



Replacing Human Vision with Machine

Ikuro Sato

Denso IT Laboratory, Inc. & Tokyo Institute of Technology, Japan

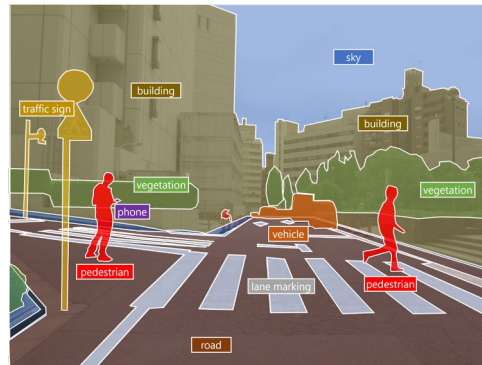
11/1/2022

Who is Ikuro Sato?

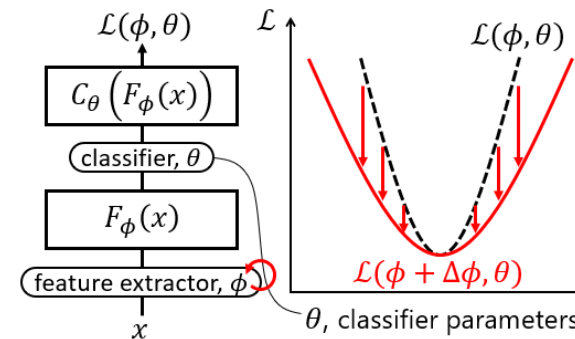
- 2005.08 Ph.D. received from University of Maryland, USA
- 2005.10~ Postdoc at Lawrence Berkeley National Laboratory, USA
- 2008.03~ Researcher at Denso IT Laboratory
- 2020.04~ Specially Appointed Associate Professor at Tokyo Tech.

Field of study

Image Recognition



Machine Learning



DENSO IT LAB Recognition and Learning Algorithm Collaborative Research Chair

<https://d-itlab.c.titech.ac.jp/>



Recognition and Learning
Algorithm Laboratory



DENSO
IT LAB



東京工業大学
Tokyo Institute of Technology

To conduct researches on **challenging and essential problems** to bring technological breakthroughs to **replace human vision with machines.**

(From left)

- Rio Yokota
- Shunsuke Ono
- Ikuro Sato
- Koichi Shinoda
- Nakamasa Inoue
- Akihiro Nomura
- Masayuki Tanaka
- Rei Kawakami
- Asako Kanezaki



The World of Driving

Symbol



<https://trafficnews.jp>

Text

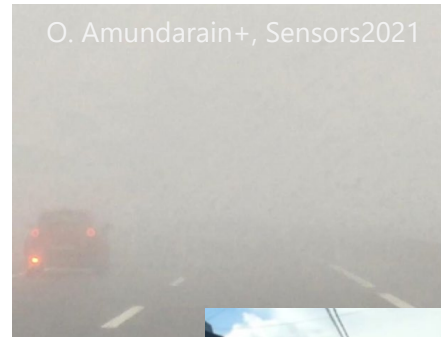


Z. Zou+, 2019



<https://kuruma-news.jp>

Weather



O. Amundarain+, Sensors2021



S. Vachmanus+, SICE2020.



Z. Zou+, 2019

Rarity



<https://sirabee.com/>



<https://trafficnews.jp/post/54477>



https://www.bengo4.com/c/23/n_9085/

The World of Driving

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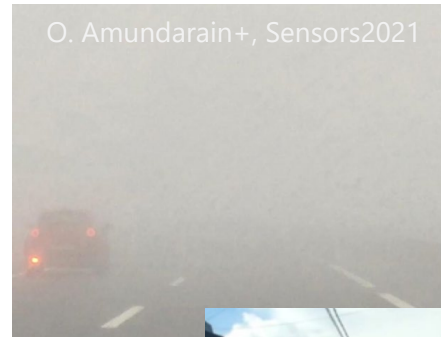


