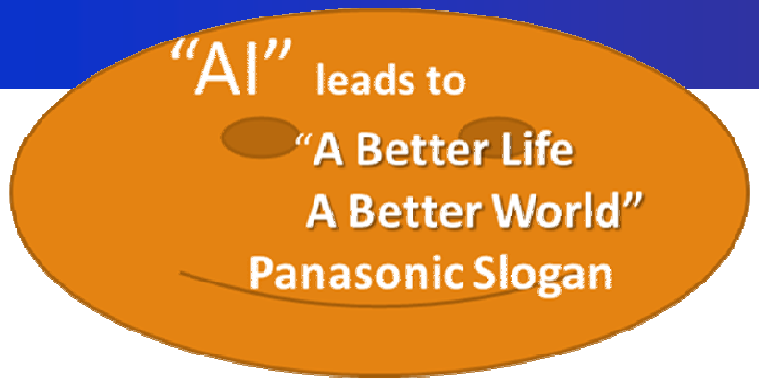

AI Advancement with Deep Learning and Its Application in Autonomous

Shen Shengmei, Jane
Panasonic R&D Center Singapore
(PRDCSG)

Oct 24, 2017

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Tel: +65 6550-5466; Mobile: +65 9173-8276
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Introduction of Panasonic

History and Management Philosophy

Contributing to the progress of society and the well-being of people through our business activities

1918	Founded by Konosuke Matsushita
	 Improved attachment plug  Double cluster socket
1932	Declared the company's "true mission"
	Established the export department to launch business overseas
1933	Introduced the "Business Division" system
1959	Established the first overseas sales company (Matsushita Electric Corporation of America)
1961	Established the first overseas factory (Dry Batteries in Thailand)
2004	Acquired Matsushita Electric Works
2008	Changed the company name to Panasonic Corporation and "Panasonic" became the unified brand name
2009	Acquired SANYO Electric
2018	100th Anniversary of the foundation

Panasonic

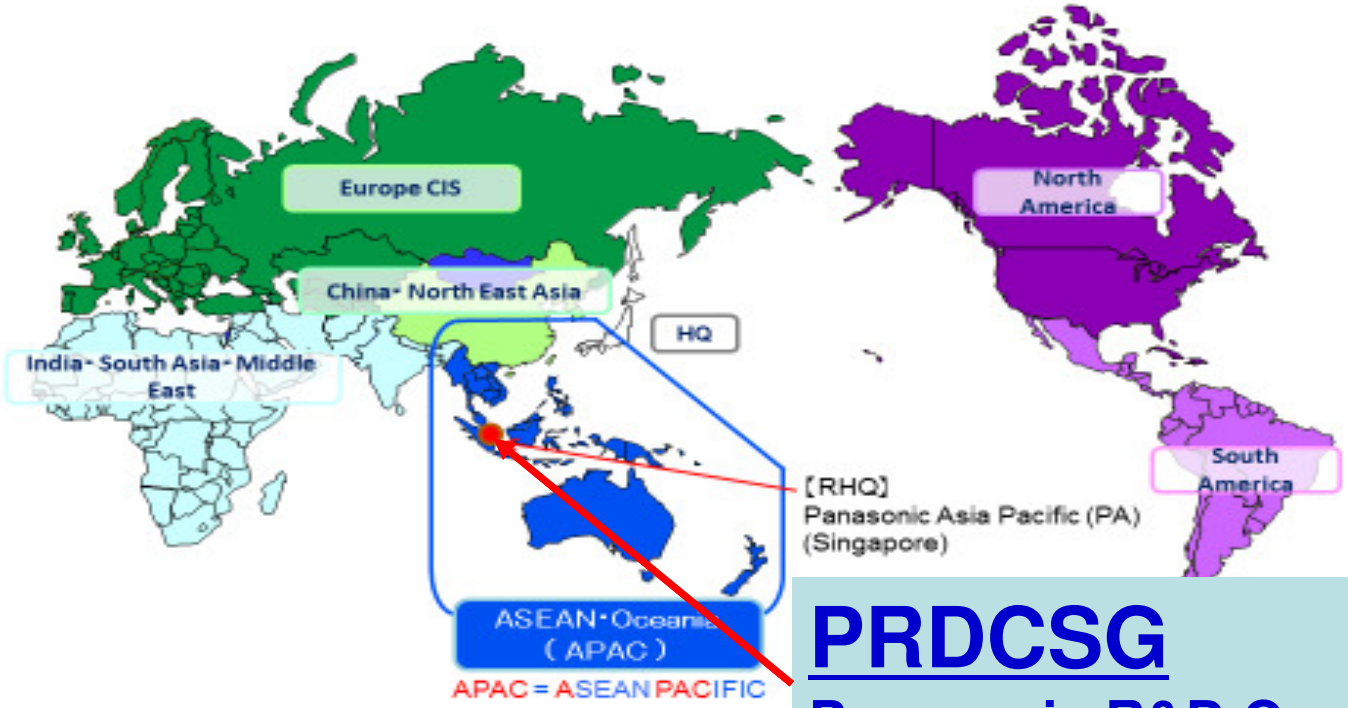
100th years Anniversary In 2018

Not only in Home Appliance, but also in Automotive, Surveillance, Logistics, Entertainment, Factory and other areas, etc. A very broad business scope

Admiring him not only for he is a funder, innovator, but also a distinguished entrepreneur, philosopher and an opinion leader. He wrote many books

Panasonic, Global Operation

Global Operation



PRDCSG

Panasonic R&D Center Singapore
27 Years History in Singapore
Leading Advanced Technology Development especially in MPEG, 3D, AI

PRDCSG: AI Contribution in Various Business

Support Panasonic business with image recognition by
i) creating competent technologies ii) innovating new uses and applications

Technology

Image Recognition
Object recognition, tracking
- Face
- Human
- Object / Scene

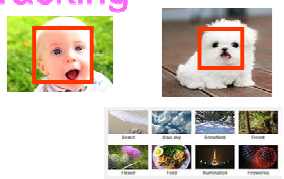


Image Processing
Image quality improvement
- High dynamic range
- Video stabilization

