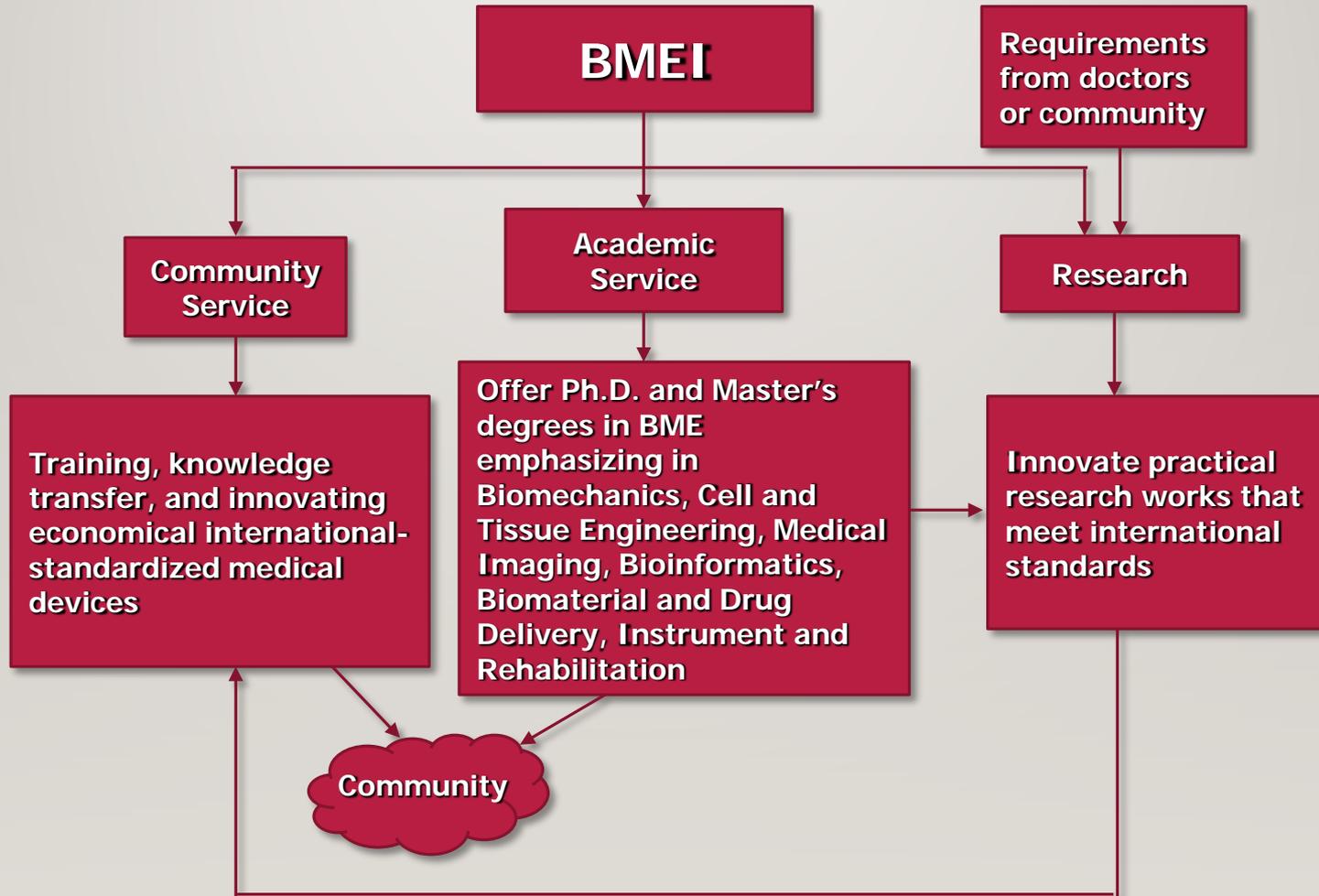
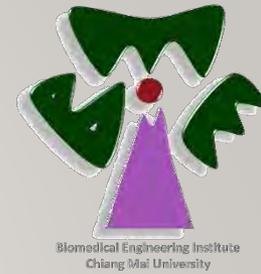


Biomedical Engineering Institute Chiang Mai University

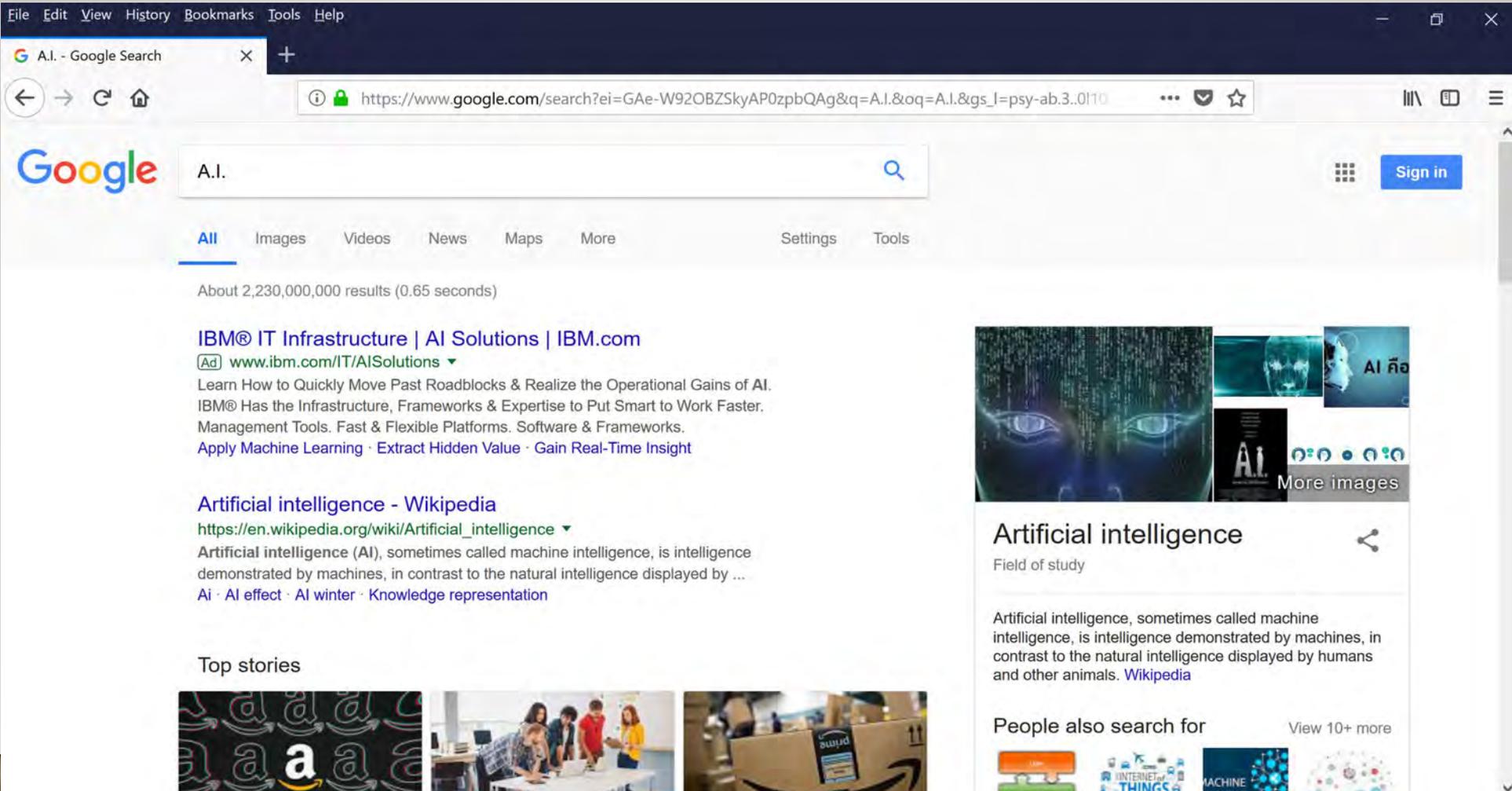
Collaboration partners:

- Faculty of Engineering
- Faculty of Medicine
- Faculty of Science
- Faculty of Associated Medical Sciences
- Faculty of Pharmacy
- Faculty of Public Health
- Faculty of Dentistry
- Faculty of Agriculture
- Faculty of Agro-Industries
- Faculty of Veterinary Medicine
- Faculty of Nursing
- Laboratory Animal Center

Biomedical Engineering Institute Chiang Mai University



A.I. Is it worth considering?



The screenshot shows a Google search for "A.I." on a desktop browser. The search results page includes a navigation bar with "All", "Images", "Videos", "News", "Maps", and "More". The search results show approximately 2,230,000,000 results in 0.65 seconds. The top result is an advertisement for IBM's IT Infrastructure and AI Solutions, with a link to www.ibm.com/IT/AISolutions. Below the ad is a Wikipedia entry for "Artificial intelligence", which defines it as intelligence demonstrated by machines, in contrast to natural intelligence displayed by humans and other animals. The "Top stories" section features three images: the Amazon logo, a group of people in a meeting, and an Amazon Prime cardboard box. On the right side, a knowledge panel for "Artificial intelligence" is displayed, including a definition and a "People also search for" section with icons for "Internet of Things" and "Machine Learning".

File Edit View History Bookmarks Tools Help

A.I. - Google Search

https://www.google.com/search?ei=G Ae-W92OBZSkyAP0zpbQAg&q=A.I.&oq=A.I.&gs_l=psy-ab.3..0l10

Google A.I.

All Images Videos News Maps More Settings Tools

About 2,230,000,000 results (0.65 seconds)

IBM® IT Infrastructure | AI Solutions | IBM.com
www.ibm.com/IT/AISolutions

Learn How to Quickly Move Past Roadblocks & Realize the Operational Gains of AI. IBM® Has the Infrastructure, Frameworks & Expertise to Put Smart to Work Faster. Management Tools. Fast & Flexible Platforms. Software & Frameworks.
[Apply Machine Learning](#) · [Extract Hidden Value](#) · [Gain Real-Time Insight](#)

Artificial intelligence - Wikipedia
https://en.wikipedia.org/wiki/Artificial_intelligence

Artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by ...
[Ai](#) · [AI effect](#) · [AI winter](#) · [Knowledge representation](#)

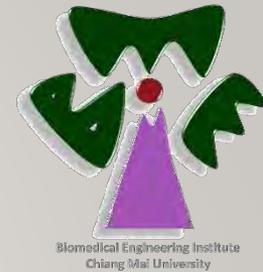
Top stories

Artificial intelligence

Field of study

Artificial intelligence, sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to the natural intelligence displayed by humans and other animals. [Wikipedia](#)

People also search for [View 10+ more](#)



Is it worth considering?

File Edit View History Bookmarks Tools Help

A.I. in biomedicine - Google Se X +

← → ↻ 🏠 🔒 https://www.google.com/search?ei=nQa-W-afJ9i6rQHoz6vADg&q=A.I.+in+biomedicine&oq=A.I.+in+bi...

Google A.I. in biomedicine 🔍

All Images News Videos Maps More Settings Tools

About 1,890,000 results (0.32 seconds)

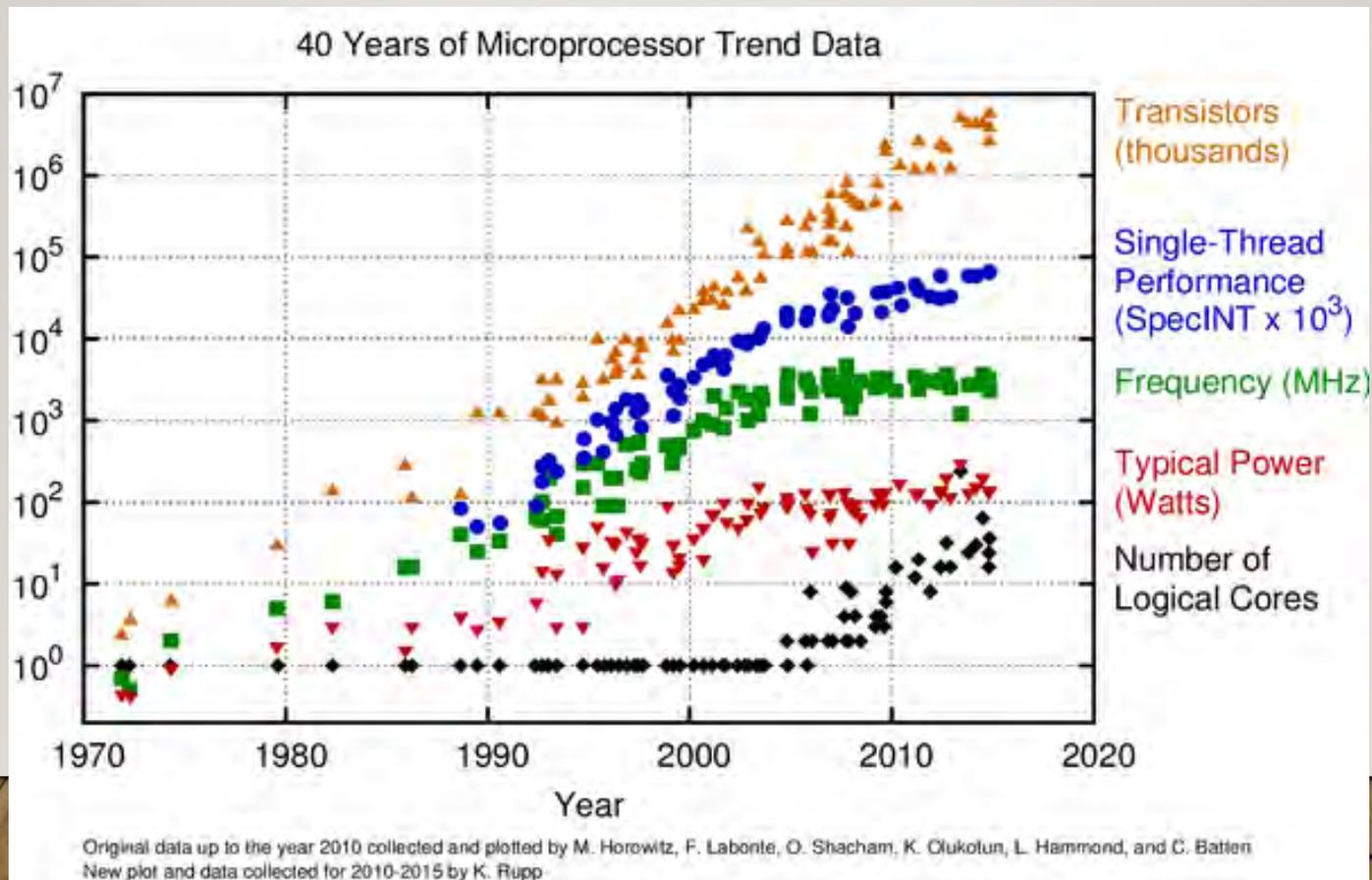
AI in Pharma and Biomedicine - Analysis of the Top 5 Global Drug ...
<https://www.techemergence.com/ai-in-pharma-and-biomedicine/> ▼
Jul 19, 2018 - Kumba covers artificial intelligence applications at Emerj, with a focus on healthcare and health-tech. She has performed research through the National Institutes of Health (NIH), is an honors graduate of Rensselaer Polytechnic Institute, and holds a Master's degree in Biotechnology from Johns Hopkins University.

Artificial Intelligence Applications in Biomedicine - Hindawi
<https://www.hindawi.com/journals/aai/2013/219137/> ▼
by P Vlamos - 2013
Nov 22, 2012 - **Artificial Intelligence Applications in Biomedicine.** "Every aspect of learning or any other feature of intelligence can be so precisely described that a machine can be made to simulate it."—The Dartmouth Summer Research Project on **Artificial Intelligence.**

Artificial Intelligence in Medicine - Journal - Elsevier
<https://www.journals.elsevier.com/artificial-intelligence-in-medicine> ▼
Natural language processing in medicine; Data analytics and mining for biomedical decision support; ... AI in medical and healthcare education; Methodological, philosophical, ethical, and social issues of AI in healthcare, medically-oriented human