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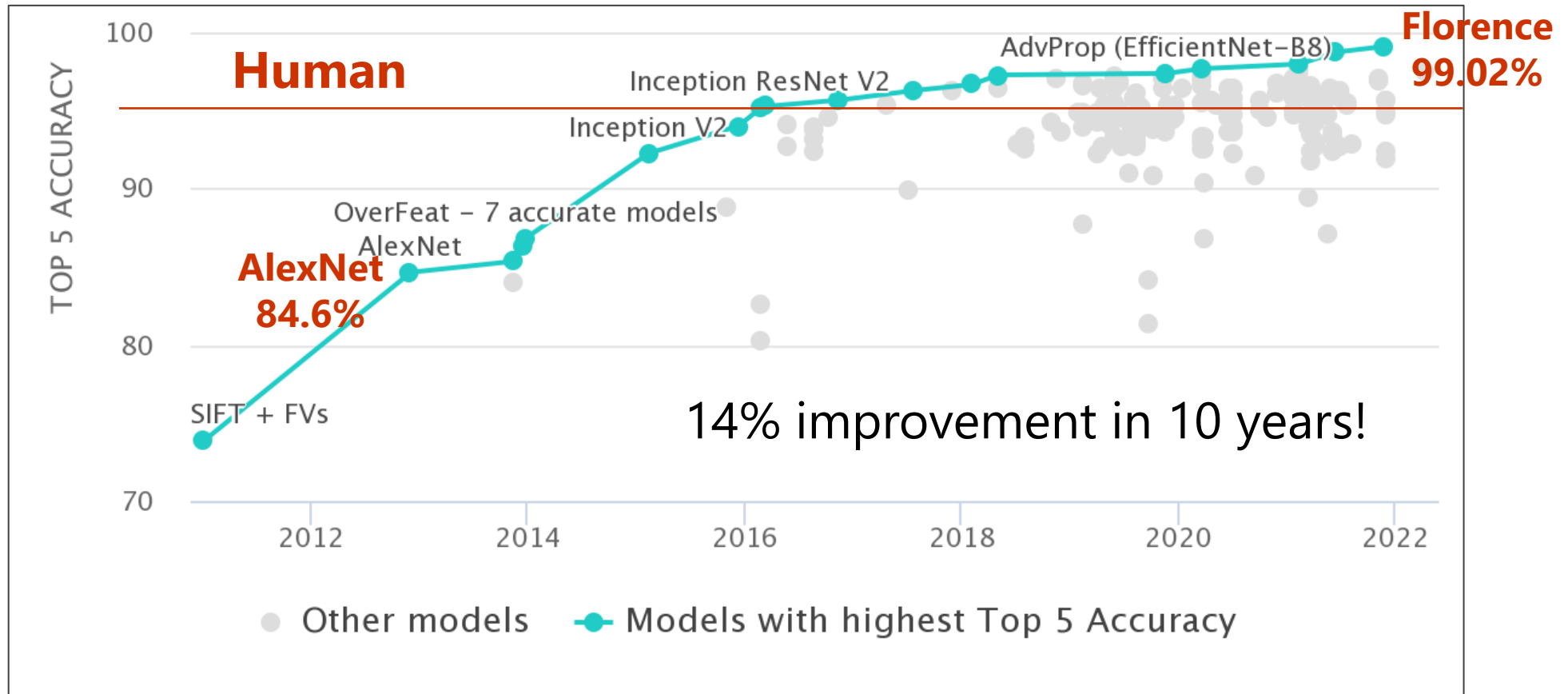