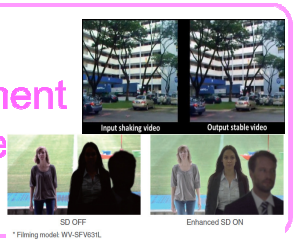
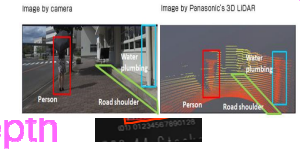


Image Sensing
2D/3D measurement
- distance, angle, depth



Market Segments

Surveillance & Security

Better security

Embedded SW & Services

Better convenience

Automotive

Better safety

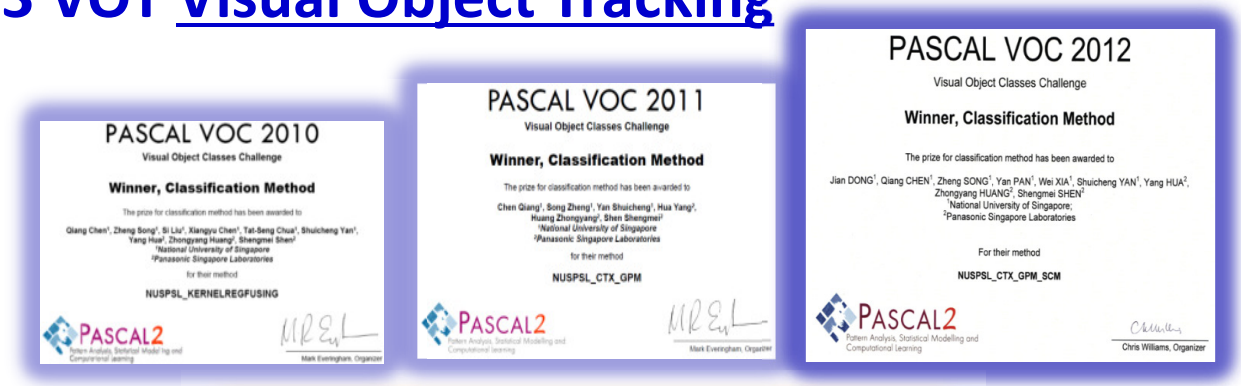
Machine Vision

Better efficiency

World-Top Competitions with Machine Learning

We won world-wide competitions from 2010-2013:

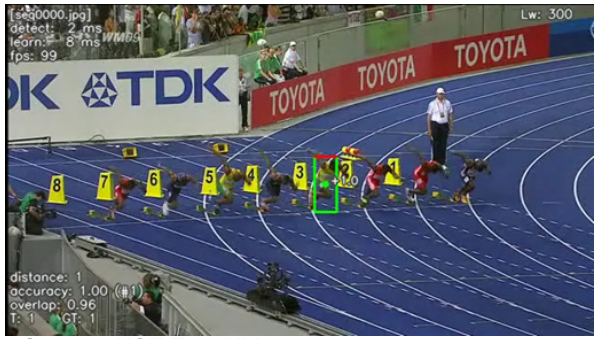
- PASCAL VOC in 2010, 2011, and 2012 in object classification, detection and segmentation
- 2013 VOT Visual Object Tracking



2013 VOT Tracking Championship

Panasonic R&D Center Singapore

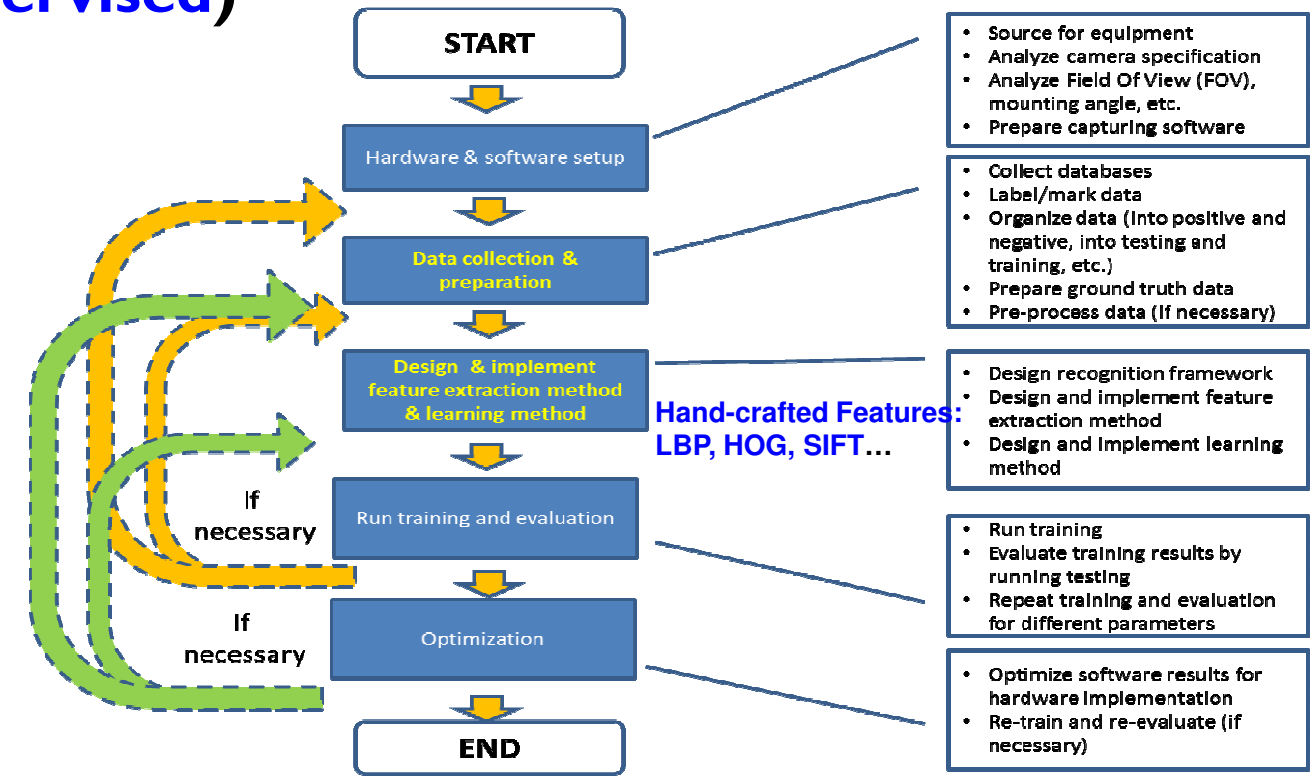
Source: PASCAL VOC



Source: VOT Test Video

Typical Development Process in Machine Learning

Typical Development Process Flow in Machine Learning (Supervised)