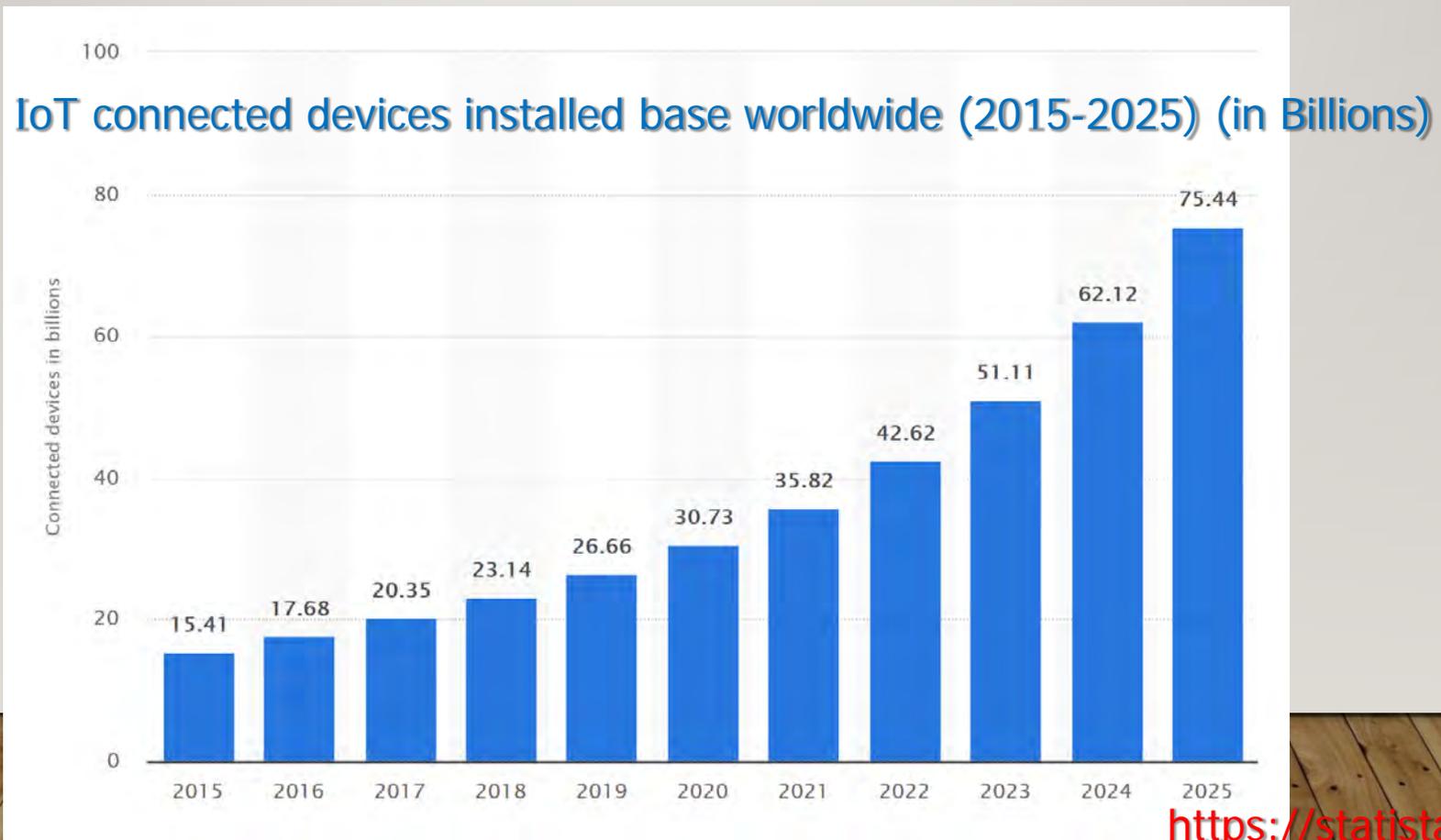
Digital Era

- ▶ Super fast development of digital devices

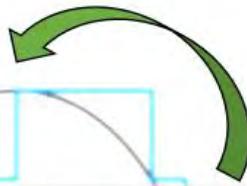


Digital Era

- ▶ Have been there for quite some time

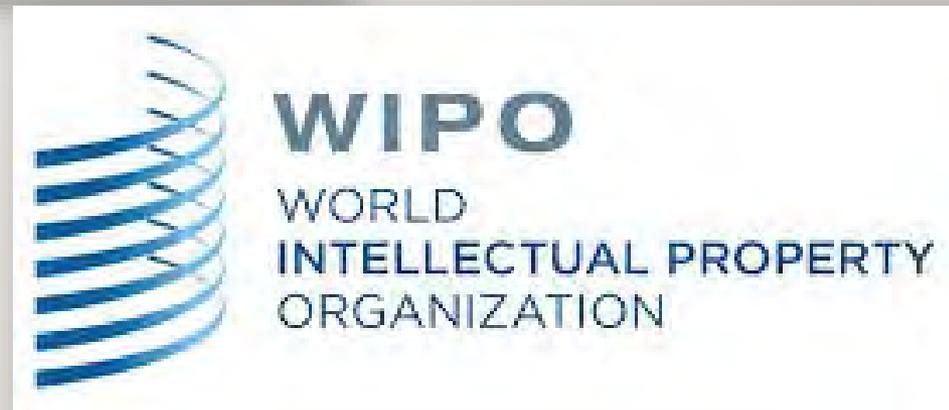
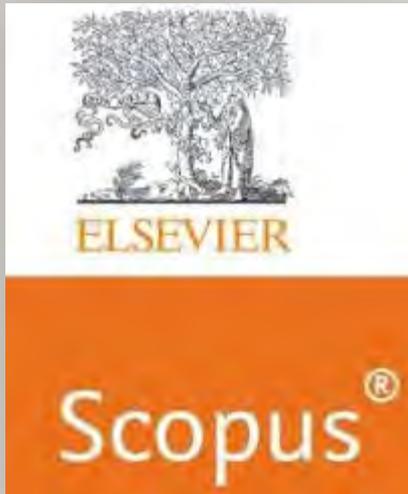
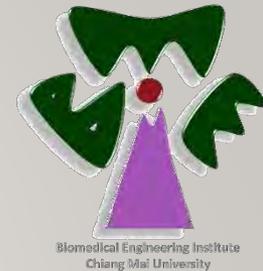


Digital Era



Analog
vs.
Digital





12.12

BIRTHDAY SALE

ส่งฟรี 0 บาท 50% OFF

12.12

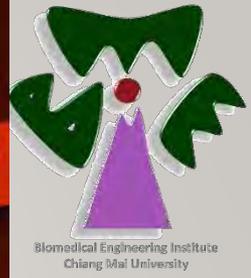
BIG SALE

12/12 SALES

there are only few days left before the second largest traditional sales on taobao

Make sure to prepare a list of the desired goods in advance to have time to buy two items for the price of one, or even cheaper!

LAZADA APP



JD.CO.TH

12.12 THE JOY OF GIFTING

ของขวัญสุดพิเศษ

WHAT'S NEW

12.12 Shopping Guide

ซื้อไปไหนมา ซื้ออะไร
สุดคุ้มสุดช้อป

12.12

LAZADA

双12

12.12

双12购物 全城钜惠

满200送60

全场不止五折 错过等一年

20% 30%

12.12 MEGA SALE

ลดสุด ไม่หยุดช้อป

12:12 FLASH SALE

12.12 SHOPPING CARNIVAL

GOOSE

11-12 ธ.ค. D-DAY

12.12 BIG DAY SALE

SPECIAL DAY

12.12 SALE

50% OFF

12.12

TODAY ONLY!!

ให้พิน วันนี้วันเดียว โห้ฮ้อปังใจจ้า

ลดเพิ่ม 12%

เมื่อซื้อครบ 1,000 บาทขึ้นไป

application



เครื่องวัดความดันแบบพกพา รััดข้อมือ หน้าจอดิจิตอล Electronic Blood Pressure Monitor รุ่น ck-102s

★★★★★ ยังไม่มีคะแนน

แบรนด์: loveyou | [เพิ่มเติม อุปกรณ์เพื่อสุขภาพ จาก loveyou in TH](#)

฿329.00
฿599.00 -45%

โปรโมชั่นหรือราคาข้างต้นจะอยู่ถึง 01/05/2018

จำนวน

[เพิ่มสินค้าลงรถเข็น](#) [สั่งซื้อได้อย่างไร?](#)



ตัวเลือกการจัดส่ง

📍 ปทุมวัน/ Pathum Wan in กรุงเทพมหานคร/ Bangkok, 10110 [เปลี่ยน](#)

📦 จัดส่งแบบธรรมดา
ได้รับภายใน พ.ศ. 3 - ๖. 7 5

📄 ส่งฟรี เมื่อมียอดสั่งซื้อขั้นต่ำ 99.00 THB เมื่อซื้อสินค้าที่จัดจำหน่ายโดย Tiger1688

📄 สามารถเก็บเงินปลายทางได้

การคืนสินค้า และ การรับประกัน

🕒 คืนสินค้าได้ภายใน 7 วัน
เหตุผลเปลี่ยนใจสามารถขอได้

🛡️ มีการรับประกันจากผู้ขาย 1 สัปดาห์





Shopee > อาหารเสริมและผลิตภัณฑ์สุขภาพ > อุปกรณ์เพื่อสุขภาพ > อุปกรณ์เสริมเพื่อสุขภาพ > เครื่องช่วยฟัง บอยเลอร์ Beurer HA20 (ให้ถ่านรวม 7 ก้อน)



✓ **ร้านแนะนำ** เครื่องช่วยฟัง บอยเลอร์ Beurer HA20 (ให้ถ่านรวม 7 ก้อน)

4.8 ★★★★★ 298 Ratings 747 ขายแล้ว

฿769 - ฿969

Shopee ถูกที่สุด การันตี

การจัดส่ง **ฟรี** **ฟรีค่าจัดส่ง**
🚚 การจัดส่ง ถึง **เขตพระนคร, จังหวัดกรุงเทพมหานคร**
ค่าจัดส่ง **฿0 - ฿28**

Variation **เครื่องช่วยฟัง** **เครื่อง+ข้อถ่าน3แผง** **เครื่อง+ข้อถ่าน5แผง**

จำนวน **- 1 +** มีสินค้าทั้งหมด 9 ชิ้น

เพิ่มไปยังรถเข็น **ซื้อสินค้า**

INTELLIGENCE



Human

Ability to

Artificial

Senses

perceive

Sensors/Data

input

input

Brain

use reasoning to understand it

Algorithms

processing

processing

Human

take actions

Computer/Robot

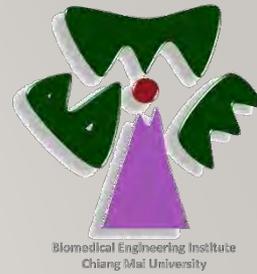
Embodiment

Embodiment

output

output

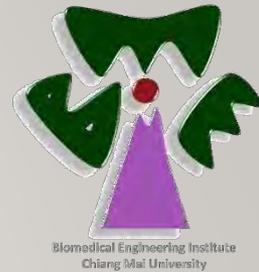
Computational Intelligence Research Lab (CI Lab)



CI Lab @ CMU (since 2001)

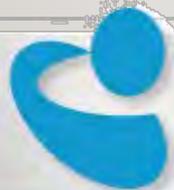


We Invent Smarter A.I.



"The Field of Interest of the Society shall be the theory, design, application, and development of biologically and linguistically motivated computational paradigms emphasizing neural networks, connectionist systems, genetic algorithms, evolutionary programming, fuzzy systems, and hybrid intelligent systems in which these paradigms are contained."

Scope of IEEE CIS



IEEE Computational Intelligence Society

Nature-Inspired Problem Solving

Neural Networks (MLP, SVM, Deep learning, etc.)

Fuzzy Sets and Systems (Fuzzy logic, Fuzzy systems, etc.)

Evolutionary Computation (GA, PSO, Cuckoo search, etc.)

From Past (AI) to Present (CI)

CI vs AI

| Computational Intelligence | Artificial Intelligence |
|--------------------------------------|--------------------------------|
| Soft Computing techniques | Hard computing techniques |
| Follows fuzzy logic | Follows binary logic |
| Nature inspired models | Based on mathematical models |
| Can work inexact and incomplete data | Not very effective |
| Probabilistic results | Deterministic results |

Research Interests:

- Signal Processing / Image Processing
- Pattern Recognition
- Artificial Intelligence
- Robotics (Hardware & Software, i.e., robots' body and brain)
- Neural Networks (including Deep learning)
- Fuzzy Systems

Research Interests:

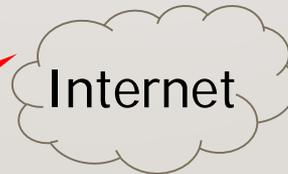
- Evolutionary Computation (Genetic algorithm, Swarm intelligence, Cuckoo search optimization, etc.)
- Data Mining / Knowledge Discovery
- Data Analysis of Any Sizes (including BIG Data)
- Internet of Things (IoT)
- Etc.

Monitoring System

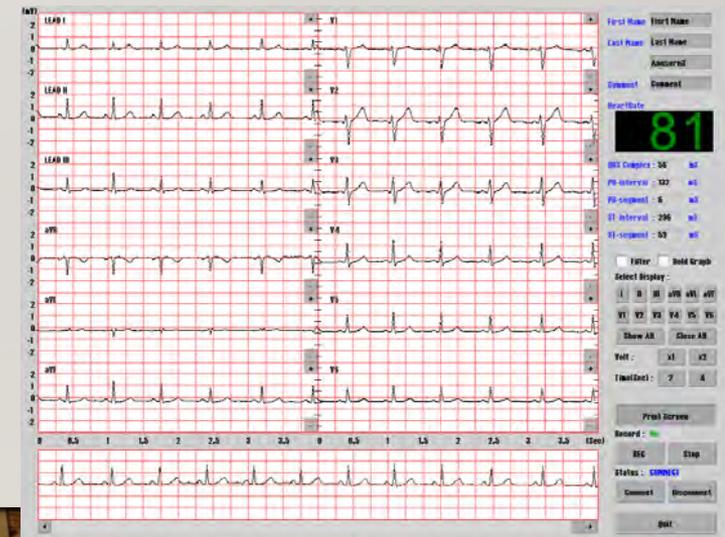
- ▶ Portable ECG via USB / Mobile network / Wi-Fi
- ▶ CMUgency



Mobile network
Wi-Fi

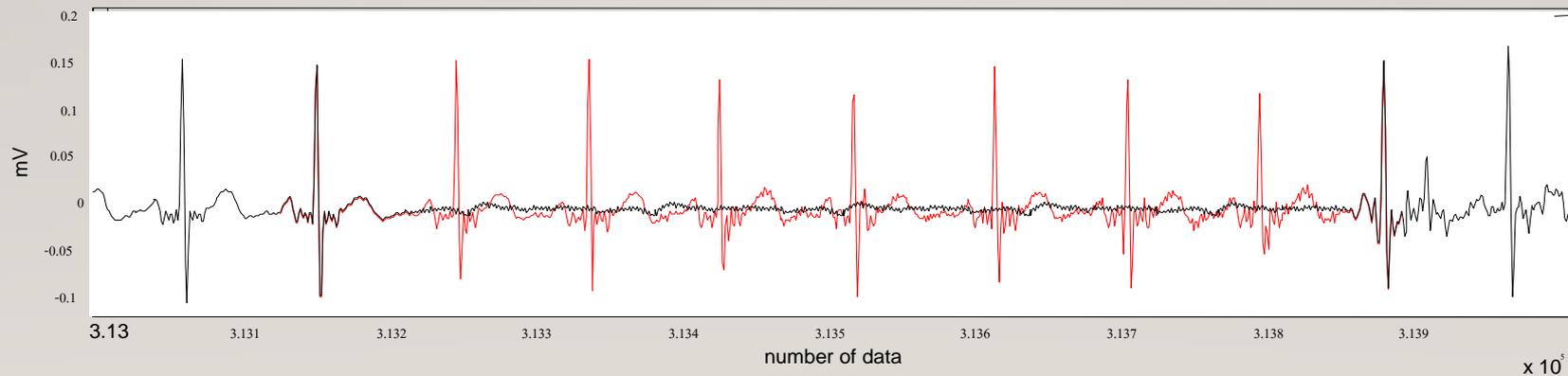
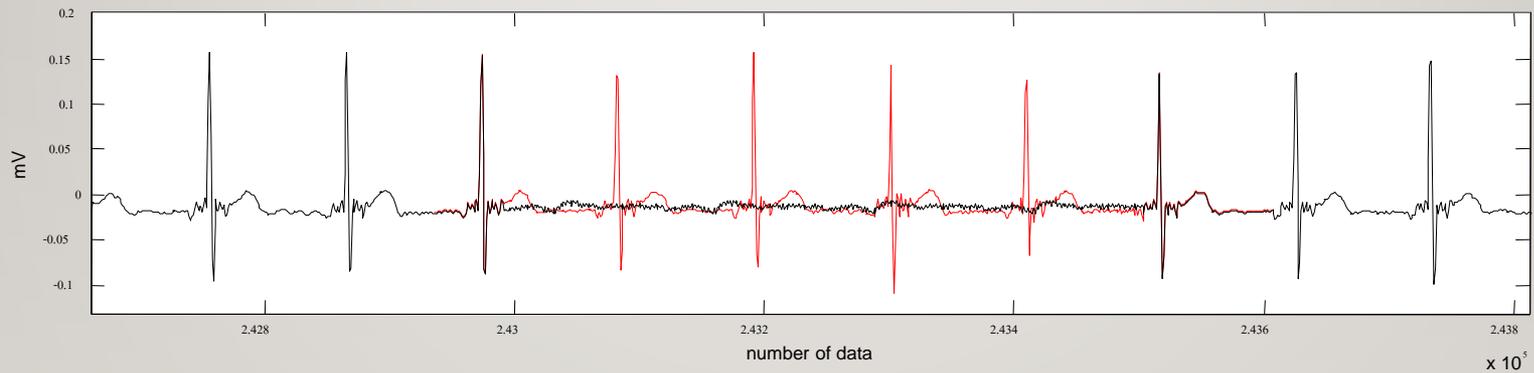


USB



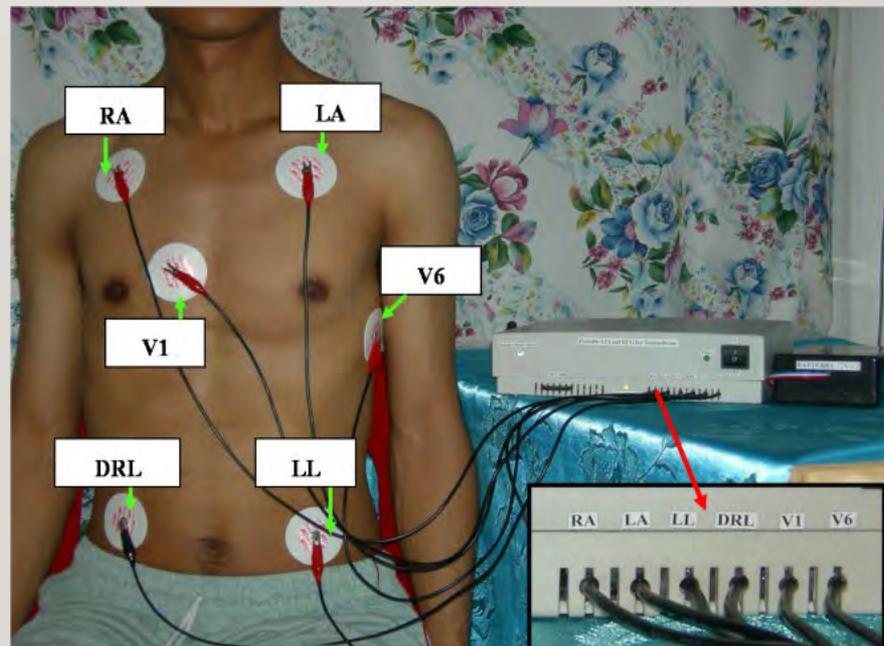
Signal Reconstruction

► ECG Reconstruction Using Linear Prediction



Signal Reconstruction

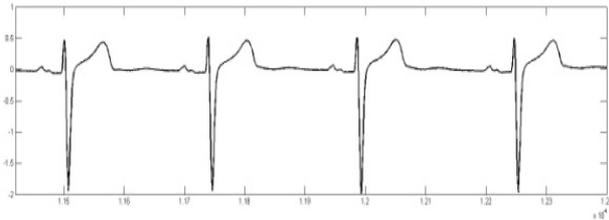
- ▶ 12-Lead ECG using only 6 electrodes
- ▶ Reconstruct V2, V3, V4, V5 using Lead I, Lead II, V1, V6



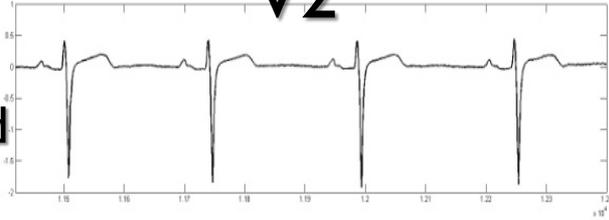
Signal Reconstruction



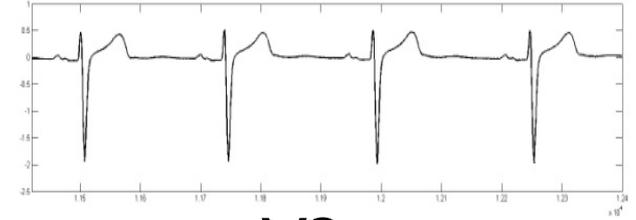
Actual



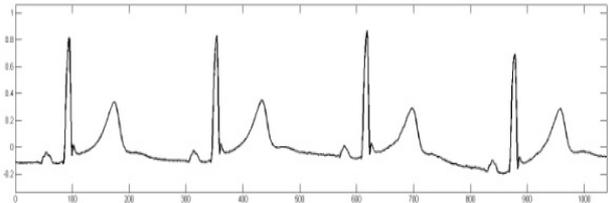
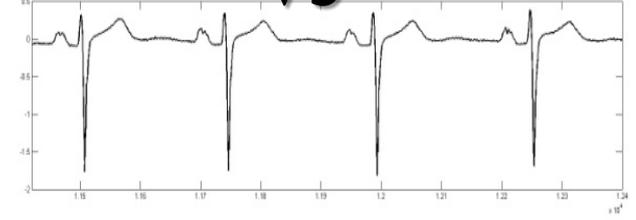
V2