Need to replace almost all aspects of human vision

Great Progress by Deep Learning

ImageNet-1K Performance vs. Year

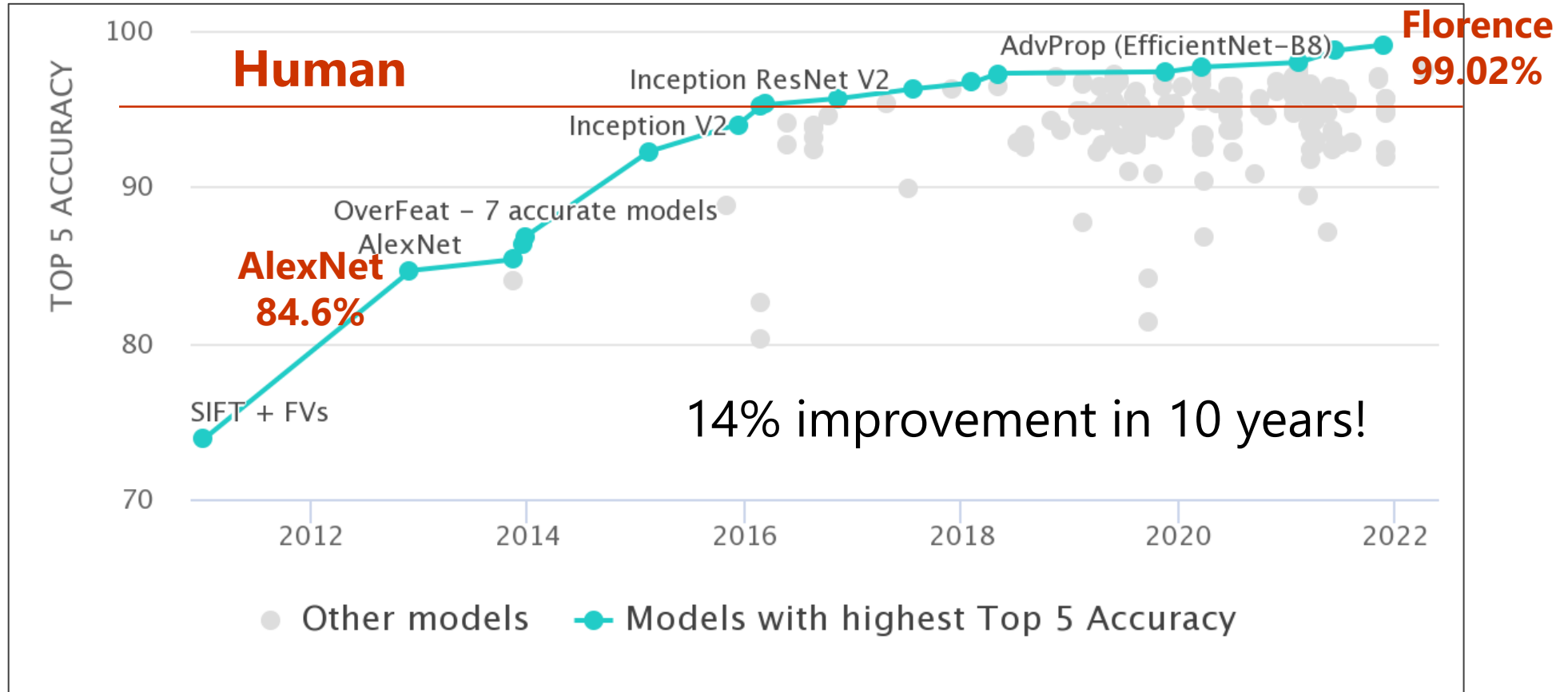
<https://paperswithcode.com>



Great Progress by Deep Learning

ImageNet-1K Performance vs. Year

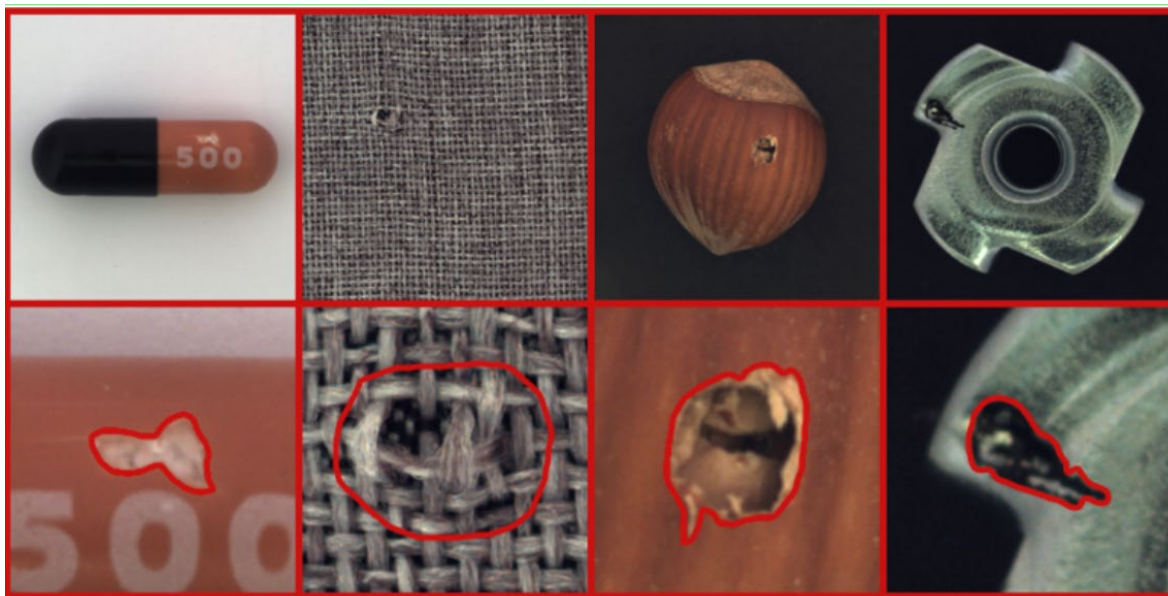
<https://paperswithcode.com>



Will the replacement happen along this direction?