Hand-crafted Feature has the limitation, cannot represent the variety contained in the data

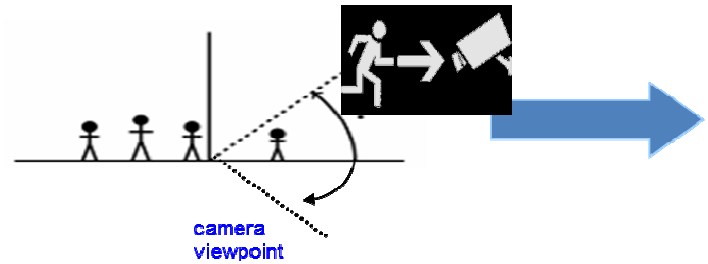
LBP: Local Binary Pattern ; HOG: Histograms of Oriented Gradients;
SIFT: Scale-invariant feature transform

Traditional Machine Learning

Issues with Traditional Machine Learning

Robustness:

- The model trained on certain range of camera angles may not produce the same accuracy for other case;
- The performance drops when the usage condition changes, for example lighting or camera views.



appearance
changes

Multiple Deployments:

- Longer time spent on customization and re-training for new use case
- Skillful & experienced engineer required to re-train the model for new deployment

Traditional Machine Learning is not good enough!

Move Machine Learning Closer to Human Brain's AI

New Era is coming with Deep Learning

To Solve those issues

"Deep Learning is a new area of Machine Learning research, with the objective of **moving Machine Learning closer to its original goals: Artificial Intelligence"**

Andrew Ng

Deep Learning Statement

Accuracy is improved from 95% to 99% with the good robustness, means a **"Game Changing",** to make impossible be possible, to derive super intelligence beyond human brain!

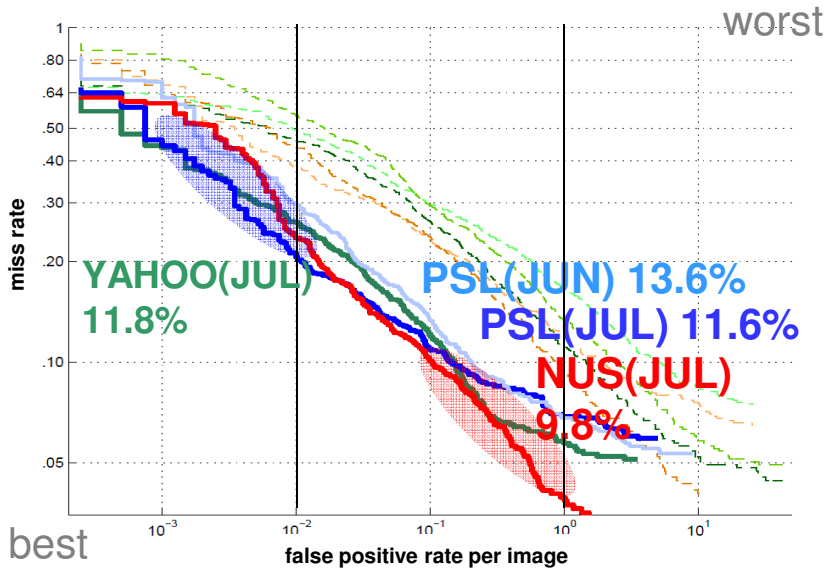
Move Machine Learning Closer to Human Brain's AI

Since 2012 we have moved to Deep Learning for
Higher Accuracy
Better Robustness
Beyond Human Intelligence

World-Top Performance with Deep Learning

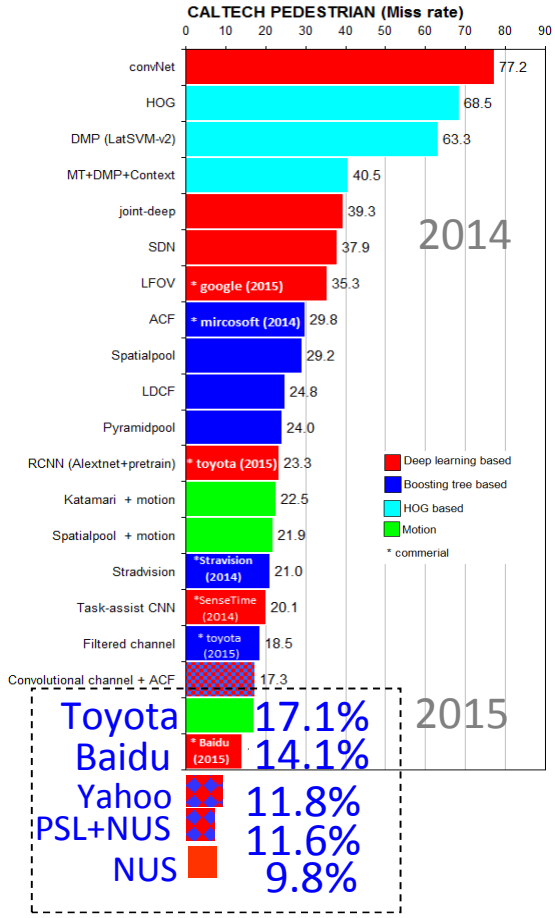
In 2015, Top result on Pedestrian Detection

Deep learning framework:



Test on Caltech dataset

Comparison to other companies



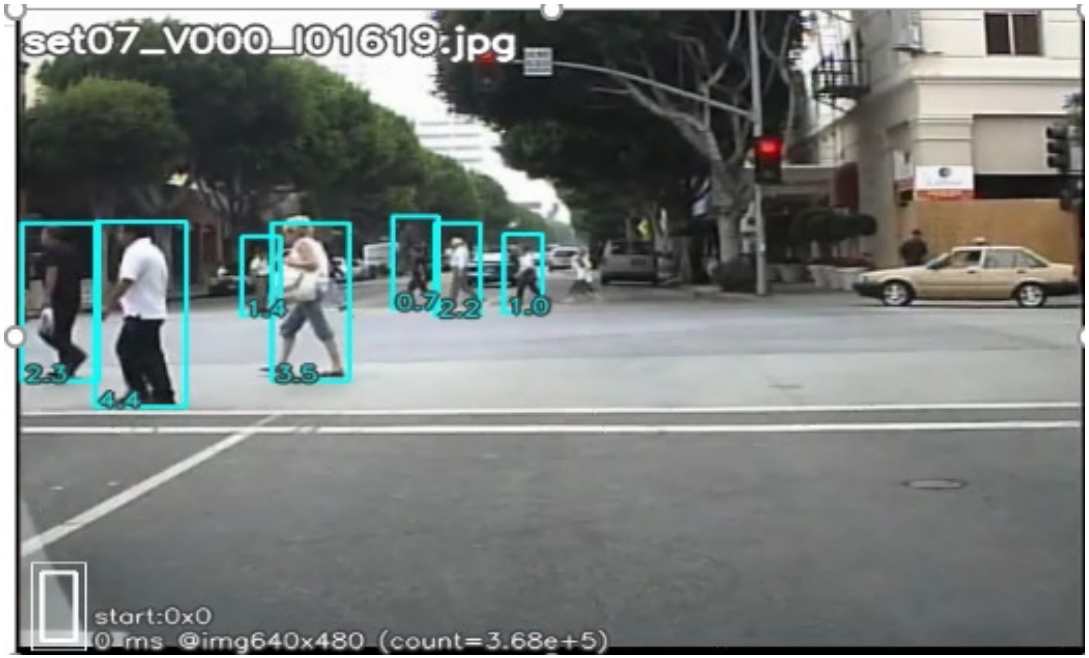
Top 5 results

Panasonic R&D Center Singapore

World-Top Performance with Deep Learning

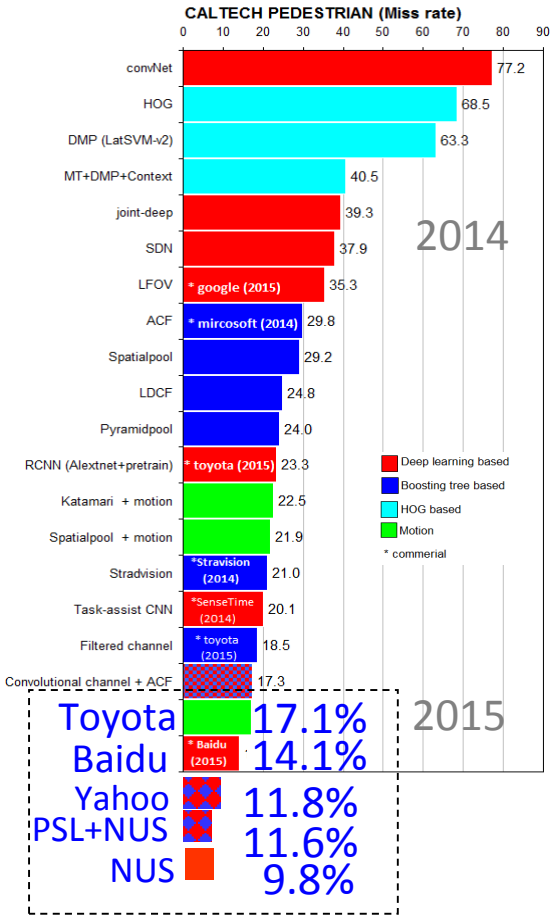
In 2015, Top result on Pedestrian Detection

Video Demo



Test on Caltech dataset

Comparison to other companies



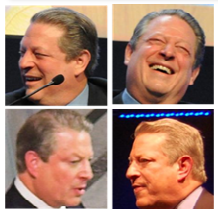
Top 5 results

World-Top Competition with Deep Learning

In 2017.3, No. 1 on NIST Face Recognition IJB-A Challenge

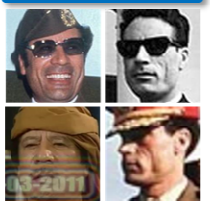
Face Recognition
World's No. 1 Position

Different Angles



Different Lightings

Occlusion



Different Cameras

Very difficult test dataset with a lot of non-frontal faces but a good reflection of real situation

N*(M40x4)+ M*(TitanXx4) used for training to win the competition

Panasonic R&D Center Singapore

Press Release

Panasonic

パナソニック株式会社
〒571-8501 大阪府門真市大字門真1006番地

Panasonic R&D Center Singapore & NUS joint collaboration

2017年5月10日

ディープラーニングの応用で世界最高水準※1の顔照合技術※2を開発

【要旨】

パナソニック株式会社は、シンガポール国立大学と共同で研究開発を行い、このほど、世界最高水準※1の顔照合技術※2を開発しました。本技術は、ディープラーニングと呼ばれる機械学習手法と、誤りを抑制する類似度計算手法を組み合わせた独自のアルゴリズムであり、人間の目でも顔の判別が困難な左右90度近い横向き、照明の明暗が強い屋外環境、サングラス・マスクなど一部顔が隠れているような状態でも顔照合を行うことができます。また、本技術は、アメリカ国立標準技術研究所（以下、NIST）が公開している、映像セキュリティ市場で撮影され得るあらゆる条件を網羅したベンチマークデータセット※3において、世界最高水準※1の顔照合性能を実現しました。