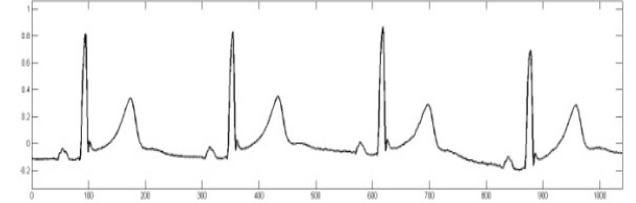
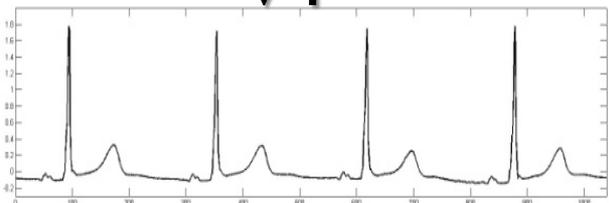
Reconstructed



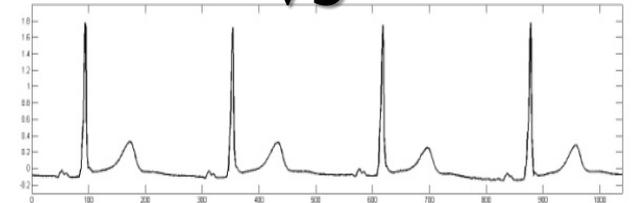
V3



V4

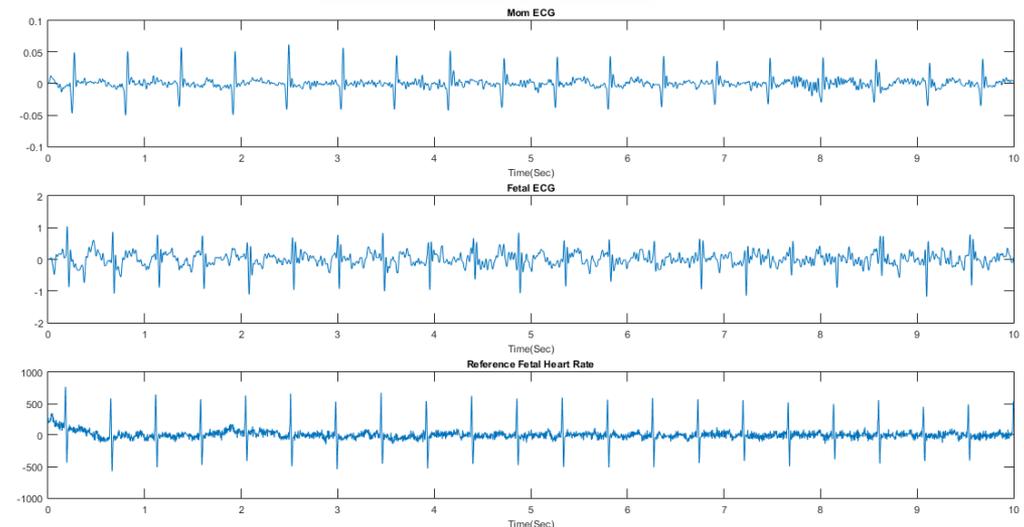
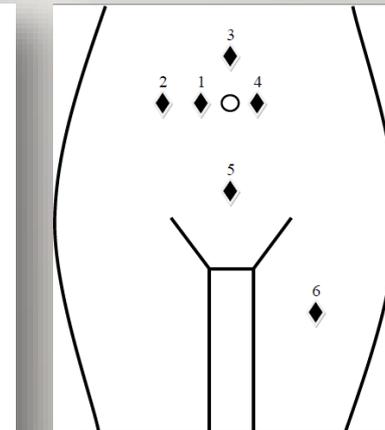
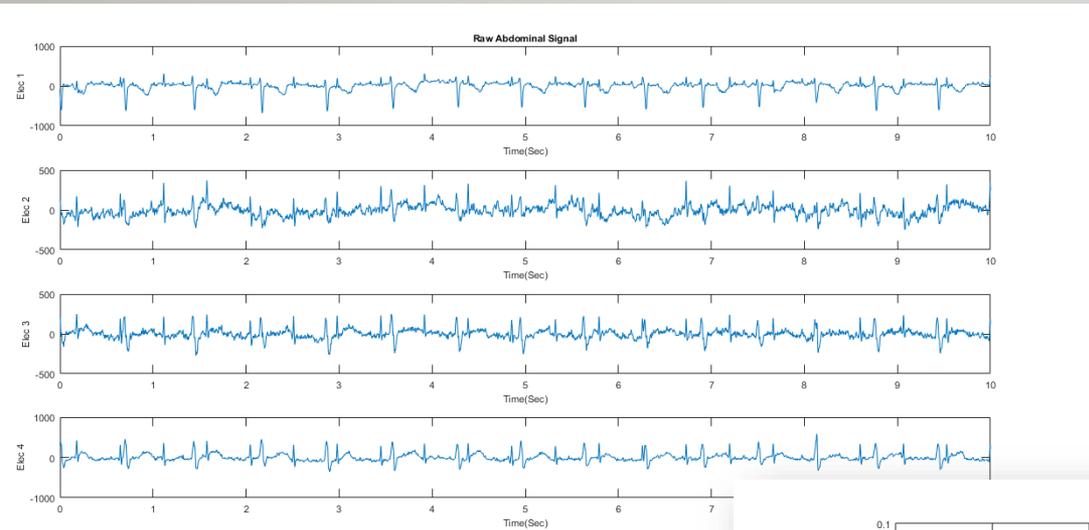


V5

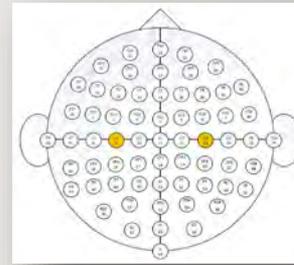


Signal Extraction/Recovery

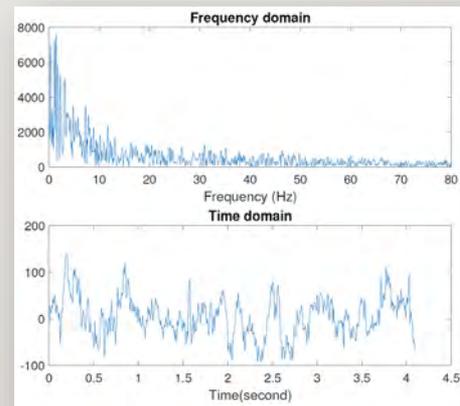
- Automatic Fetal ECG Extraction



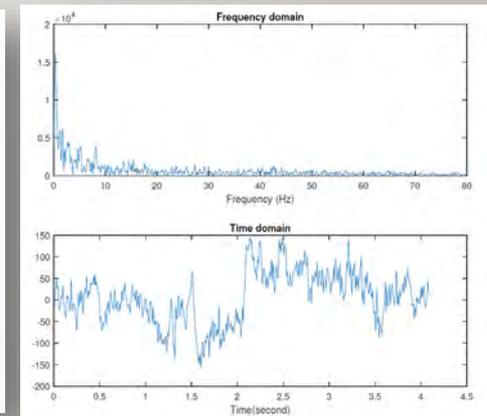
Signal (Binary) Classification



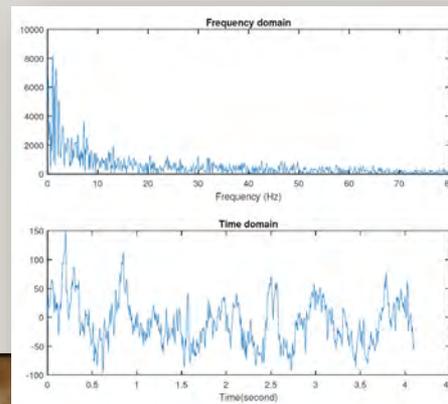
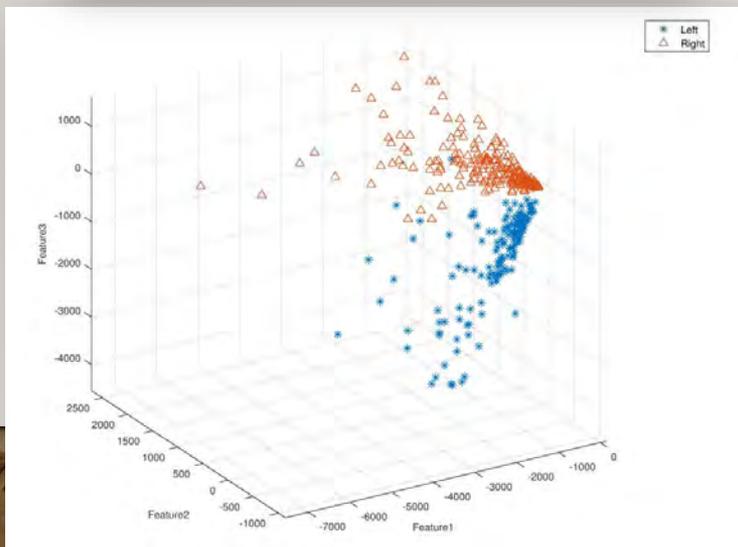
- Imagery Hand Movement Classification Using EEG



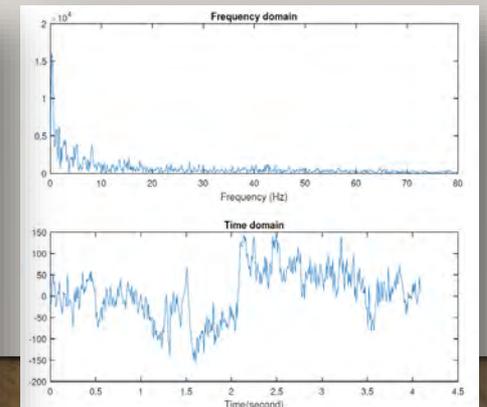
C3, Left fist movement



C3, Right fist movement



C4, Left fist movement



C4, Right fist movement

Monitoring/Warning System



Engineering Institute
University

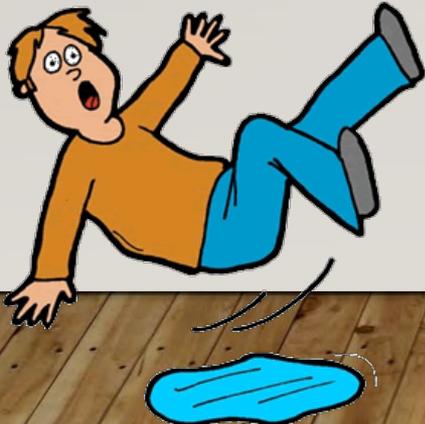
▶ Head Positioning System for Retinal Detachment Patients



Monitoring/Warning System

▶ Fall Detection Systems

▶ Accelerometer-based



สภานวัตกรรมชีวการแพทย์
มหาวิทยาลัยเชียงใหม่



Beaming
Motivating
Encouraging
Innovative

FALL DETECTOR
BMEI

สูงวัย ปลอดภัย
ป้องกันการล้ม
จุดเริ่มต้นของอุบัติเหตุ

เครื่อง
ตรวจจับ
การล้ม

FALL DETECTOR
BMEI

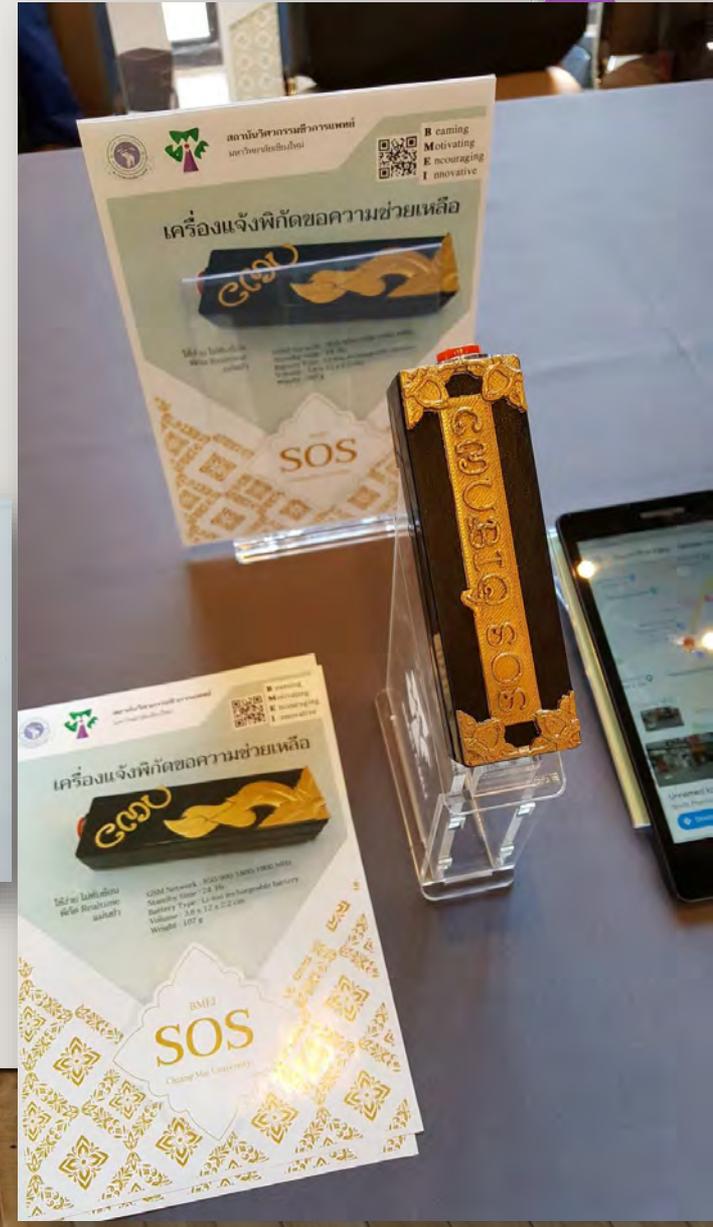
BMEI
FALL
Detector
Chiang Mai University

Monitoring/Warning System



Warning System

- CMU UbiqSOS



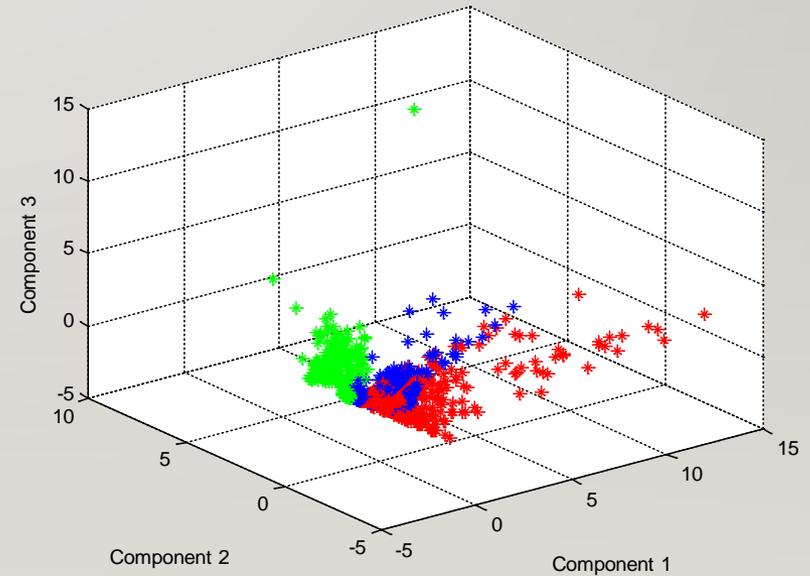
Monitoring/Warning System

► Fall Detection Systems: Image-based



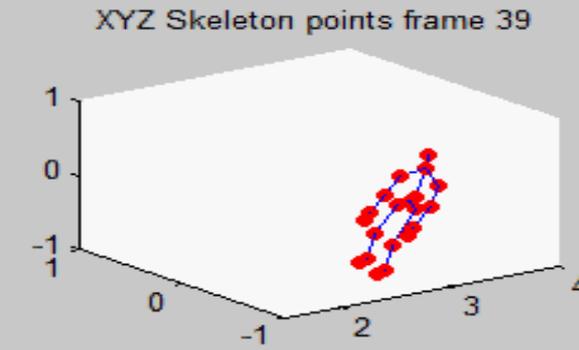
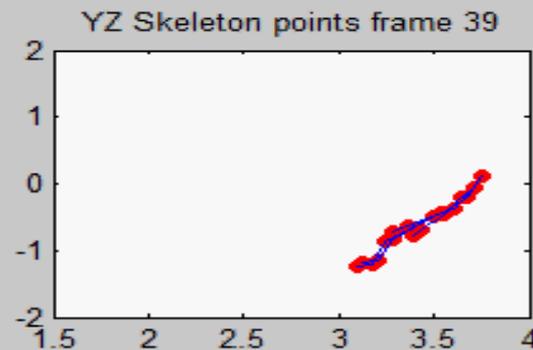
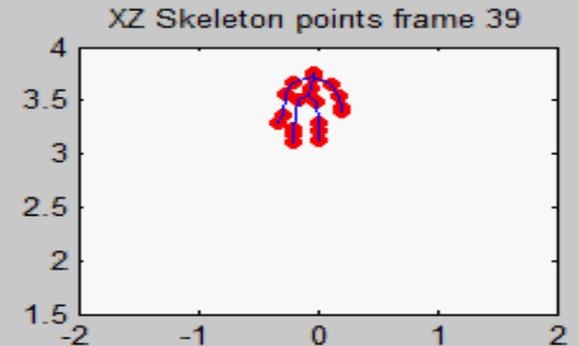
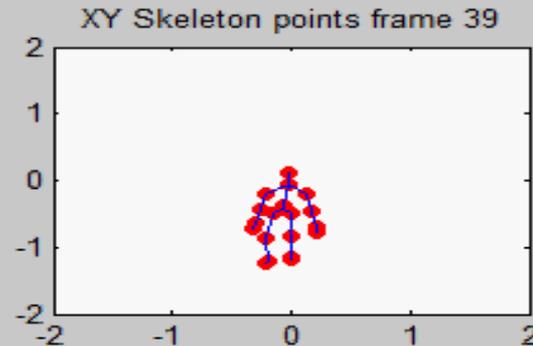
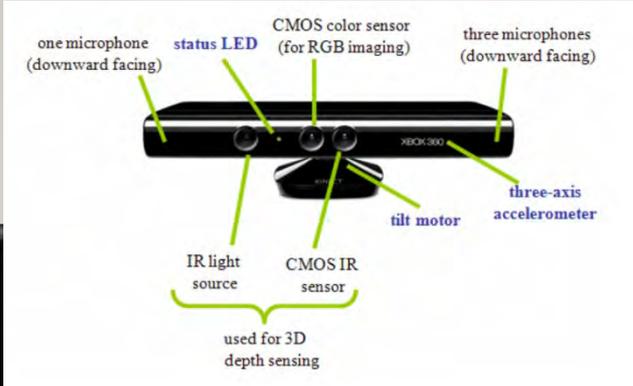
* Standing * Sitting * Lying