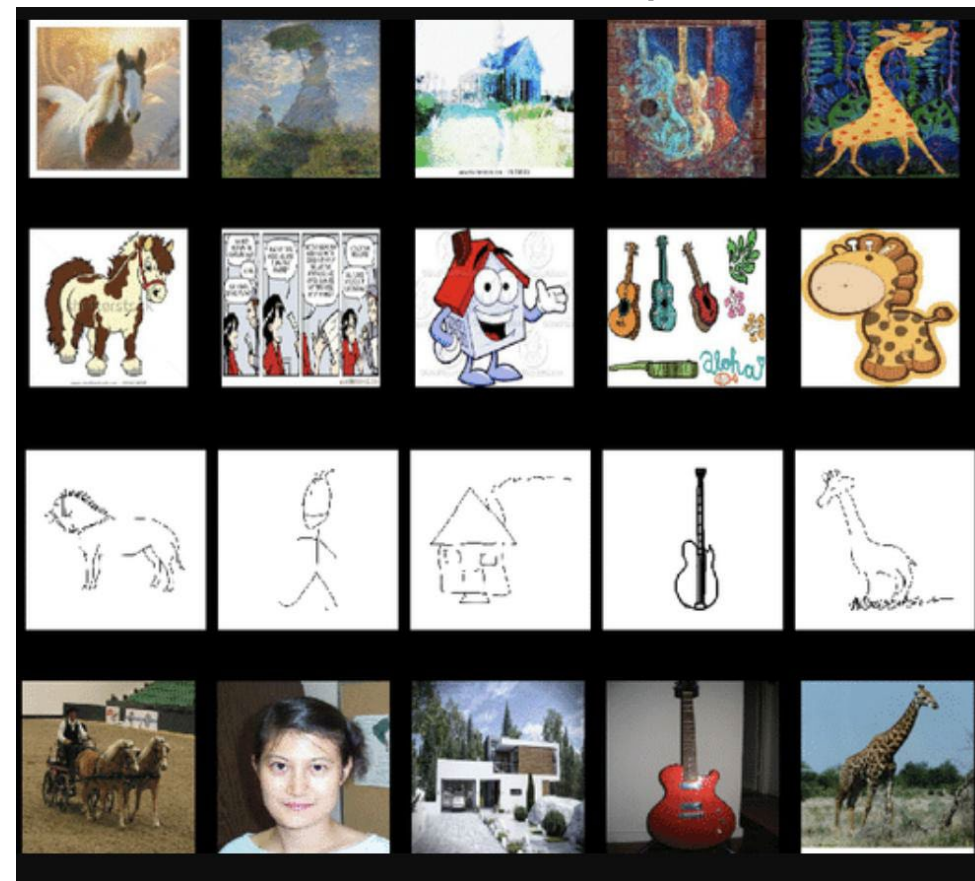
Tasks that brains are far better

Anomaly Detection



MVTec dataset

Domain Gap



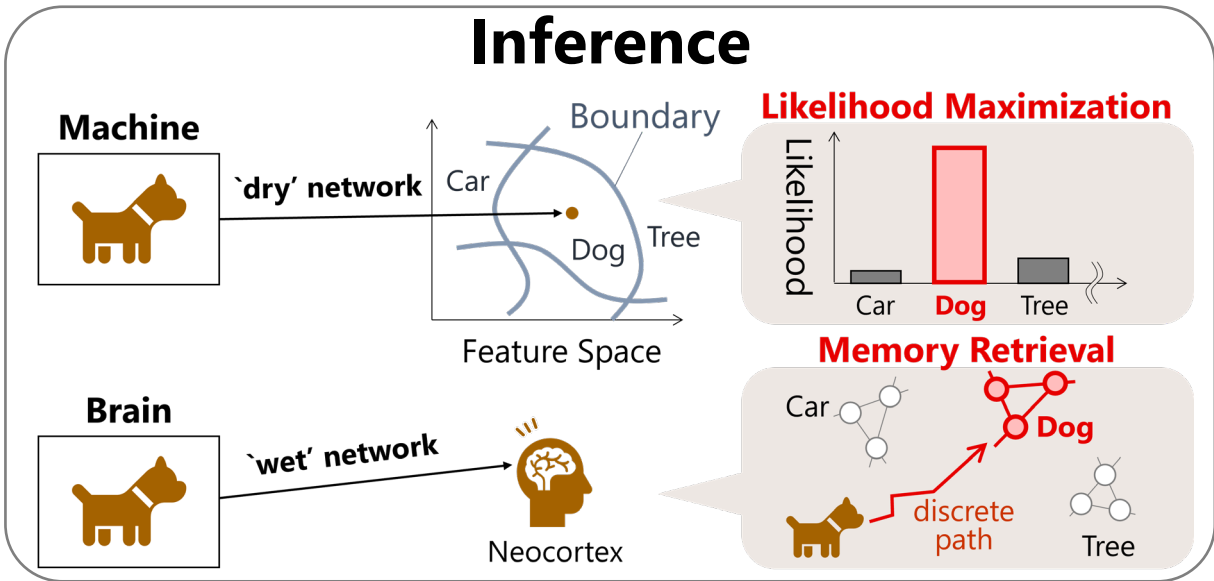