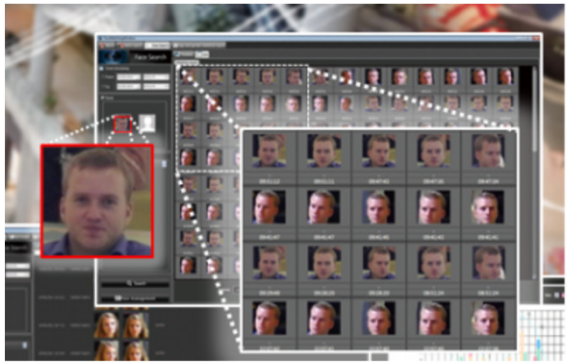
【開発の背景】

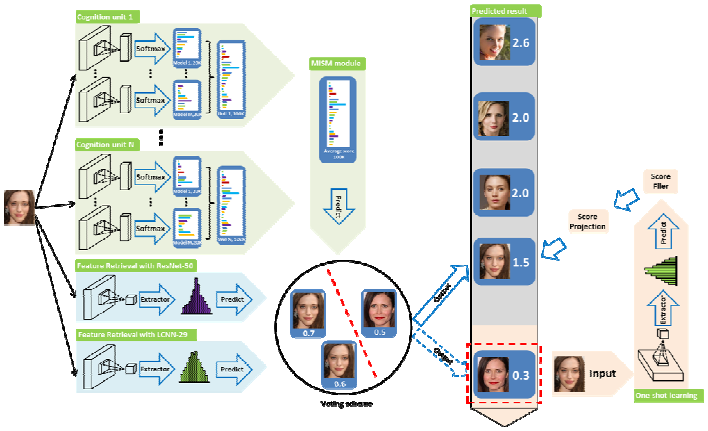
従来の顔照合技術には、(1)左右45度以上の顔向きが付いた場合、(2)屋外で照明の明暗が強い場合、(3)サングラス・マスクなど一部顔が隠れている場合に、顔照合に失敗するという課題がありました。この課題の解決へ向け、当社のコネクティッドソリューションズ社イノベーションセンターとパナソニックR&Dセンターシンガポールは、2015年度からシンガポール国立大学と共同で顔照合技術の性能改善に取り組んできました。具体的に、まずディープラーニングと呼ばれる機械学習手法のネットワーク構造を改良し、真横向きや一部顔が隠れていても個人を

World-Top Performance with Deep Learning

In 2017.7, No. 1 on MS Cele-1M Face Challenge

1M face identities with 100 images for each identity(average) → huge data





Face Source: MS Cele 1M

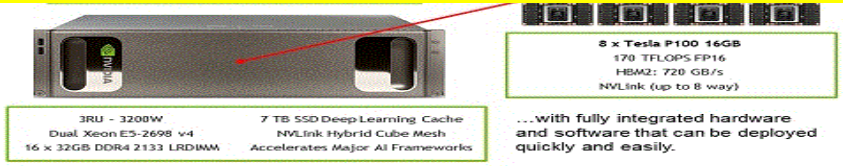
Leaderboard Challenge-1 @ ICCV Workshop 2017

With External Data, Last Updated: 7/18/2017

Random Set | Hard Set

Rank	Team Id	Team Name	Affiliation	Data	Coverage@P=0.95	Team member name
1	41	Panasonic-NUS	Panasonic, National University of Singapore	Aligned Faces	0.875	Yan Xu* (Panasonic), Yu Cheng* (Panasonic),
2	37	Turtle	Chongqing Institute of Green and Intelligent	Aligned Faces	0.862	Pengcheng Liu (CIGIT), Kai Li (CASIA), Cheng Cheng
3						
4						
5	3					
6	2					

DGX-1 GPU machine used in the Training, winning the competition



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World-Top Performance with Deep Learning

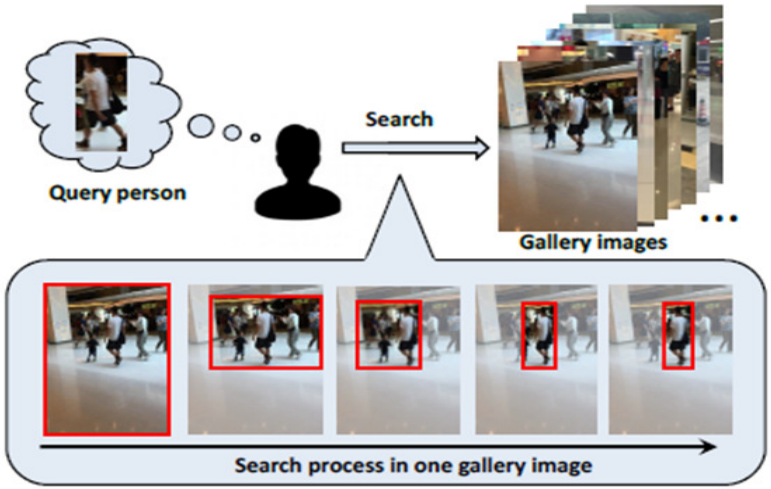
Deep Learning vs. Traditional Machine Learning

Video Demo

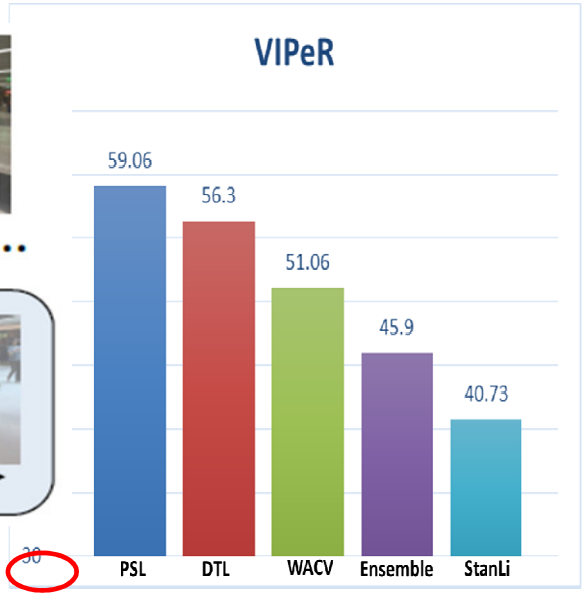
Deep Learning provides much robustness performance than Traditional machine learning

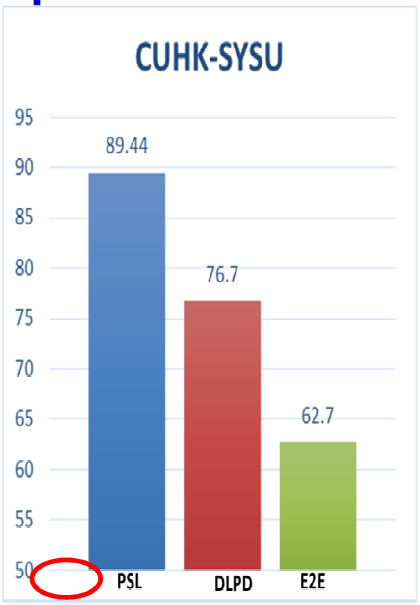
World-Top Performance with Deep Learning