3D data distribution of Hu Moments using three Principal Components of three actions



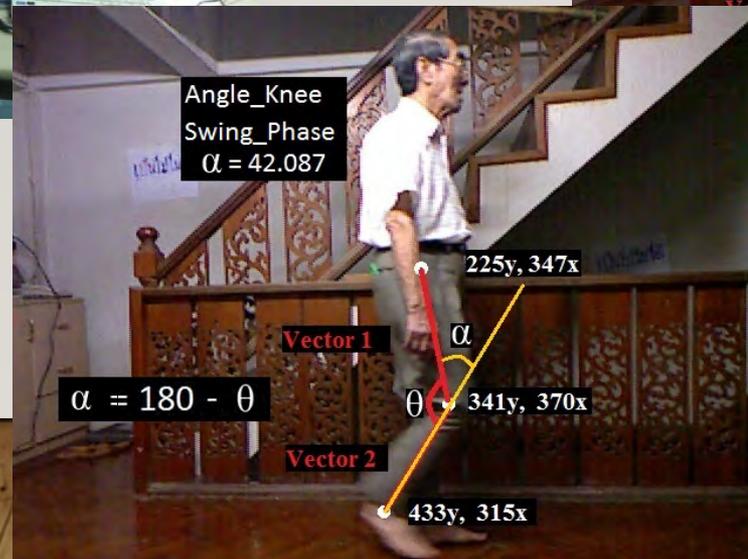
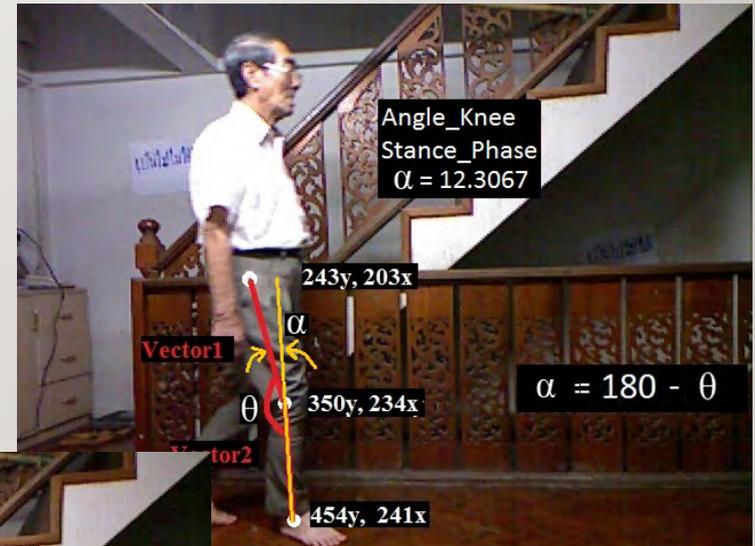
Monitoring/Warning System

► Fall Detection Systems: Image-based (Microsoft Kinect)

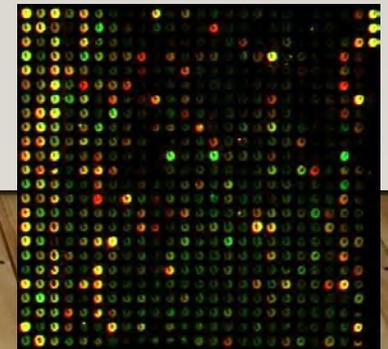


Assessment System

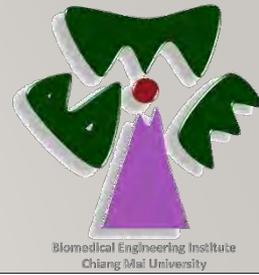
► Automatic 3D Gait Evaluation System in Geriatric Rehabilitation



- Neuro-Fuzzy Methods (**Feature Selection** and **Inference Classification**): Colon Cancer, Diffuse Large B-Cell Lymphoma (DLBCL), Ovarian Cancer, Glioma Tumor, Lung Cancer
 - Diffuse Large B-cell Lymphomas (DLBCL) Dataset :
 - 100.00 %, 97.40%, 90.91%, & 92.21% when the numbers of selected linguistic features are set to 14, 10, 5, & 3, respectively. Classification rate (10-fold cross validation)
 - MDM4, STX16, NR1D2, DCLRE1A, PARK7, ATIC, HG4263-HT4533_at, CSRPI, NASP, PGKI, HLA-DPBI_2, HLA-A_2, ITK_2, and PLGLB2



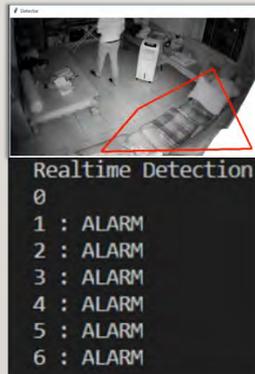
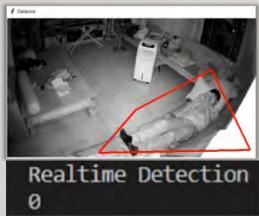
Monitoring/Warning System



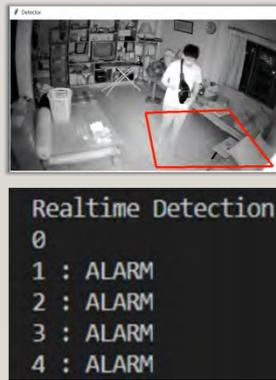
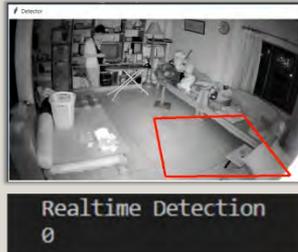
► CMU !-Warn :

Intelligent Warning System for Elderly

โหมตแจ้งเตือนเมื่อผู้สูงอายุออกจากพื้นที่เฝ้าระวัง



โหมตแจ้งเตือนเมื่อผู้สูงอายุเข้ามาในพื้นที่อันตราย



Security (Login System)



ระบบล็อกอินเพื่อป้องกันไม่ให้ผู้อื่นเข้าไปดูรูปภาพที่ถูกถ่ายจากกล้องของท่านได้




สถาบันวิศวกรรมชีวการแพทย์
มหาวิทยาลัยเชียงใหม่

Learning,
Motivating,
Encouraging,
Innovative

สอดส่องความปลอดภัย
อุ่นใจกับ Smart Home

ตรวจจับ Real Time ทุกการเคลื่อนไหว
แจ้งเตือนผ่านสมาร์ตโฟน
ตลอด 24 ชั่วโมง

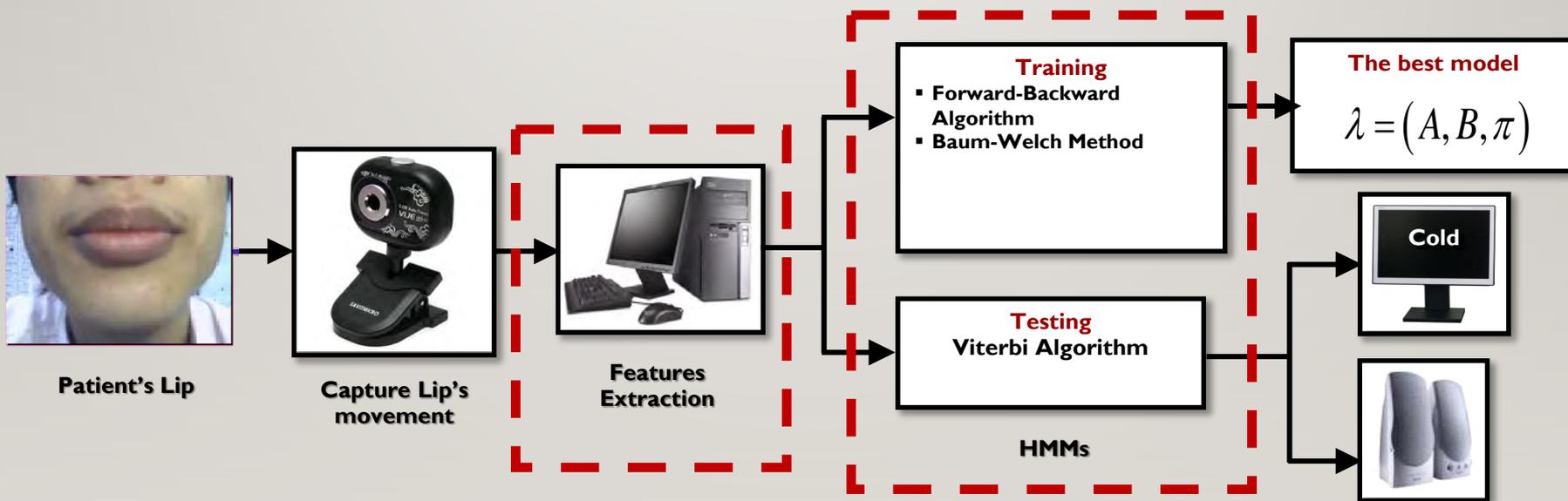
ระบบตรวจจับ
การเคลื่อนไหว




BMEI
SMART HOME
Chiang Mai University

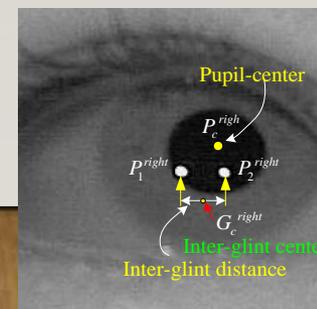
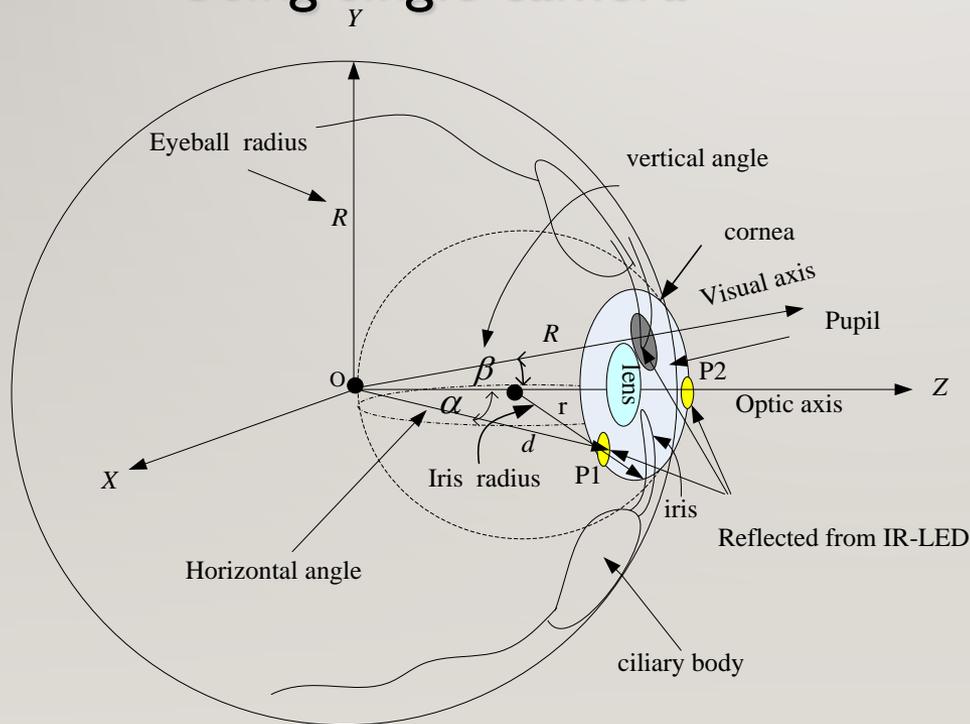
Human-Machine Interface

- Automatic Lip Reading Using Hidden Markov Models

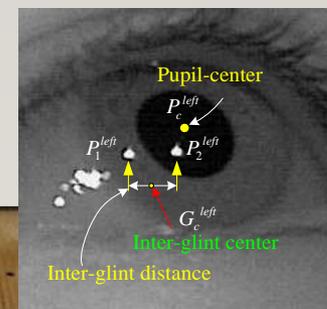


Human-Machine Interface

- Automatic Eye-Gaze Tracking System
 - Using single camera



Right Eye



Left Eye

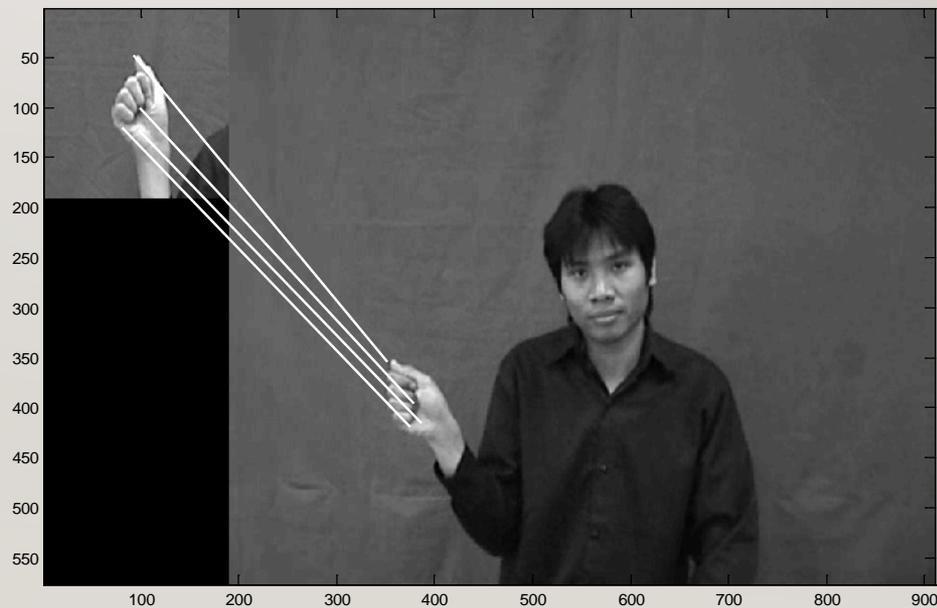
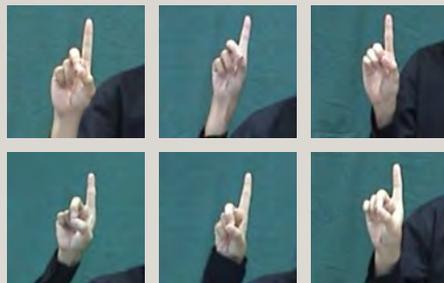
Human-Machine Interface

▶ Hand Sign Translation

ป



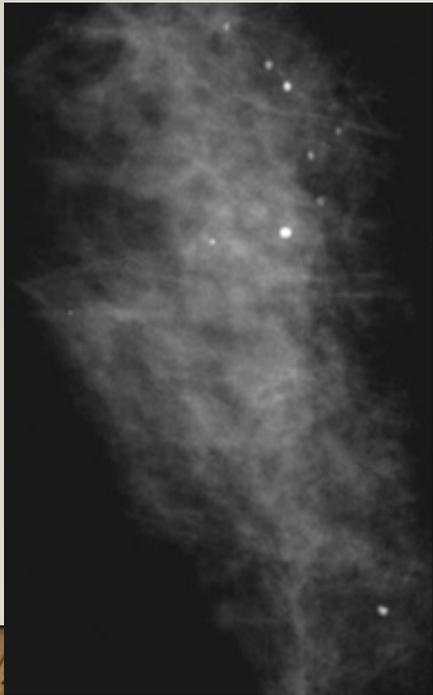
ค



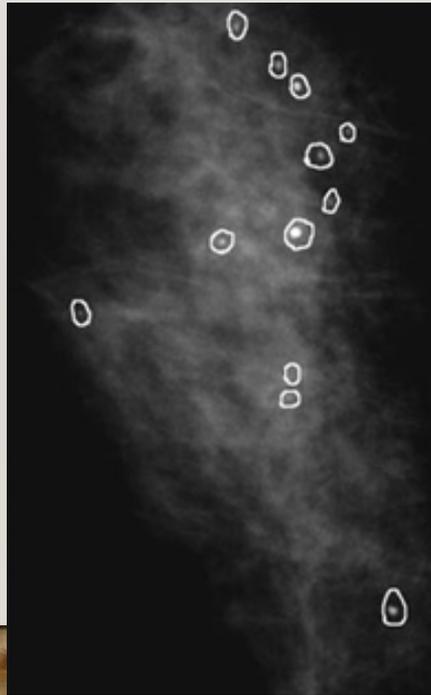
Assistive Tool (Detection)