PACS dataset, image from J. Xu, et al., 2019.



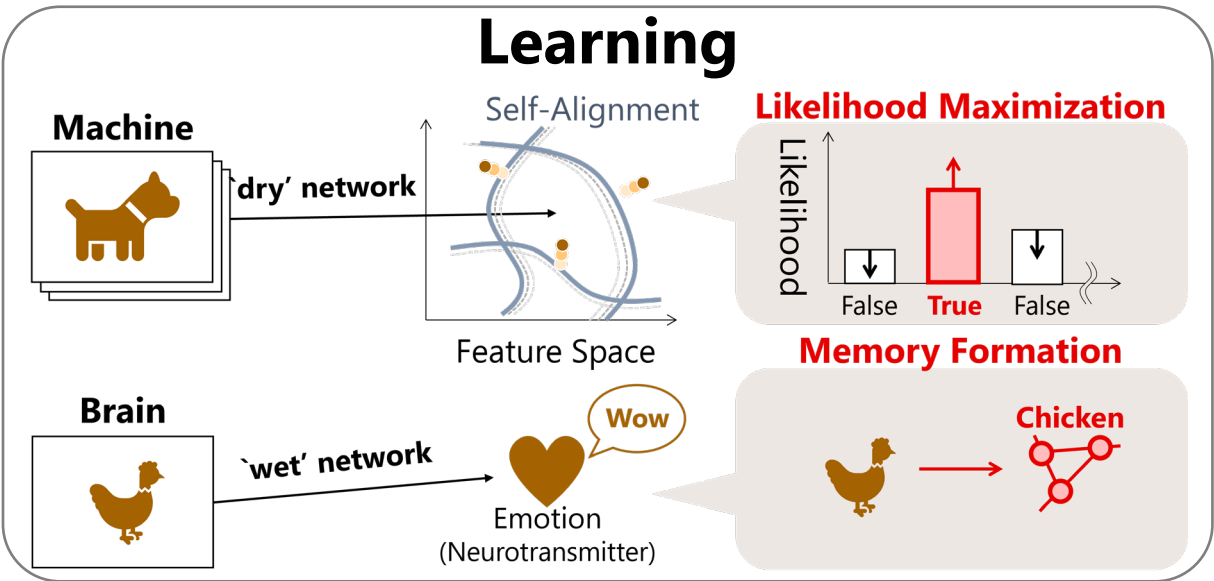
Performance gap between machines and brains