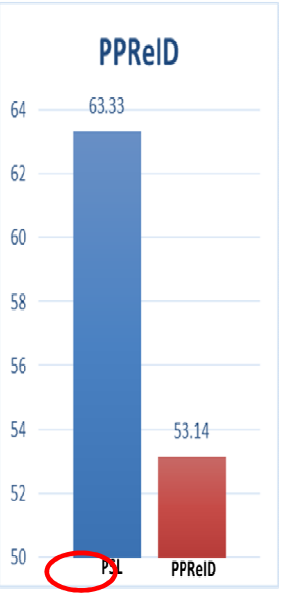
In 2016 Person Re-Identification for different datasets



Benchmark Results on Popular Datasets in 2016:







Re-identify a person across multiple cameras

We achieved top results for different datasets

- VIPeR : very small and challenging
- CUHK-SYSU : Biggest dataset for person re-id
- PPReID : Partial person re-id dataset

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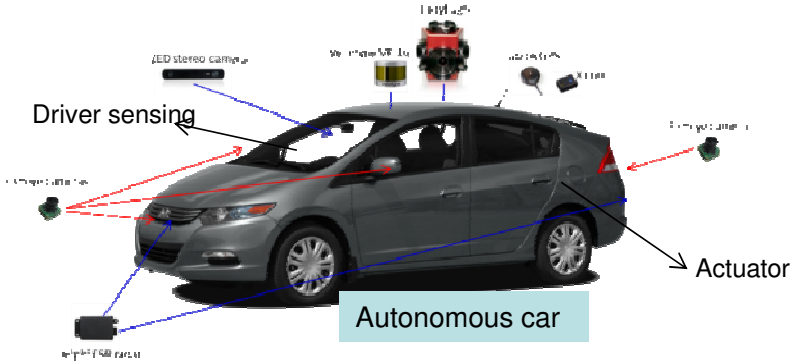
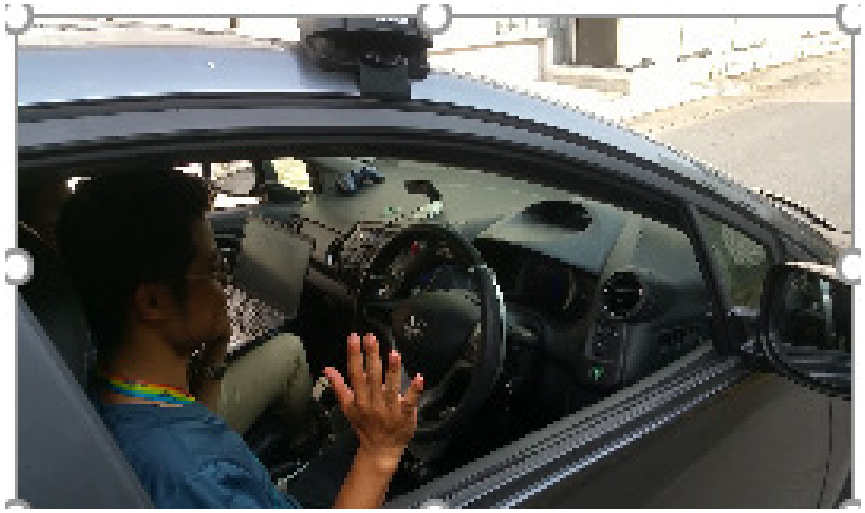
AI for Autonomous

AI for Autonomous & Automotive Applications

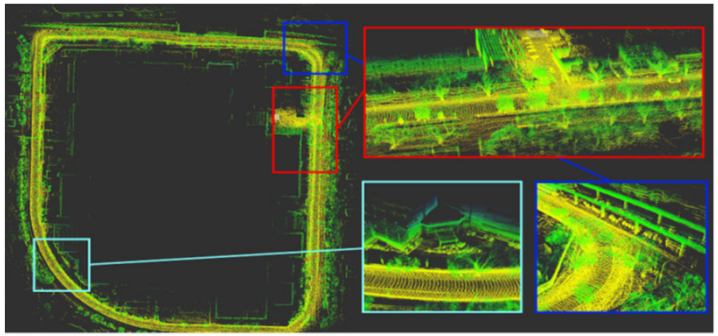
PRDCSG's autonomous car prototype



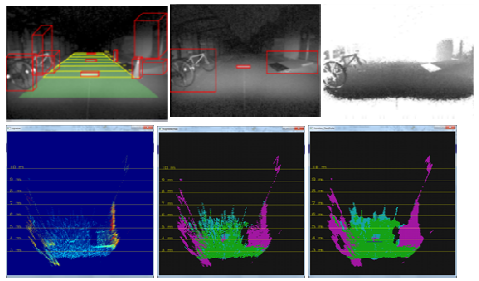
Demo Video



Visual Self-Localization



Freespace and Obstacle detection



(for AGV: Automated Guided Vehicle)

- **Driver Control Modelling, Deep Reinforcement Learning**
- **Multi objects detection and classification using DL**
- **Multi objects tracking using DL**
- **Driver sensing for safety & comfortable driving**

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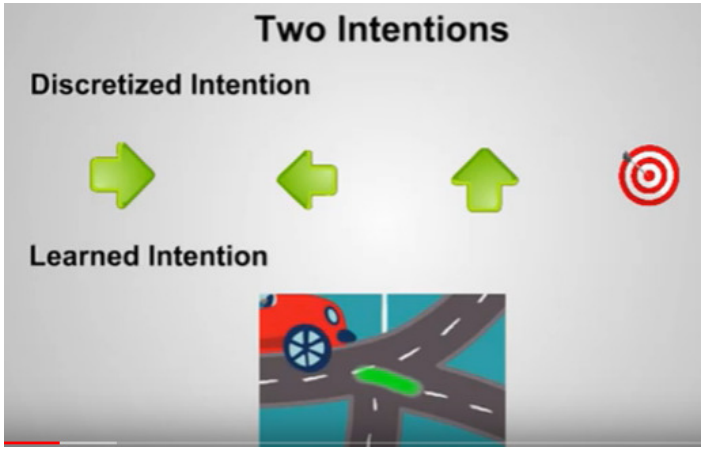
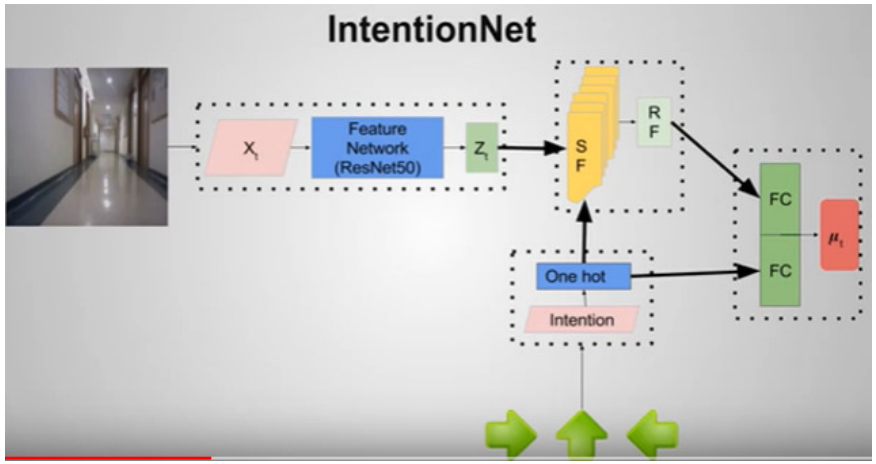
AI for Autonomous & Automotive Applications