► Microcalcification Detection in Mammograms Using Interval Type-2 Fuzzy Systems

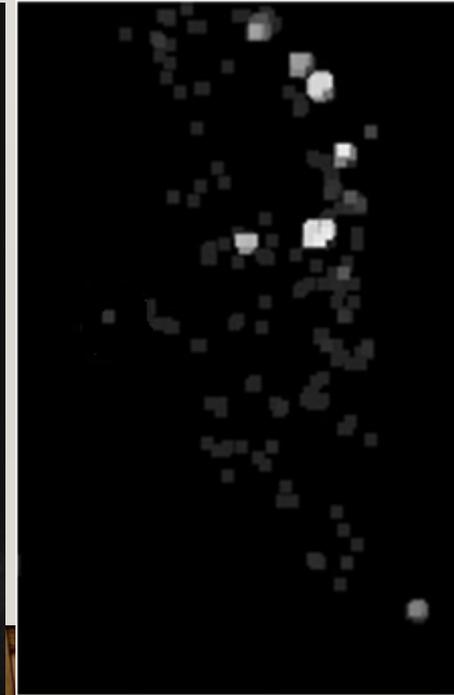
Original
Mammogram



Expert's
Opinion

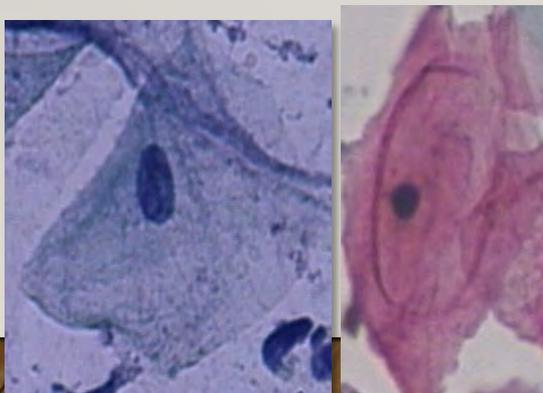
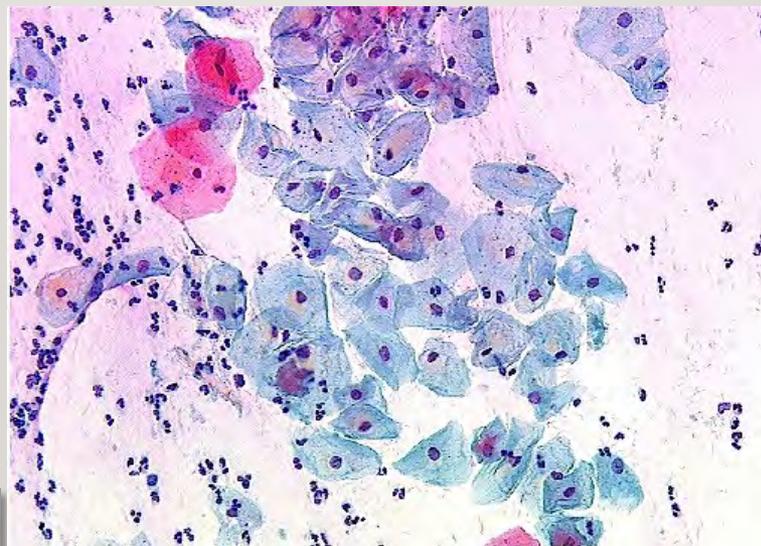


Output

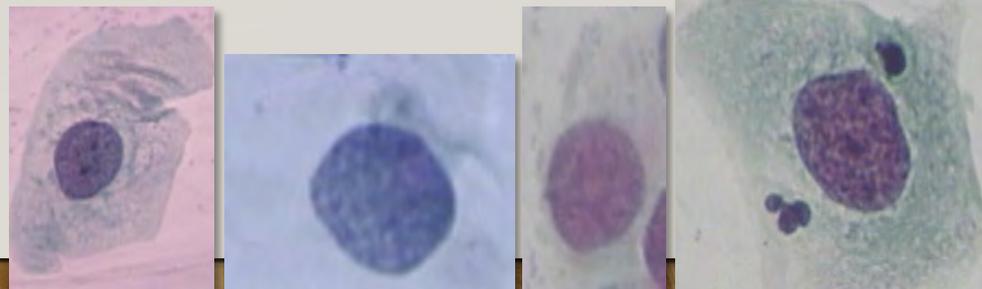


Assistive Tool (Detection)

▶ Cervical Cell Classification in Pap Smears



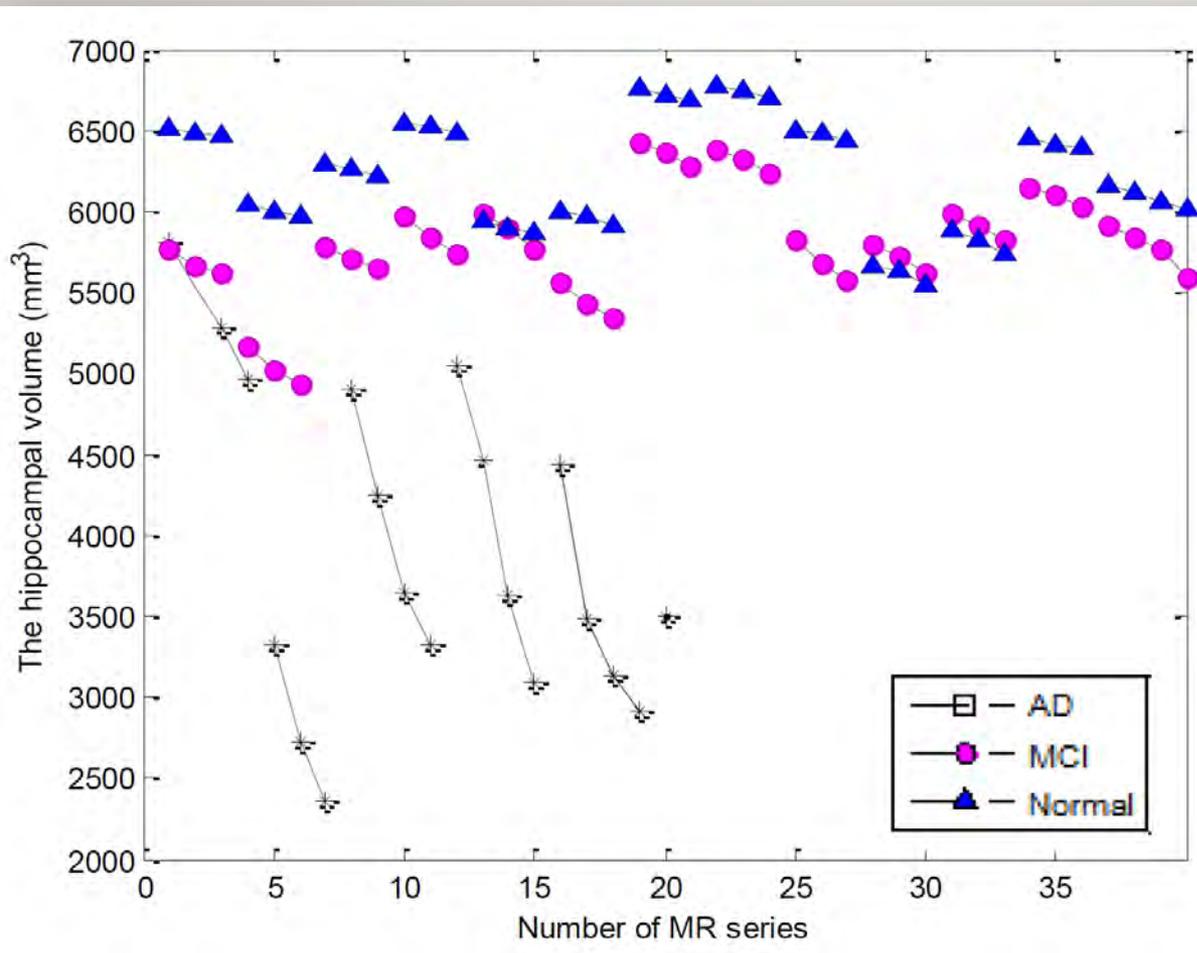
Normal



Abnormal

Assistive Tool (Estimation)

- Fully Automatic Brain Segmentation for Alzheimer's Disease

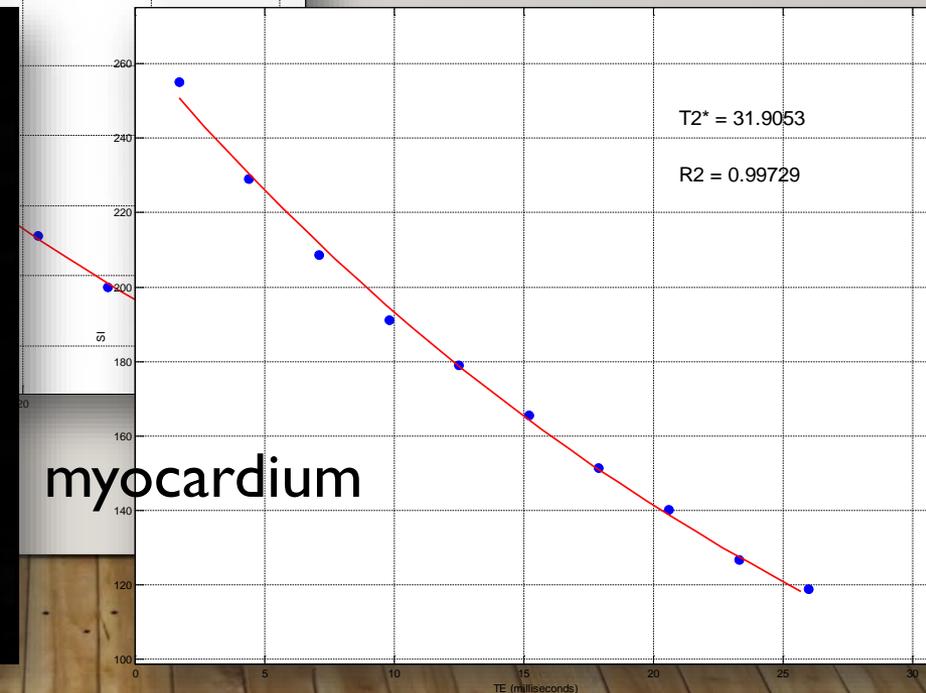
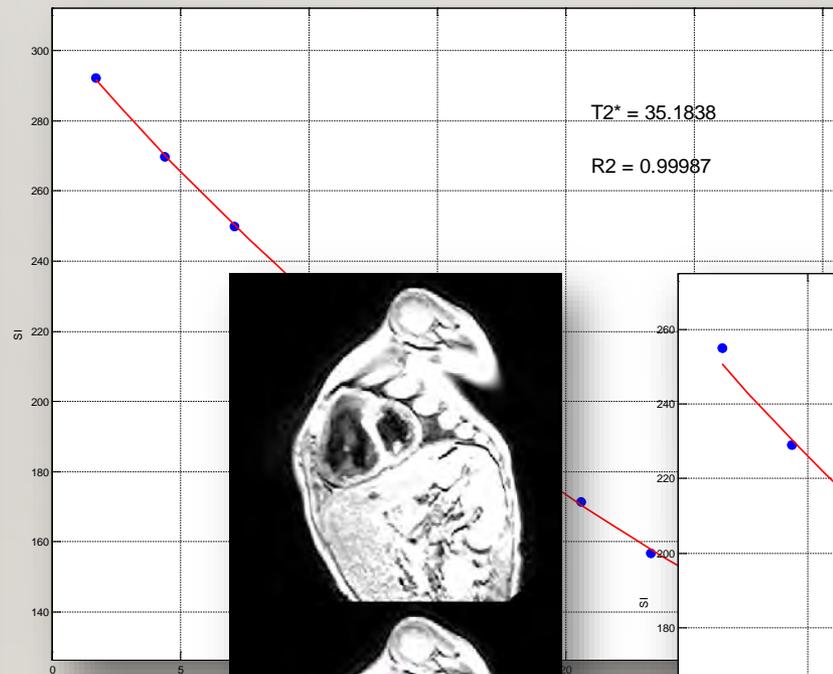
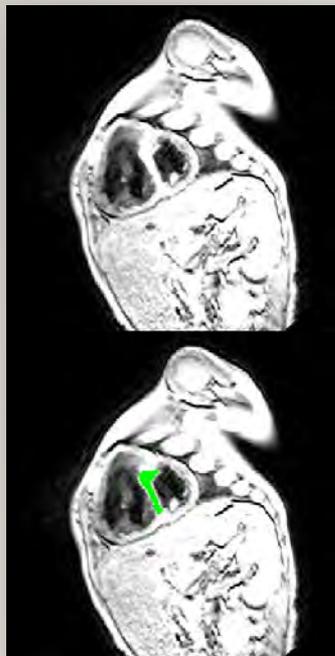


initiative (ADNI)



Assistive Tool (Estimation)

- Fully Automatic T2* Relaxation Time Estimation from MRI



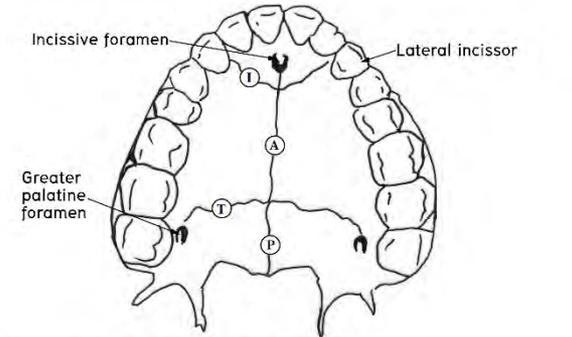
interventricular septum

myocardium



Assistive Tool (Estimation)

► Age Estimation from Maxillary Sutures Closure



I = Incisive suture (Right to left lateral incisor)
A = Anterior maxillary suture (origin : incisive foramen)
T = Transverse maxillary suture (Right to Left Greater palatine foramen)
P = Posterior maxillary suture



30 years old



82 years old

Assistive Tool (Estimation)

- ▶ Fuzzy C-Means-Based Segmentation for Burn Color Images



Original Image



Expert's Opinion

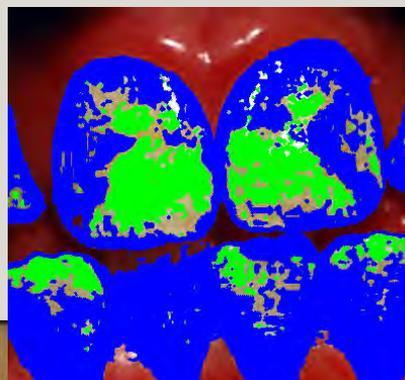
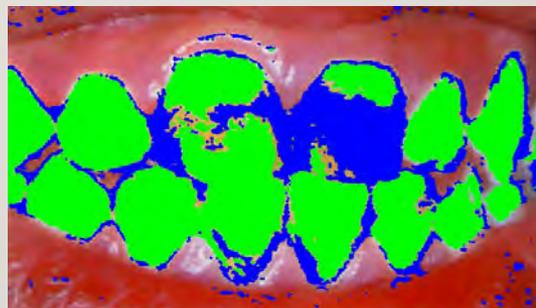


Proposed

Assistive Tool (Detection/Estimation)

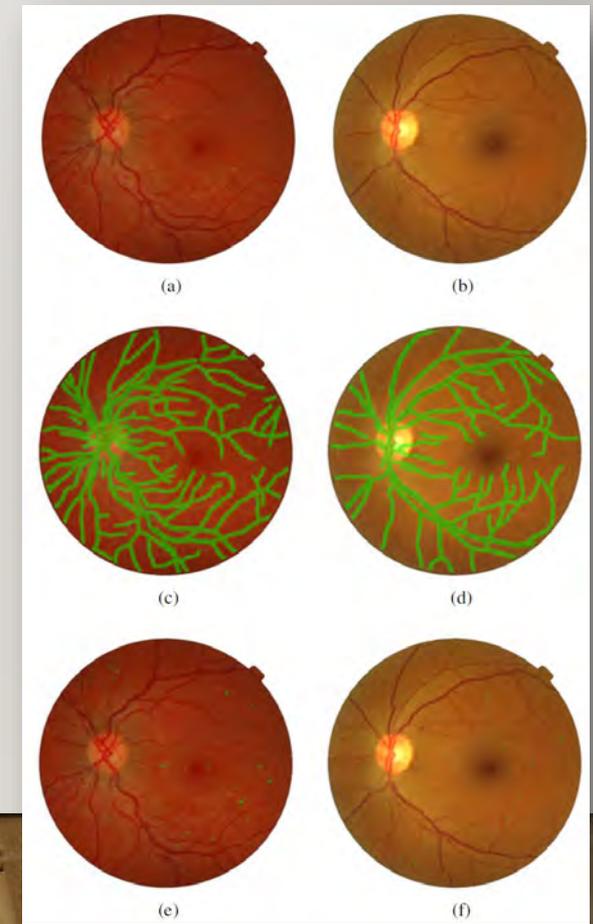
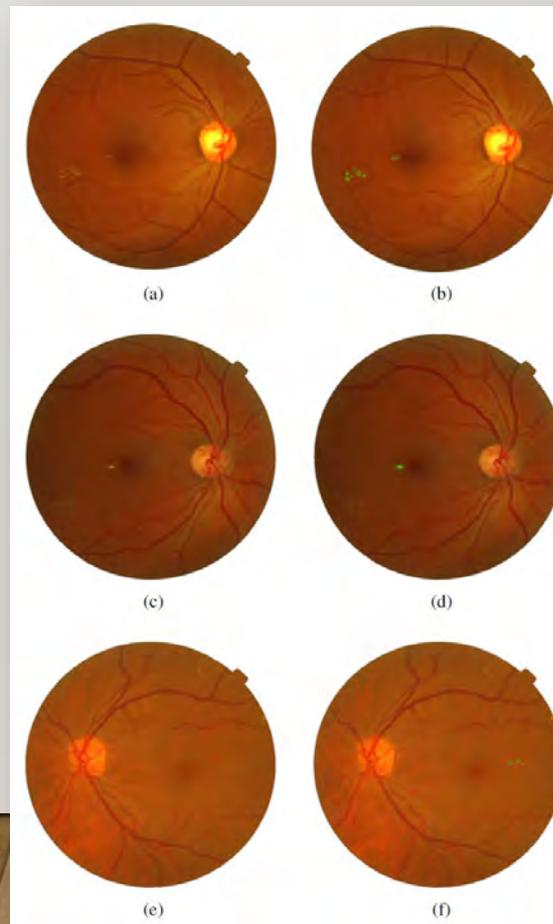
► Dental Fluorosis Assessment (Web-based /Smart phone)

In collaboration with the Intercountry Centre for Oral Health



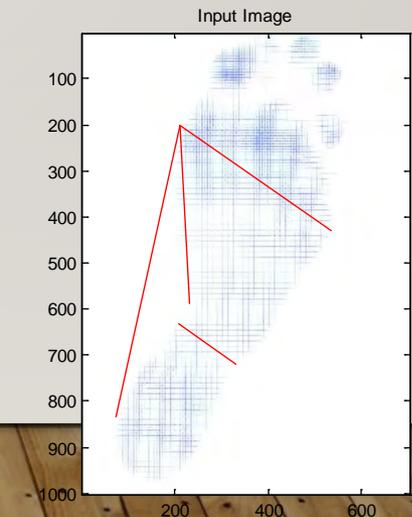
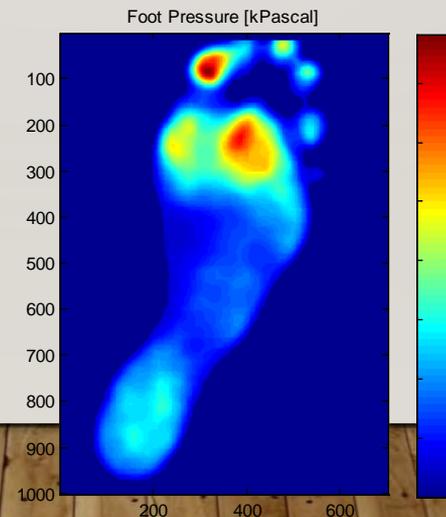
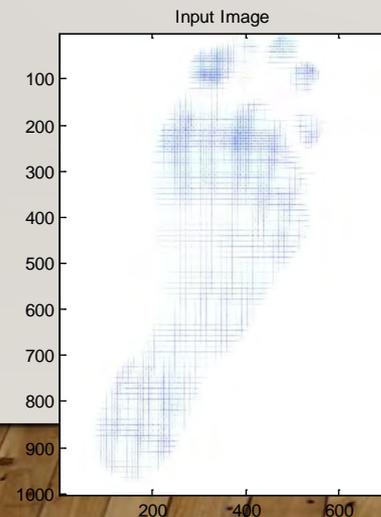
Assistive Tool (Detection)