Differences between Machine and Brain

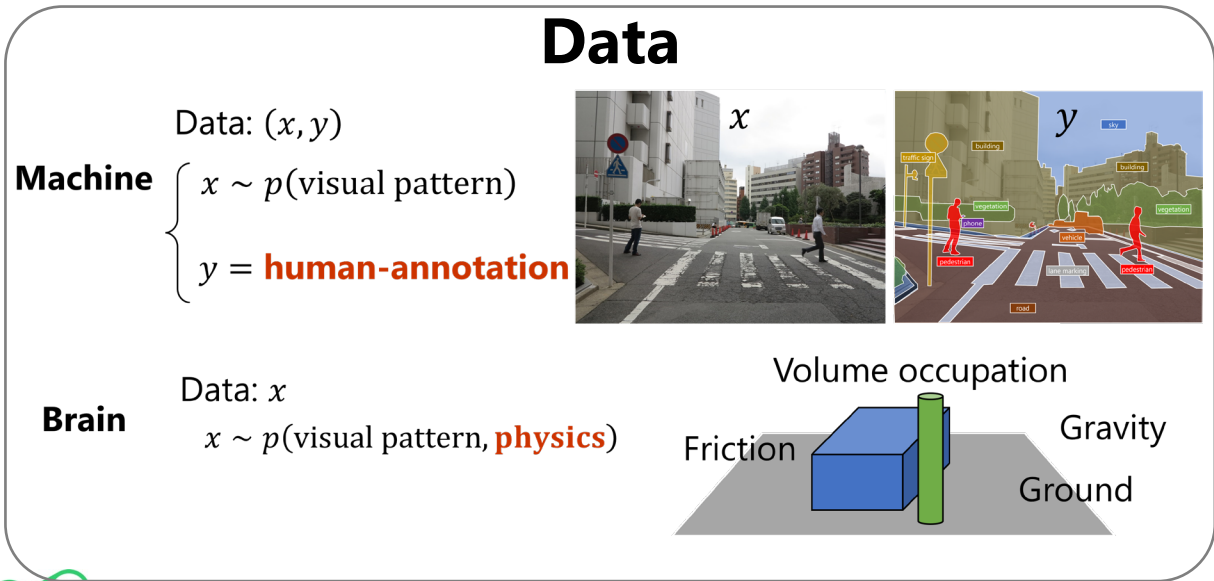
Inference



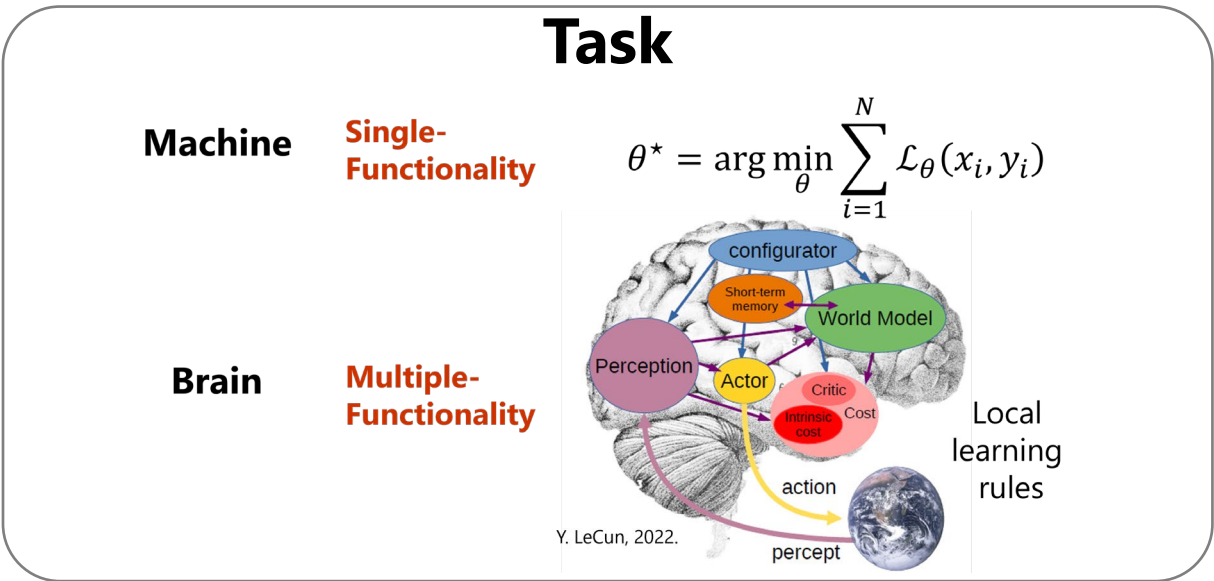
Learning



Data



Task



Replacement of Human Vision with Machines

Machine-Learning Modeling

Memory

**Discrete
Represent-
ation**

**Physical
Consistency**

**Multi-
Functionality
(Local Update)**

**Generic
Feature**

**Multi-
Modality**

**Self-Super
vision**

**Metric
Learning**

**Bayesian
NN**

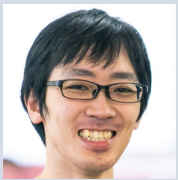
etc.

Research Theme

Collaborators



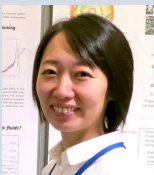
T. Ota



K. Ishikawa



N. Inoue



R. Kawakami



M. Tanaka



I. Sato

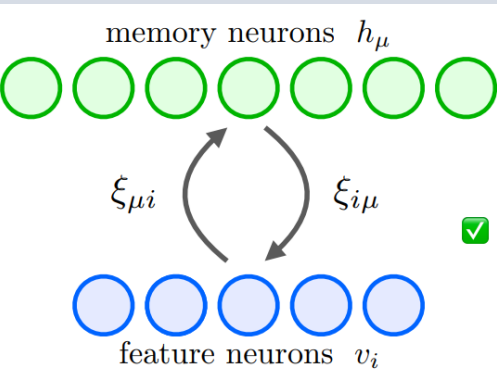
Background

Memories expressed by fixed points of a closed network (Krotov & Hopfield, 2021)

Specific formulation → Self-Attention Mechanism

Contribution