Driver Control Modelling, Deep RL, IntentionNet

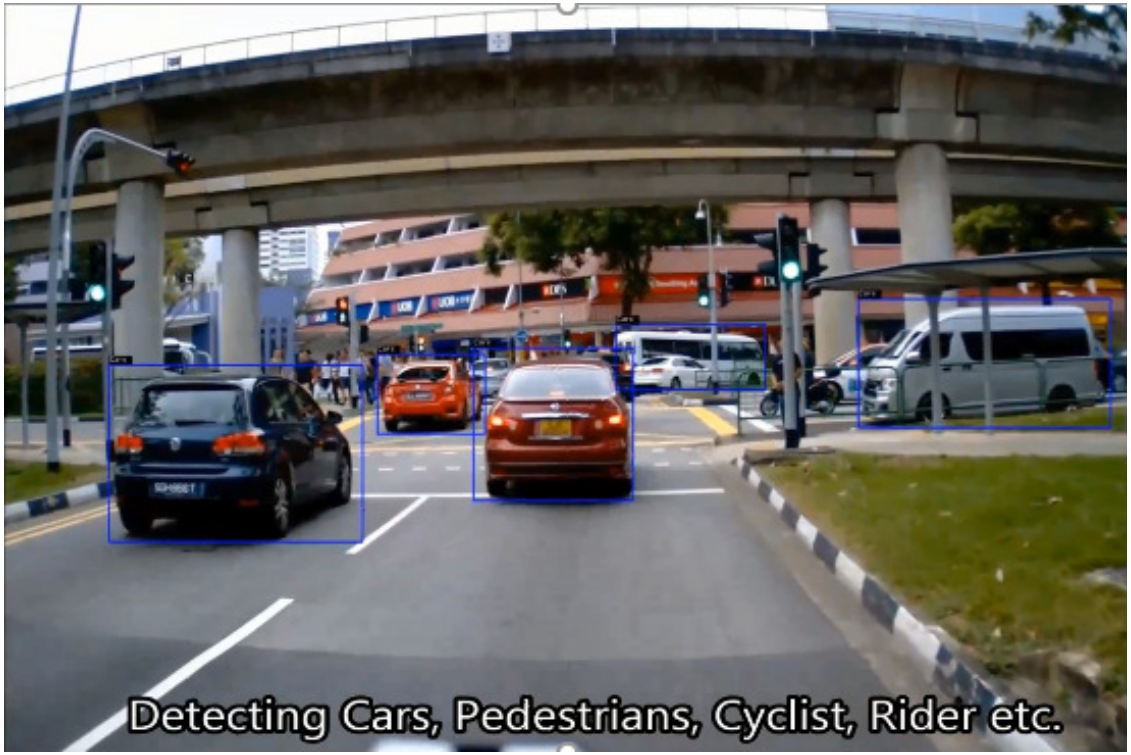




AI for Autonomous & Automotive Applications

Multi objects detection, DL implemented in PX2
Traffic Scene Segmentation, DL implemented in PX2

Video Demo



NVIDIA DRIVE PX2

AI for Autonomous & Automotive Applications

Driver Sensing for safe and comfortable driving

Contactless technology measures blinking and facial expressions and detects even very low, hardly noticeable levels of drowsiness

Indices related to drowsiness (ex)
***Sleepier one gets**

【Blinking】
- Shorter intervals between blinks
- Slower blinking

⋮

【Facial expressions】
- Close eyelids, open lips
- Frequent yawning

⋮

Approx. 1800 parameters

Drowsiness Level (Current)

1 2 3 4 5

Proprietary AI processing predicts "drowsiness"

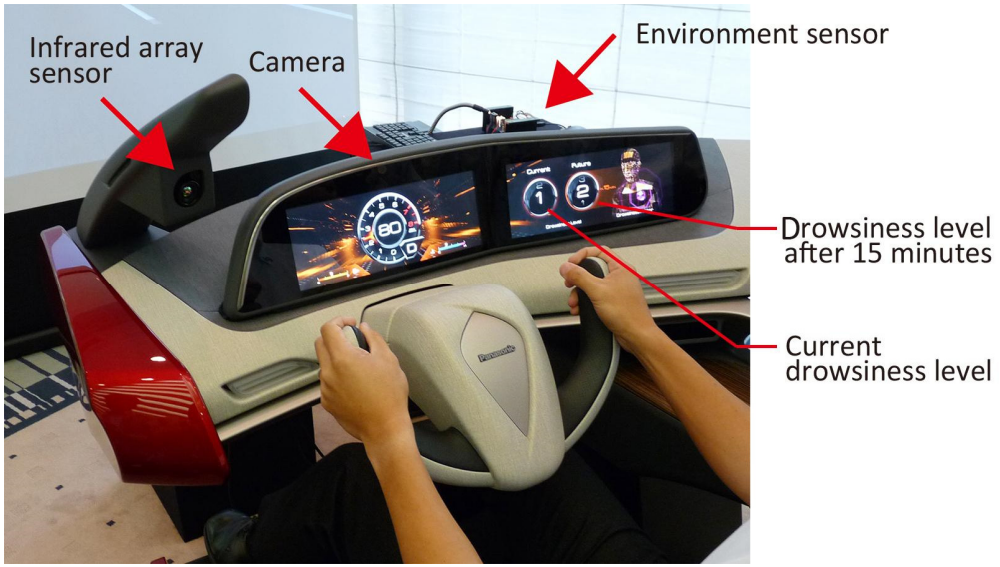
Based on the results from the drowsiness-facial expression analysis conducted in collaboration with The Ohara Memorial Institute for Science of Labour.