▶ Exudate / Micro-aneurysm / Hemorrhage Detection in Fundus Image



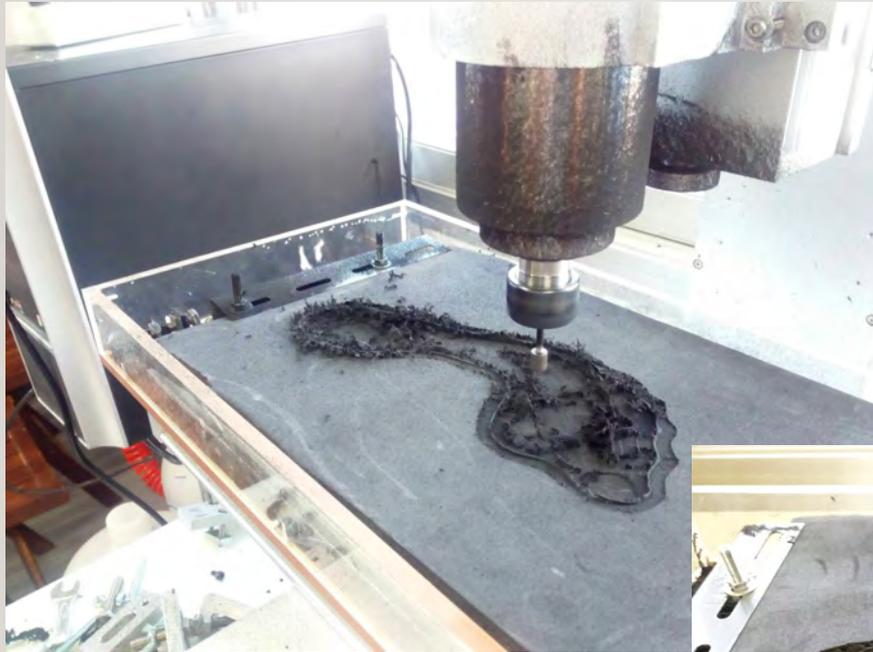
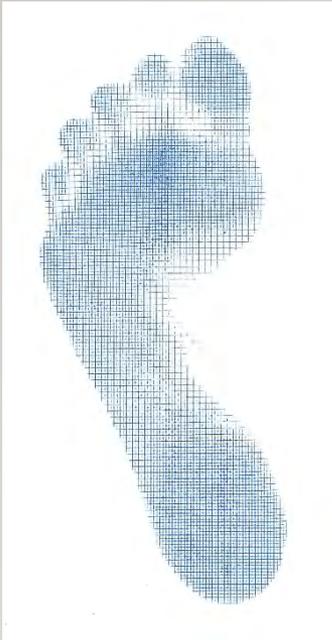
Assistive Tool (Transform)

- ▶ Harris mat \rightarrow Foot pressure map without pressure sensors



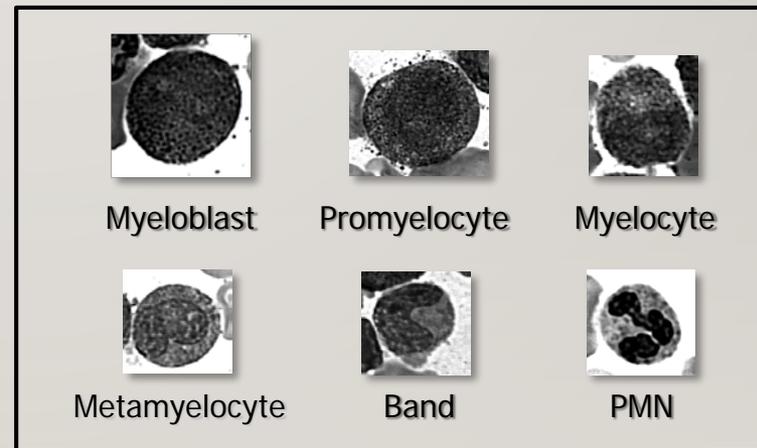
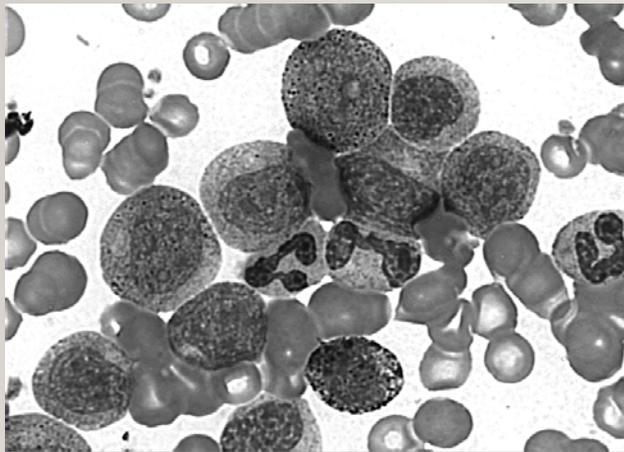
Assistive Tool (Transform)

▶ Harris mat → Foot pressure map → Shoe insoles

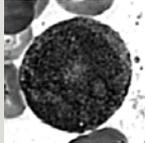
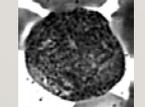
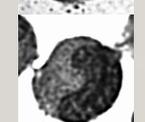


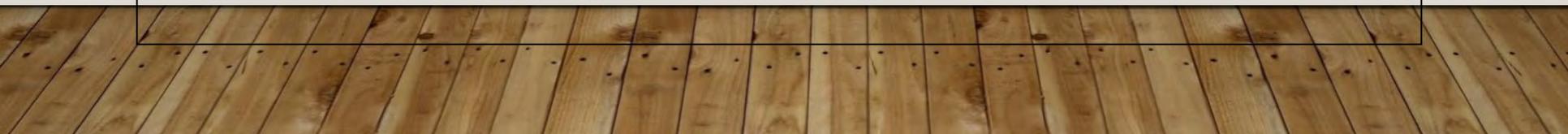
Assistive Tool (Classification)

▶ Differential White Blood Cell Counting in Bone Marrow



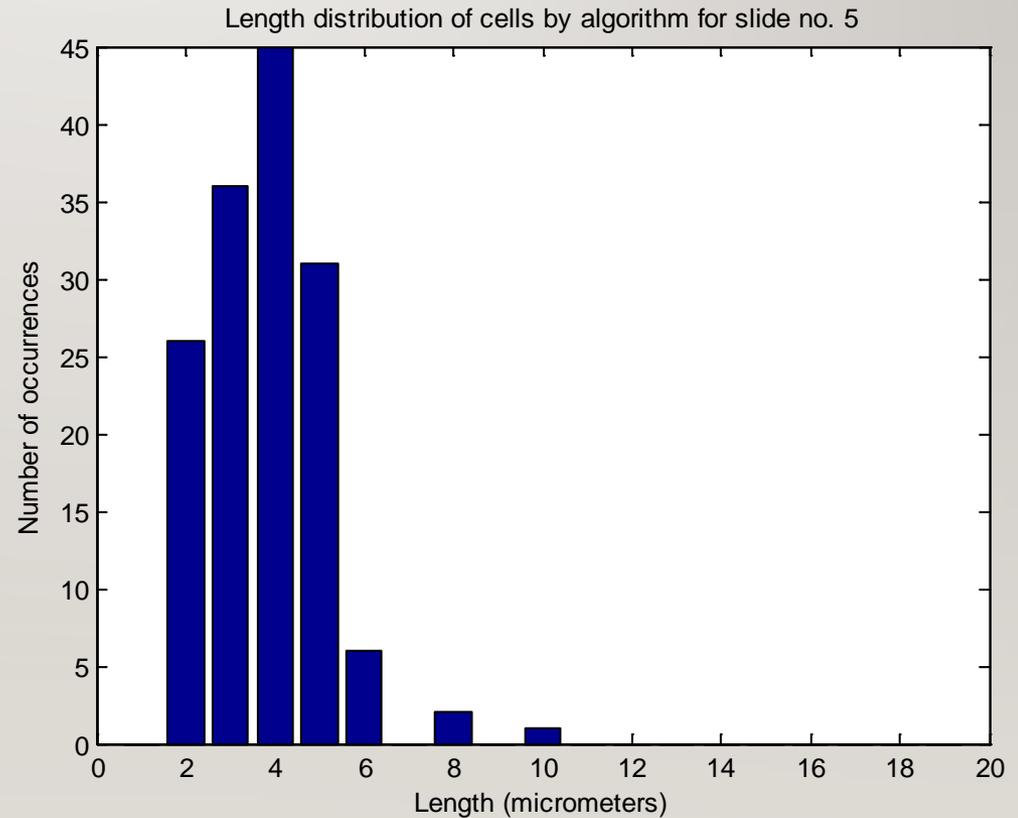
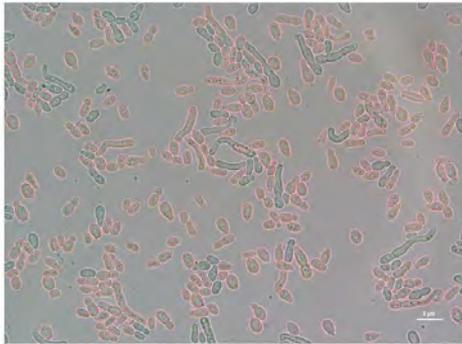
Assistive Tool (Classification)

| | Grayscale image | Expert's manually-segmented image | Algorithm's segmented image |
|---------------|---|---|---|
| Myeloblast |  |  |  |
| Promylocyte |  |  |  |
| Myelocyte |  |  |  |
| Metamyelocyte |  |  |  |
| Band |  |  |  |
| PMN |  |  |  |



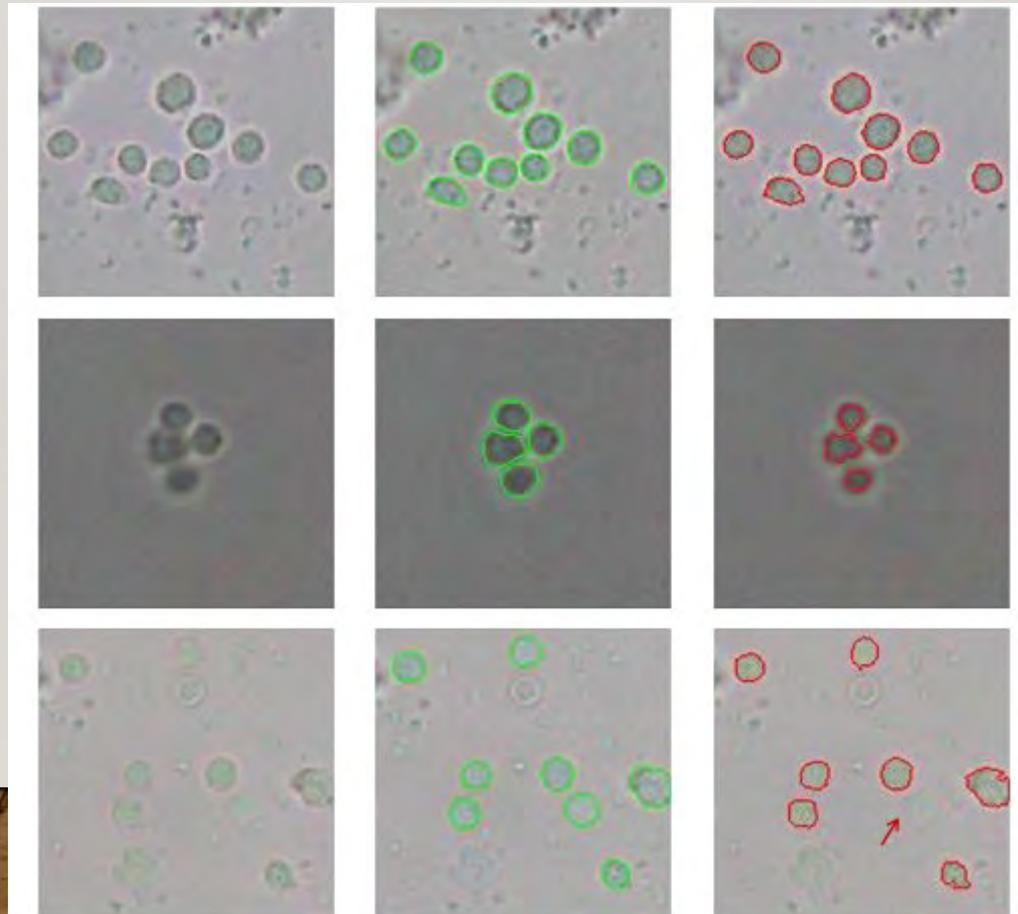
Assistive Tool (Detection/Estimation)

- Quantitative estimation of hyphal growth of *Malassezia furfur*



Assistive Tool (Detection)

- CD4+ Lymphocyte Counting in Low Resolution Fluorescence and Bright Field Images



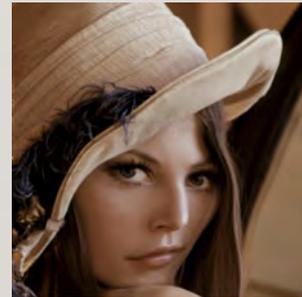
Assistive Tool (Image Registration)

Space Independent Curve-based Deformable Image Registration

Reference Image



Source (Distorted) Image

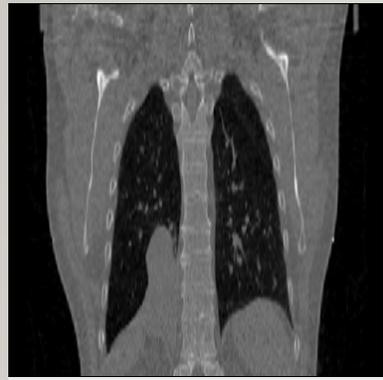


Registered Image



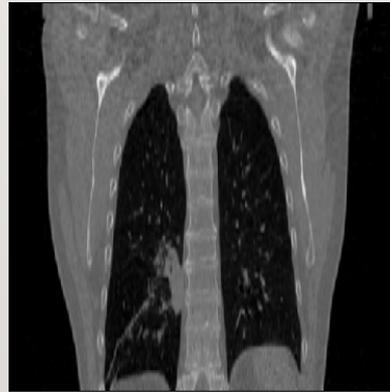
Assistive Tool (Image Registration)

Curve-based deformable image registration : single modality

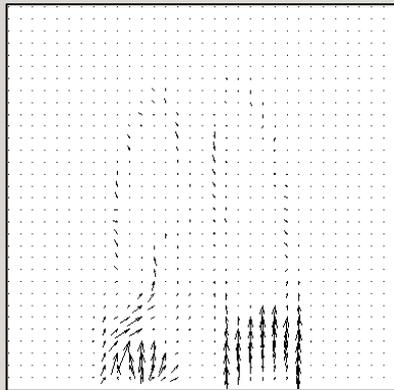
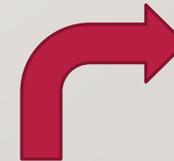


CT : 1st Fraction

Curve-based DIR



CT : 2nd - 3rd week later



DVF

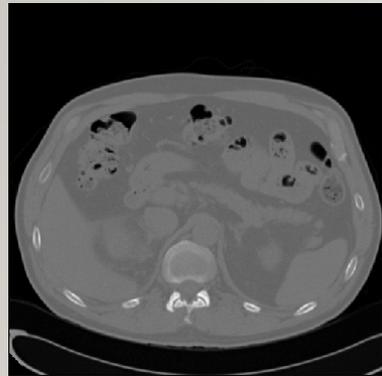
Moving pixel



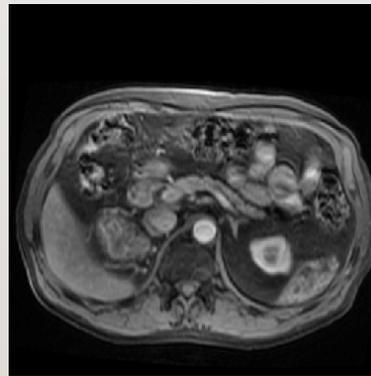
CT : deformed image

Assistive Tool (Image Registration)

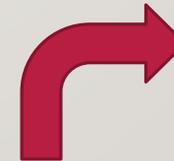
Curve-based deformable image registration : multiple modality



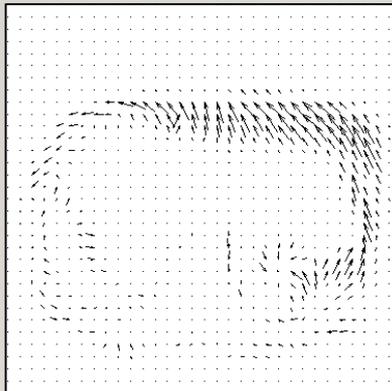
Curve-based DIR



MRI : source image

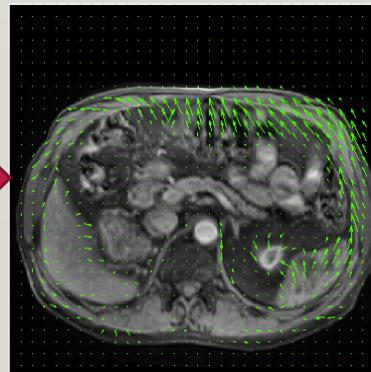


CT : reference image

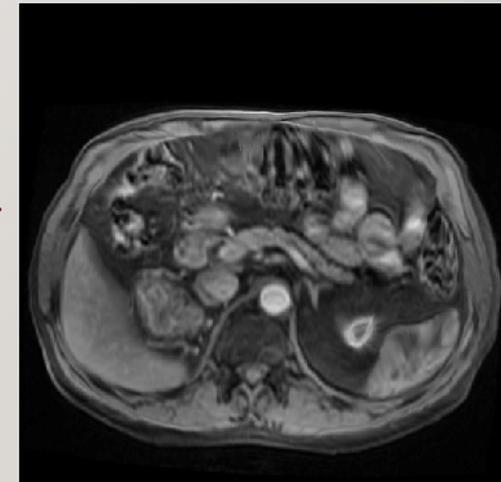


DVF

Moving
pixel

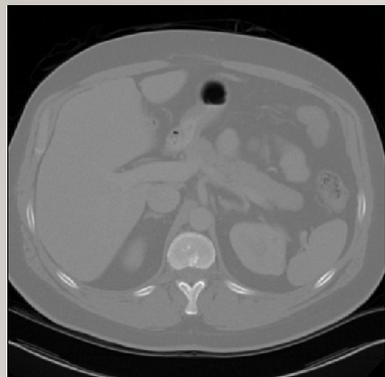


MRI : deformed image



Assistive Tool (Image Registration)