Embedded forgetting functionality of memories during training improves recognition performance.



Baseline	0.21
Ours	0.18 😊

→ Error rate
Immune repertoire classification accuracy

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Research Theme

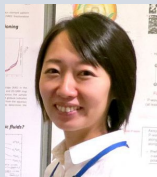
Collaborators



R. Yamada



N. Inoue



R. Kawakami



M. Tanaka



I. Sato

Background

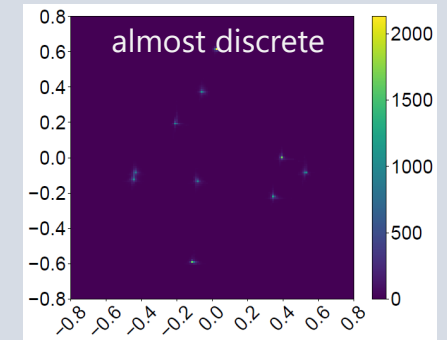
Discrete representations obtained by breaking layer-wise co-adaptation (I. Sato et al., 2019)

Contribution

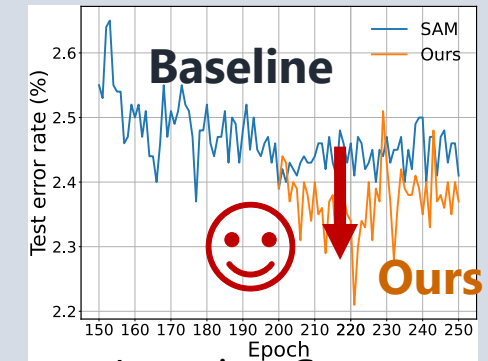
Showed such an optimizer flattens loss landscape.

- Theoretical derivation
- Demonstration of high recognition accuracy

Received MIRU Nagao Prize (2022).
Accepted to ICML2022.



2D distribution of representations



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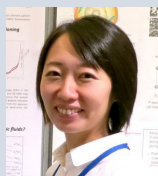
etc.