Level of drowsiness*	1	2	3	4	5
	Not sleepy	A little sleepy	Sleepy	Quite sleepy	Extremely sleepy
Some signs	・Gaze moves quickly and often ・Blinking cycle is even	・Gaze moves slower ・Lips part open	・Blinking is slow and often ・Incidental movement, such as mouth moves, etc.	・Conscious blinking ・Yawning	・Close lids ・Head tilts forward

* The Ohara Memorial Institute for Science of Labour's "5 Levels of Drowsiness"

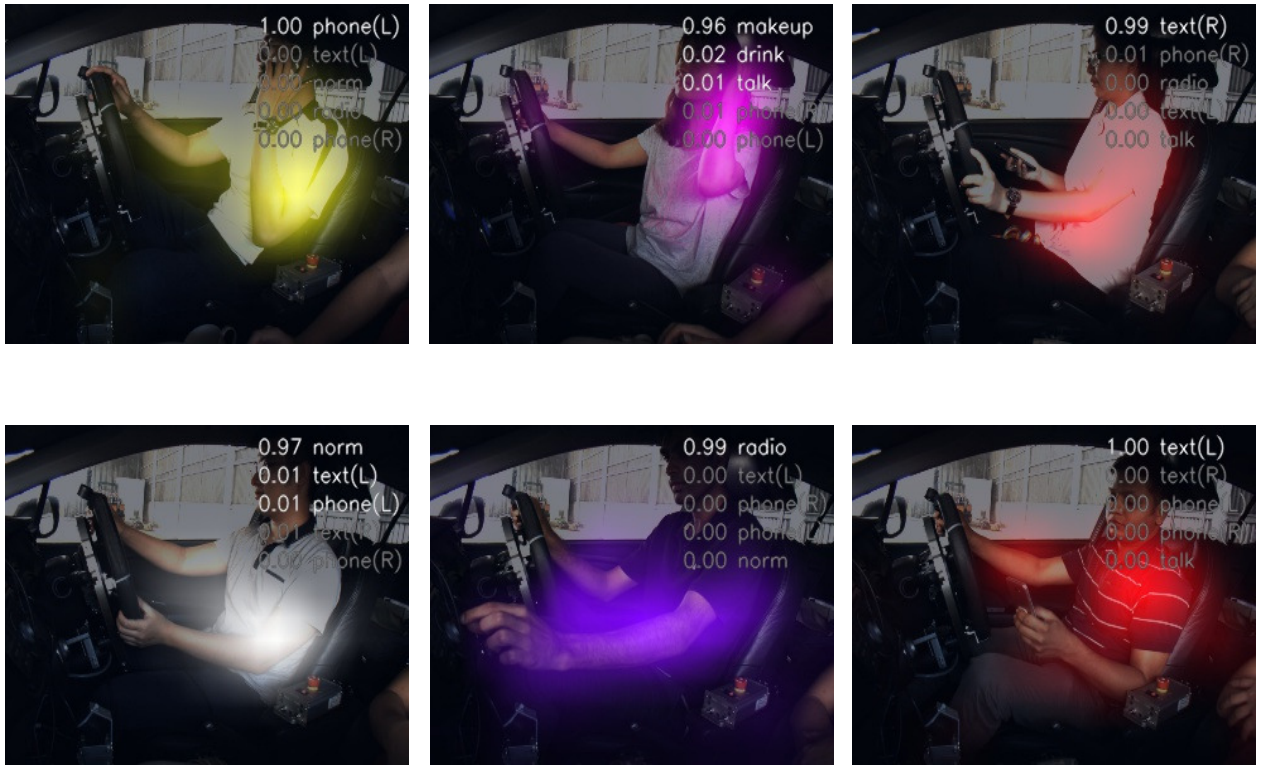
"Drowsiness Detection"

http://news.panasonic.com/global/stories/2017/49621.html
https://www.engadget.com/2017/08/01/panasonic-drowsy-driver-ai-infrared/
http://news.panasonic.com/global/press/data/2017/07/en170727-3/en170727-3.html



AI for Autonomous & Automotive Applications

Driver Sensing: Driver Behavior Recognition



The 10 classes to predict are:

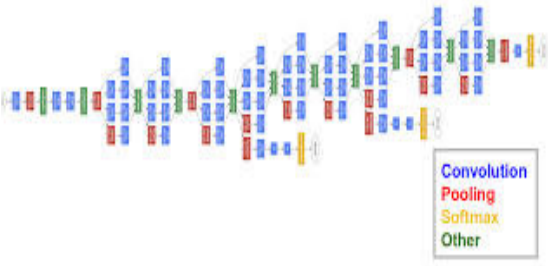
- c0: normal driving
- c1: texting – right
- c2: talking on the phone – right
- c3: texting – left
- c4: talking on the phone – left
- c5: operating the radio
- c6: drinking
- c7: reaching behind
- c8: hair and makeup
- c9: talking to passenger

Participate in Kaggle Competition

3 Key Factors & Strategy for AI Development

3 Key Factors to work on Deep Learning:

1) **People & Domain Knowledge**
2) **Big Data**
3) **GPU resource Platform**



AI Expert with Domain Knowledge: (1)

- **Deep Learning Architecture**
- **Engineering Skills**

(2)

(3)

- **GPU Cluster for Training**
- **Deployment GPU platform**
- **Optimization for deployment in Embedded H/W, PX2**

DeepL_DataHub

- Resource & Knowhow:

Data collection & annotation

- Various Assisting Tools
- Semi-auto labeling

PRDCSG: GPU Cluster:
DGX1, 8xGPU-P-100
40xP-TitanX, 8xM40, ….

Panasonic R&D Center Singapore

AI Advancement and Its Applications

Thank You for your Attention!

Panasonic R&D Center Singapore

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