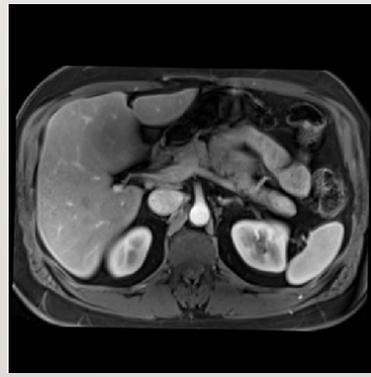
Curve-based deformable image registration : multiple modality



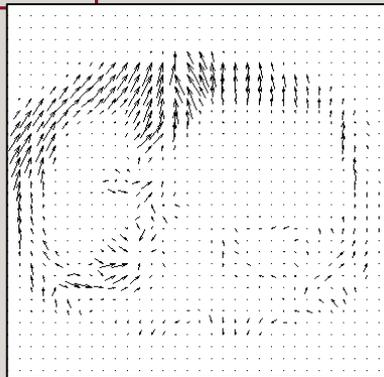
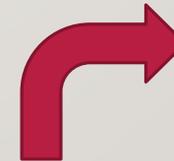
Curve-based DIR



CT : reference image

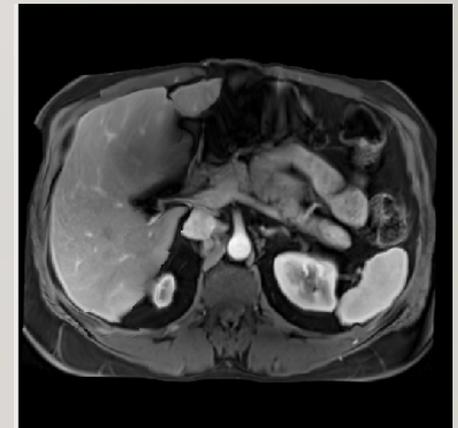
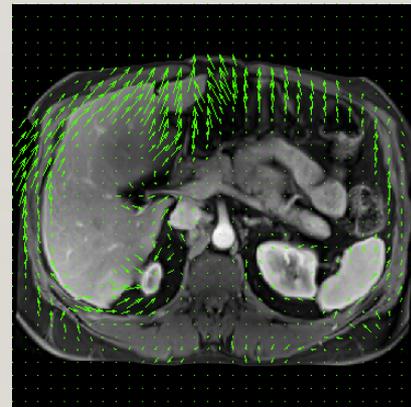


MRI : source image



DVF

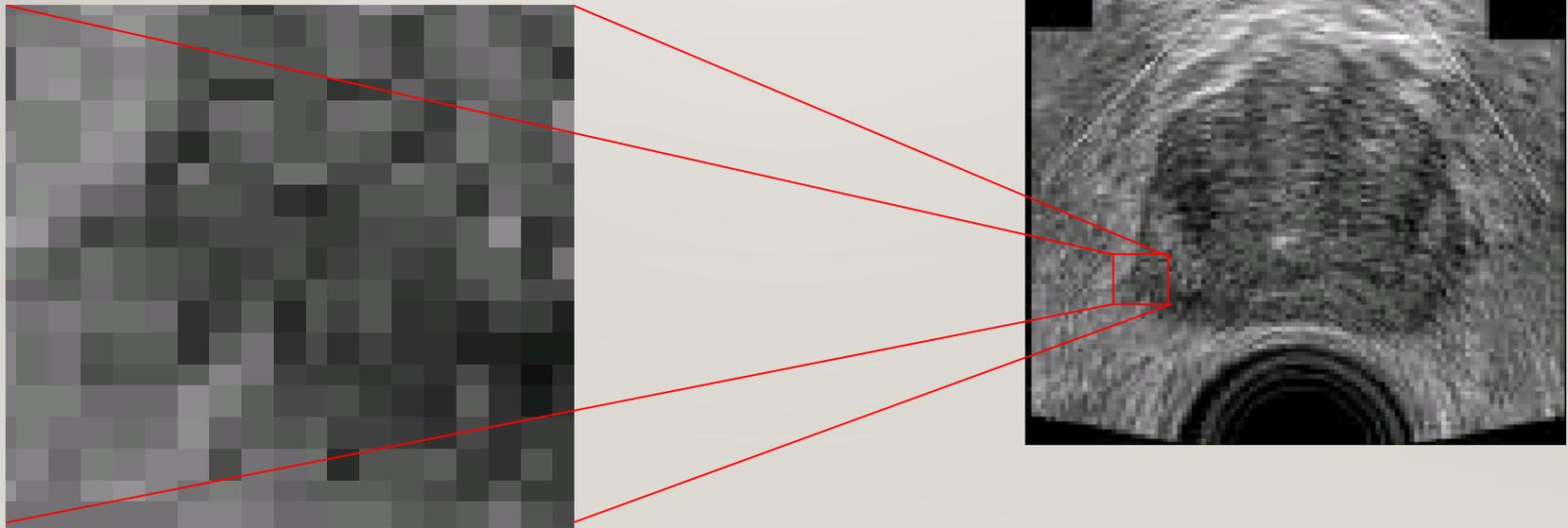
Moving
pixel



MRI : deformed image

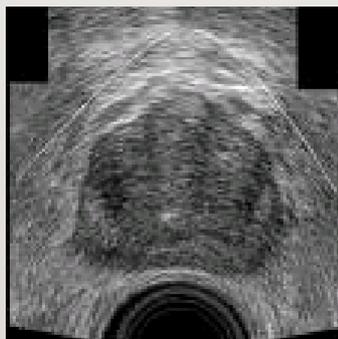
Assistive Tool (Boundary Detection)

- Novel Edge Following Technique for Ill-defined Edges



Assistive Tool (Boundary Detection)

- Novel Edge Following Technique for Ill-defined Edges



Prostate ultrasound image



Sobel



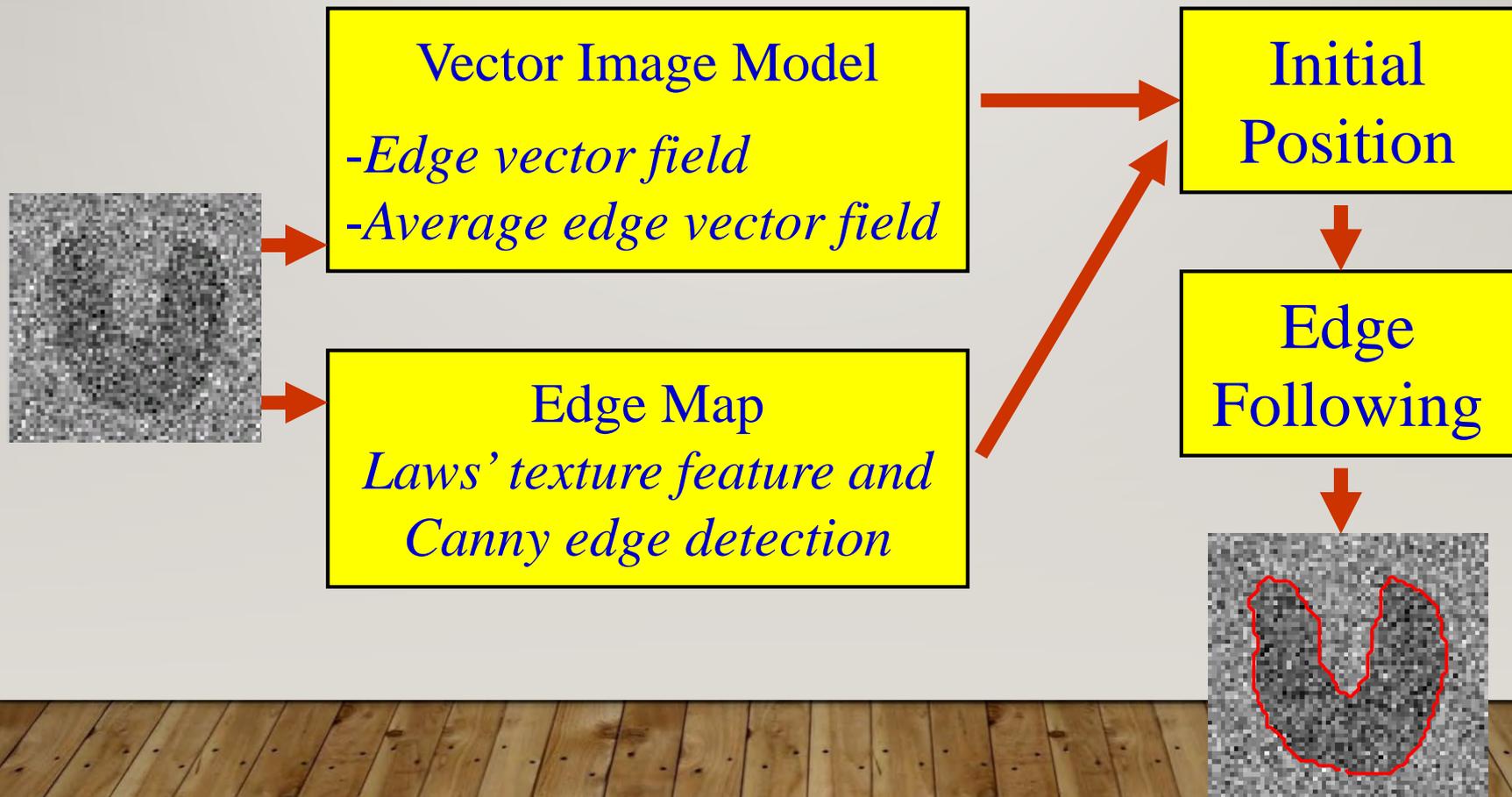
Canny



Zerocrossing

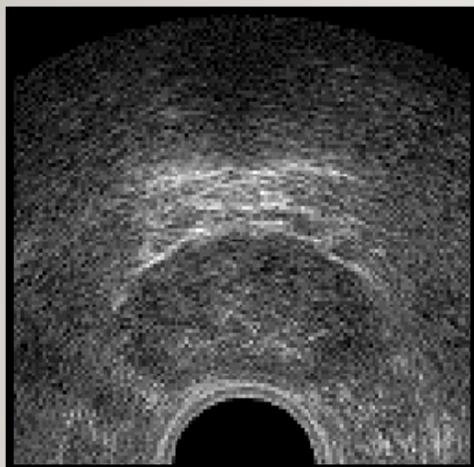
Assistive Tool (Boundary Detection)

- Novel Edge Following Technique for Ill-defined Edges

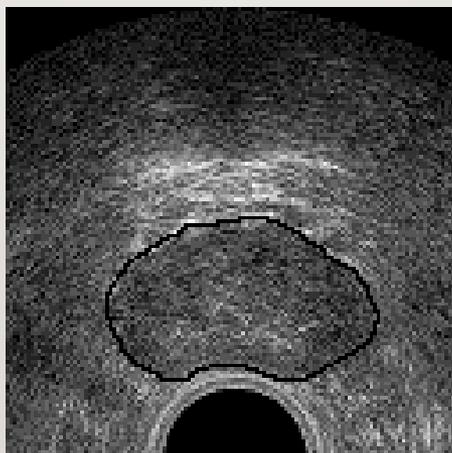


Assistive Tool (Boundary Detection)

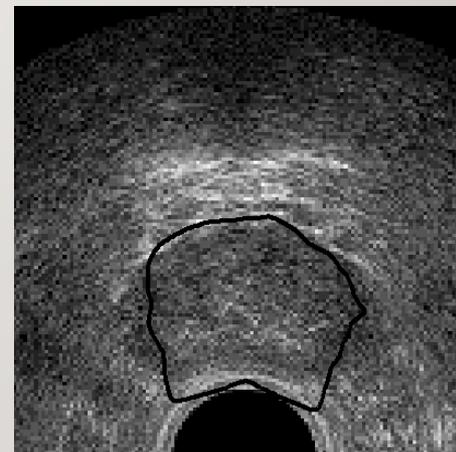
Prostate Ultrasound Images



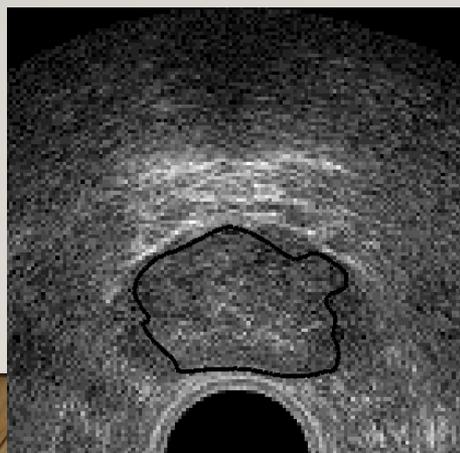
Original Image



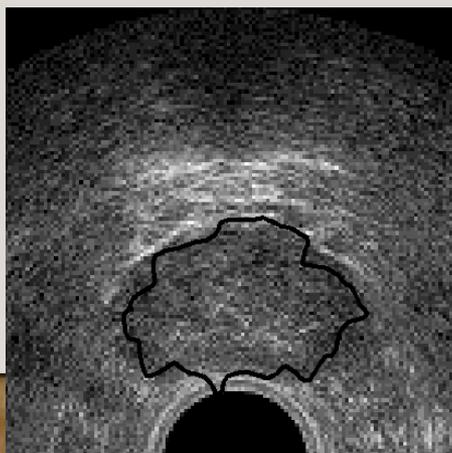
Ground thruth



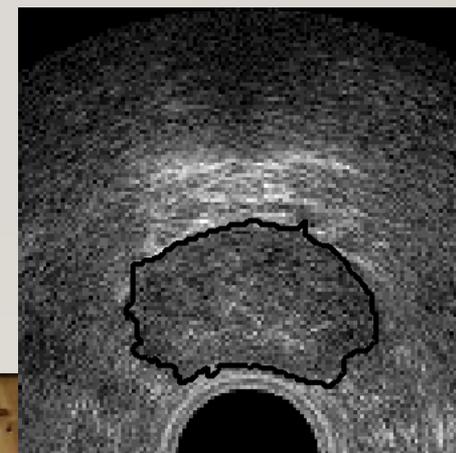
ACM



GAC



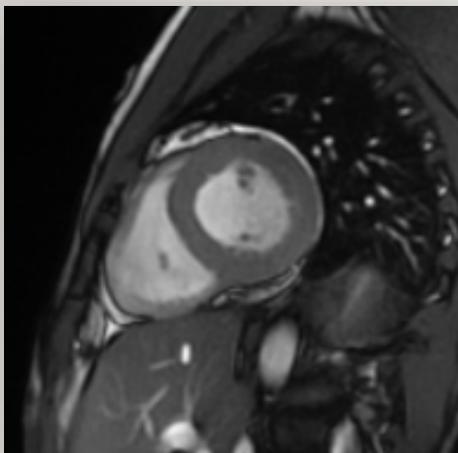
GVF



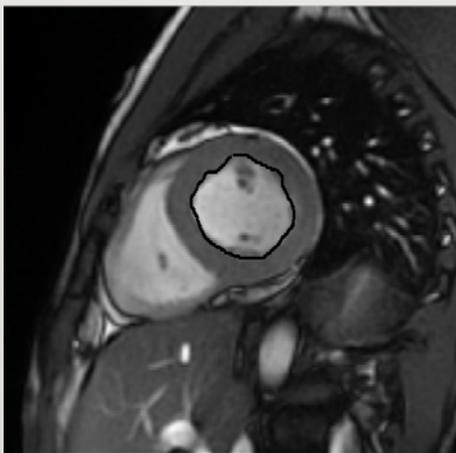
CMU

Assistive Tool (Boundary Detection)

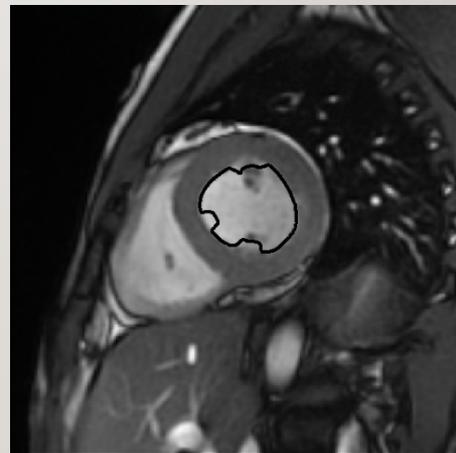
Left Ventricle in cardiac MRI



Original Image



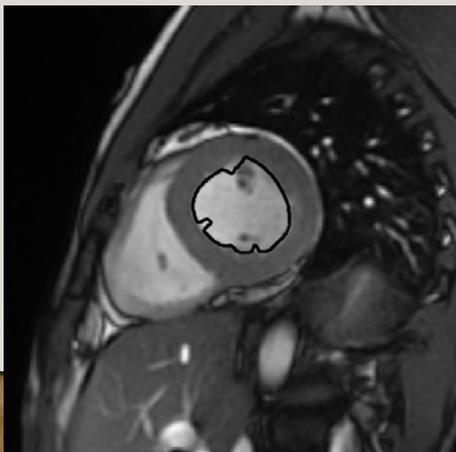
Ground thruth



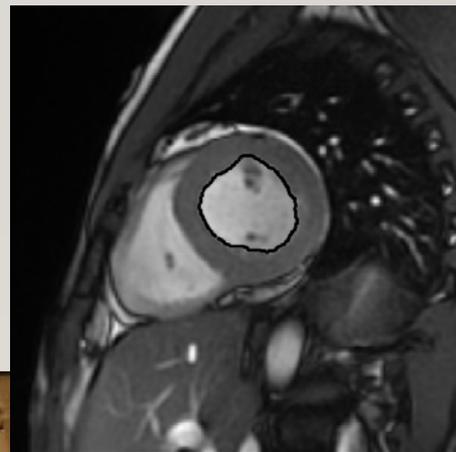
ACM



GAC



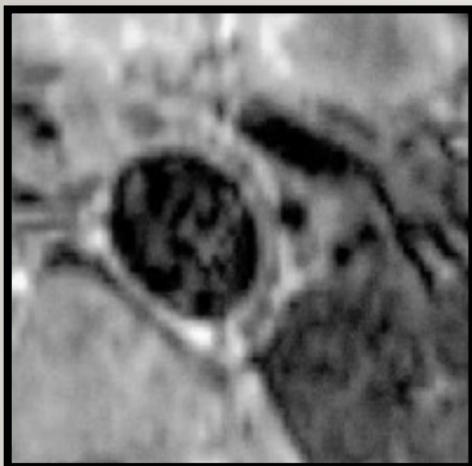
GVF



CMU

Assistive Tool (Boundary Detection)