Research Theme

Collaborators



R. Isobe



R. Kawakami



I. Sato

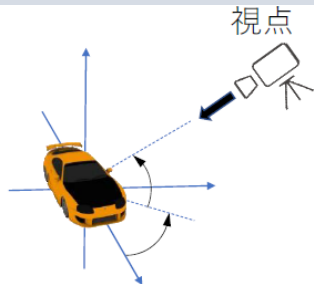
Task

To predict viewing direction to an object

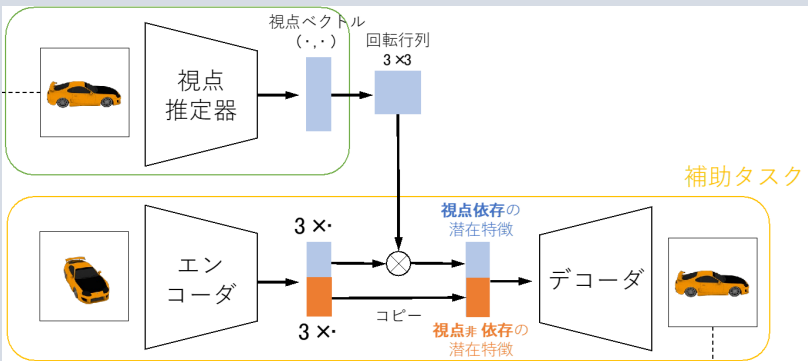
Contribution

Found that auxiliary image generation task can enhance physical consistency.

- Demonstrated outperformance of existing method



Viewing direction prediction task



Proposed model

Memory

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Represent-
ation

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(Local Update)

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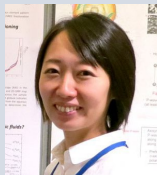
etc.

Research Theme

Collaborators



T. Shibuya



R. Kawakami



N. Inoue



I. Sato

Background

Target Propagation has been proposed as a biologically-plausible deep net training algorithm.

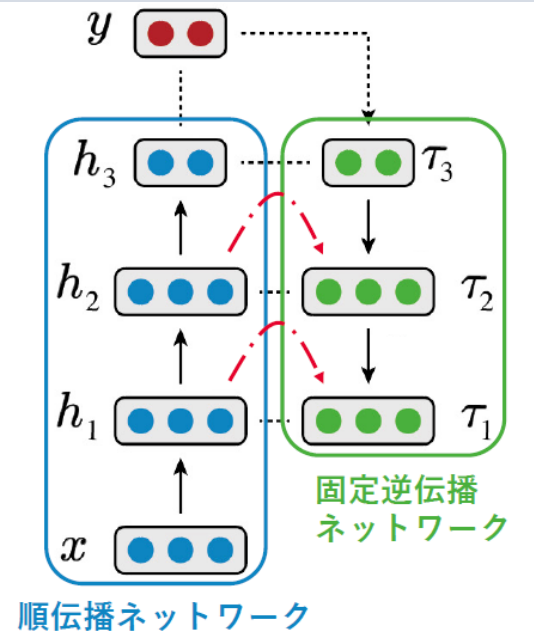
- Local learning rules

Contribution

Proposed a new learning rule, much simpler than existing approaches.

- Robust to different hyperparameter settings

Received MIRU Interactive Presentation Award (2022).



Memory

Discrete Represent-ation

Physical Consistency

Multi-Functionality (Local Update)

Generic Feature

Multi-Modality

Self-Super vision

Metric Learning

Bayesian NN

etc.

Summary

- We, RLA Lab., are **one of the largest research groups on recognition and learning** in Japan.
- We aim to develop algorithms for **replacing human vision with machines**.

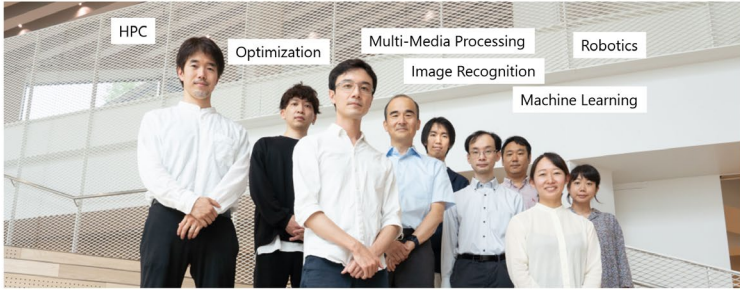
DENSO IT LAB Recognition and Learning Algorithm Collaborative Research Chair <https://d-itlab.c.titech.ac.jp/>

Recognition and Learning Algorithm Laboratory DENSO IT LAB 東京工業大学 Tokyo Institute of Technology

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