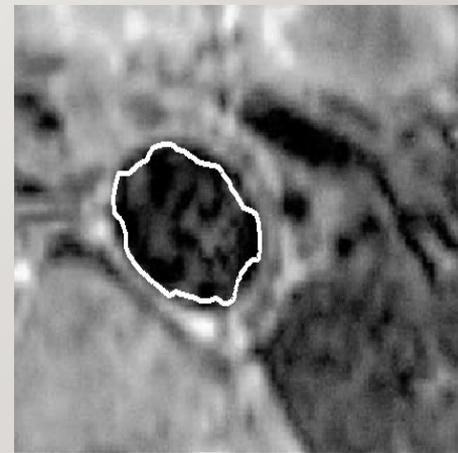
Aorta in cardiovascular MRI



Original Image



Ground thruth



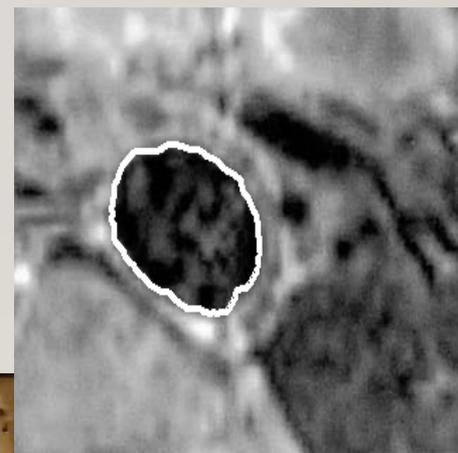
ACM



GAC



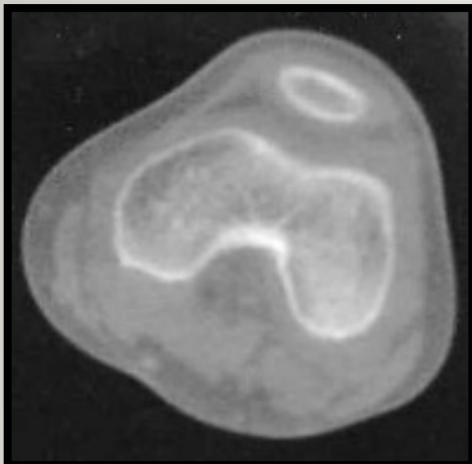
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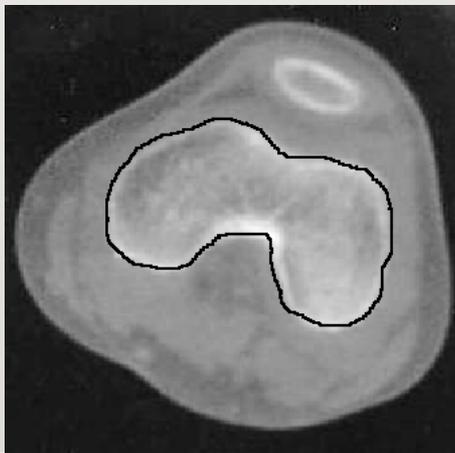
CMU

Assistive Tool (Boundary Detection)

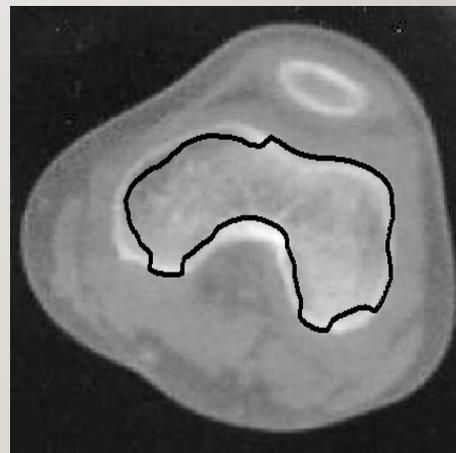
Knee Joint in CT Images



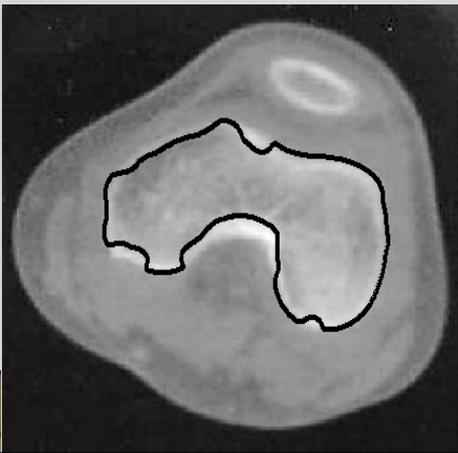
Original Image



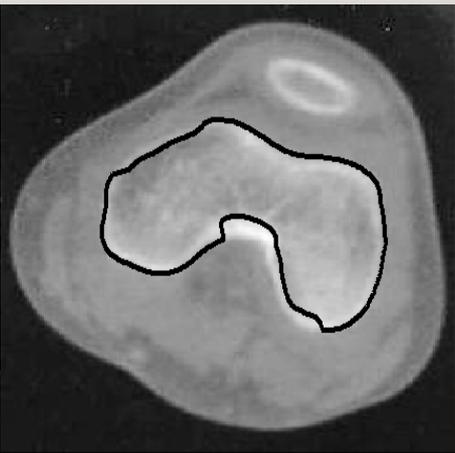
Ground thruth



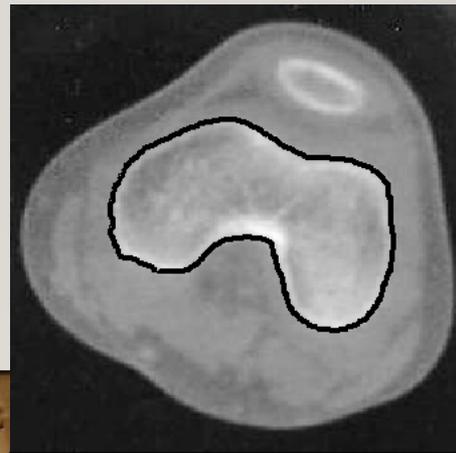
ACM



GAC



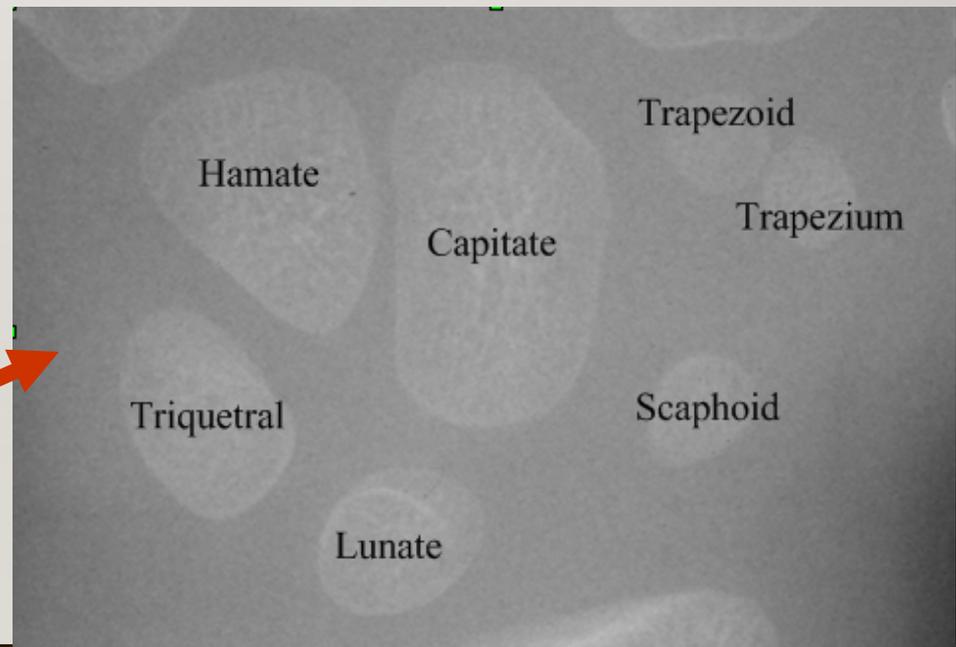
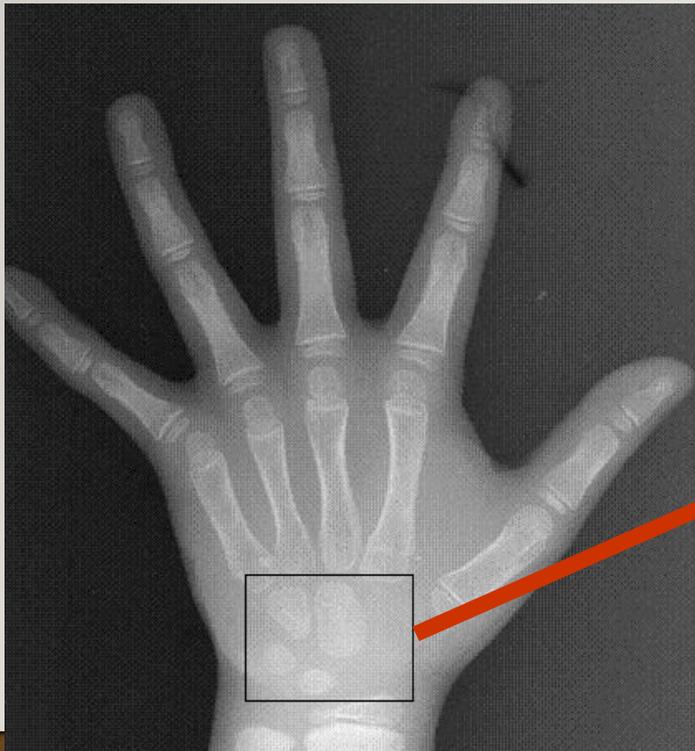
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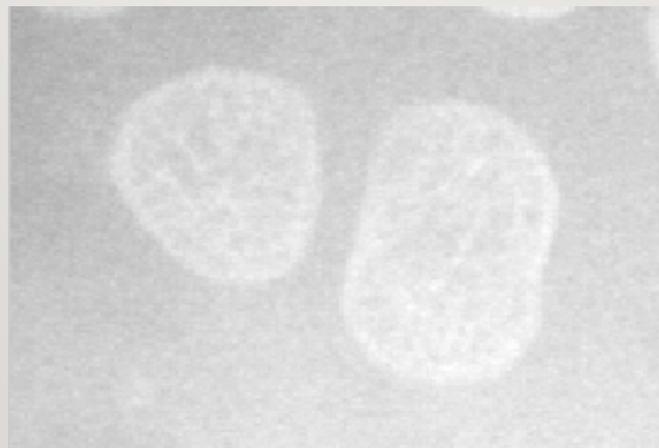
CMU

Assistive Tool (Boundary Detection)

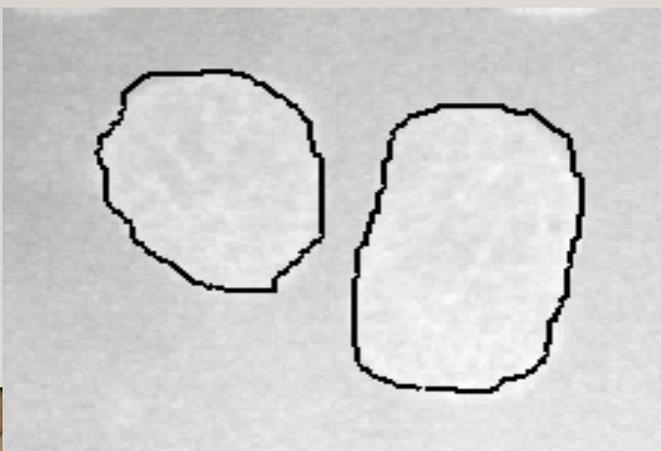
Carpal Bone Images



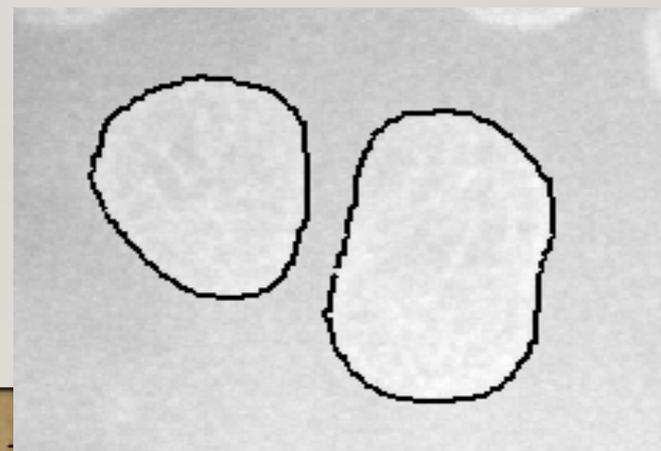
Assistive Tool (Boundary Detection)



Carpal Bone Images

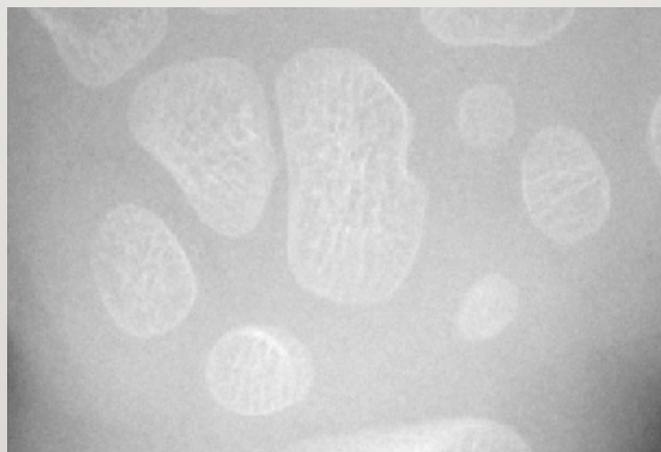


Expert Doctor

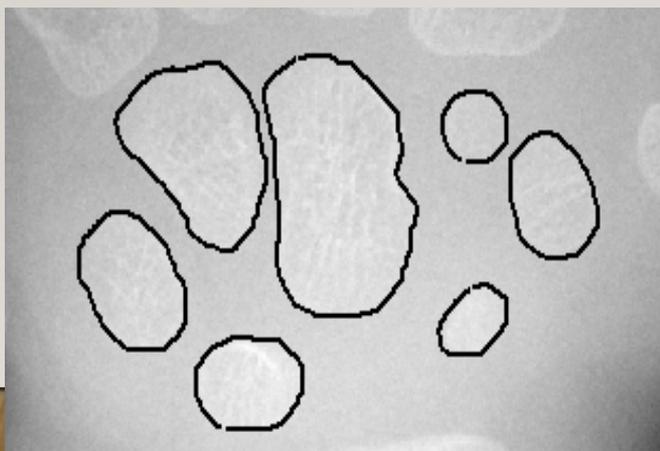


CMU

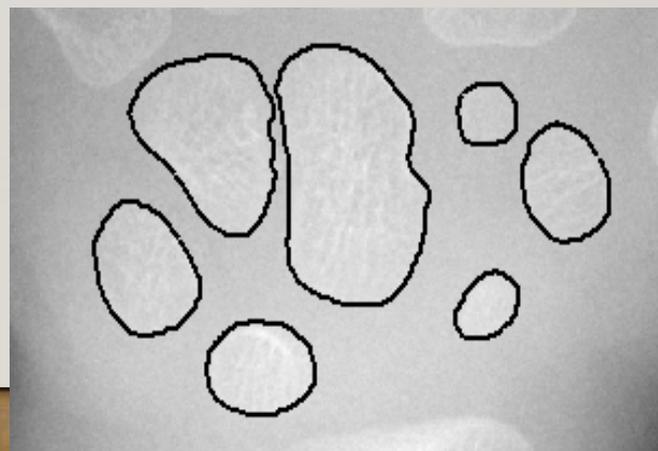
Assistive Tool (Boundary Detection)



Carpal Bone Images



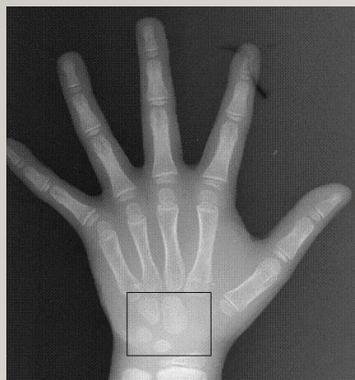
Expert Doctor



CMU

Assistive Tool (Estimation)

Application to Bone Age Assessment in Young Children



Region of
carpal bone

Edge
Detection

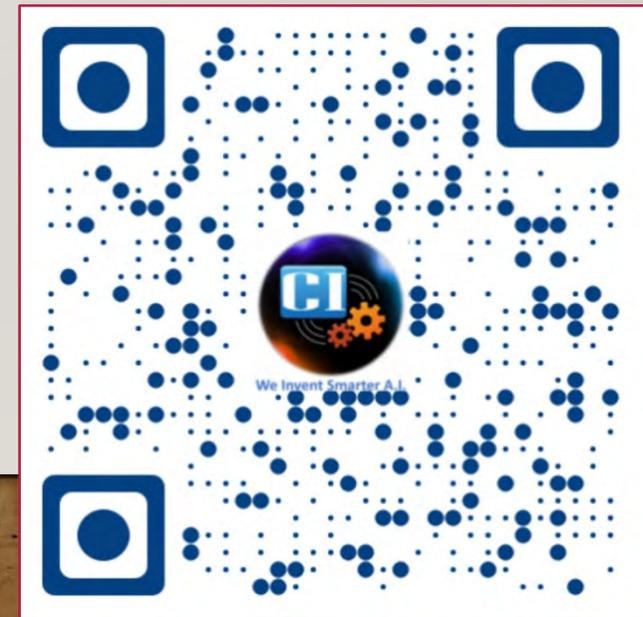
Feature
Extraction

Result

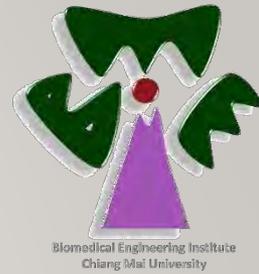
Bone Age
Assessment

| Race | | Neural network regression | Support vector regression |
|-----------------------|-------------|---------------------------|---------------------------|
| | | Mean Abs Error | Mean Abs Error |
| Asian (AS) | Male (22) | 5.41 month | 3.18 month |
| | Female (20) | 4.59 month | 2.87 month |
| Caucasian (CA) | Male (20) | 4.86 month | 2.87 month |
| | Female (18) | 5.06 month | 1.89 month |
| African-American (AA) | Male (29) | 8.68 month | 5.26 month |
| | Female (21) | 7.15 month | 3.98 month |
| Hispanic (HI) | Male (28) | 8.44 month | 4.57 month |
| | Female (22) | 6.29 month | 3.70 month |

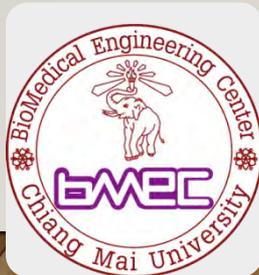
- Just some examples of our work
- <http://ci.cpe.eng.cmu.ac.th/>
- Google / Scopus / WOS:
 - Theera-Umpon or Auephanwiriyaikul



Special Thanks



► Colleagues & Students



Beaming

Motivating

Encouraging

Innovative

Thank You
Khob Khun Krub

