A Fast Object Recognizer with a Very Small Number of Information using Human Cognitive-Inspired Computation Model

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Board of Supervisors dan *Co-Founder*, *Indonesia Artificial Intelligence Society* (IAIS)
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INAPR Weekly Seminar
1 Juli 2022

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Maha Mengetahui (Memiliki Ilmu) , the All Knowing

"Mereka menjawab: 'Maha Suci Engkau, **tidak ada yang kami ketahui selain dari apa yang telah Engkau ajarkan kepada kami**; sesungguhnya Engkaulah Yang Maha Mengetahui lagi Maha Bijaksana"

*"They said, "Exalted are You; **we have no knowledge except what You have taught us**. Indeed, it is You who is the Knowing, the Wise"*

(QS. Al-Baqarah: 32)

Outline

- INTRODUCTION
- BACKGROUND AND SUPPORTING THEORIES
- IMPLEMENTING THE FAST OBJECT RECOGNIZER
- CONCLUSION AND FURTHER WORKS

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- Senior Electrical Engineer Officer at Abdulrachman AFB, 2nd Operation Command, Indonesian Air Force

https://www.linkedin.com/in/a-prof-dr-ir-arwin-datumaya-wahyudi-sumari-s-t-m-t-ipm-asean-eng-acpe-a2378169/

https://scholar.google.co.id/scholar?hl=en&as_sdt=0%2C5&q=arwin+datumaya+wahyudi+sumari&oq=

https://www.scopus.com/authid/detail.uri?authorId=35175182800

https://www.researchgate.net/profile/Arwin_Sumari

Military (Indonesian Air Force)

- Indonesian Air Force Academy – 1991 (2nd Lt.)
- School of Electronic Officer Branch – 2002 (Captain)
- School of Unity of Command – 2003 (Captain)
- School of Command and Staff – 2011 (Lt.Col.)
- Defense Management Course, NPS, USA – 2014 (Colonel)
- National Security Leadership, George Washington University, USA – 2014 (Colonel)

Academic Career

- S.T. in Electronics Engineering ITB, focus on Artificial Neural Networks (ANN) – 1996
- M.T. in Computer Engineering ITB, focus on Multi-Agent System (MAS) – 2008 Fast-Track to S-3 in 2007
- Dr. in Electrical Engineering and Informatics ITB, focus on Cognitive Artificial Intelligence (CAI) – 2010
- Team Leader, Cognitive Artificial Intelligence Research Group (CAIRG) since 2019
- Assistant Professor on Assymetric Warfare, IDU – 2015
- Adjunct Professor, Perbanas Institute - 2017
- Secretary, Indonesia Artificial Intelligence Society – 2019-2021
- Adjunct Professor, State Polytechnic of Malang – 2019

Our Team

Cognitive Artificial Intelligence Research Group (CAIRG)

Established in 2007 by Prof. Dr-ing. Ir. Adang Suwandi Ahmad, DEA, IPU (RIP in 2019) succeeded by Colonel Dr. Ir. Arwin Datumaya Wahyudi Sumari, S.T., M.T., IPM, ASEAN Eng., ACPE

A Collaboration of Researchers from Universities and Institutions to Advocate the Application of Cognitive Artificial Intelligence for Humankind

Republic of Indonesia

Original Indonesian Cognitive AI Technology – Knowledge Growing System (KGS)

A system that is **capable of growing its own knowledge** as the accretion of information it receives as the time passes

(Arwin Datumaya Wahyudi Sumari & Adang Suwandi Ahmad, 2009)

Growing the Knowledge → Intelligent Activity → Cognitive

Invented in 2008, Registered Patent in 2019, https://pdki-indonesia.dgip.go.id/index.php/paten/bkp4UkZEY2NsWURwYmduMGIvdDJ1dz09?q=P00201902101&type=1

International Best Paper Award – Italy 2016
Elementary Mechanism of KGS

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4th INTERNATIONAL CONFERENCE on
Advances In Computing, Electronics and Communication

ACEC'16
15-16 December (Thursday & Friday), 2016

Certificate

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https://stei.itb.ac.id/id/blog/2017/02/06/kolonel-lek-dr-arwin-datumaya-wahyudi-sumari-raih-penghargaan-internasional/

Cognitive AI and KGS R&D Milestones

2008 – The invention of Maximum Score of the Total Sum of Joint Probabilities (MSJP) as new learning method for intelligent agent also MAS

2010 – Knowledge Growing System (KGS) as a new perspective in AI – stated and published

2018 – Cognitive Processor based on KSG

2019 – 3 Registered Patents for KGS CAI

2020 – KGS for Covid-19 Detection System with BPPT (1 more Registered Patent)

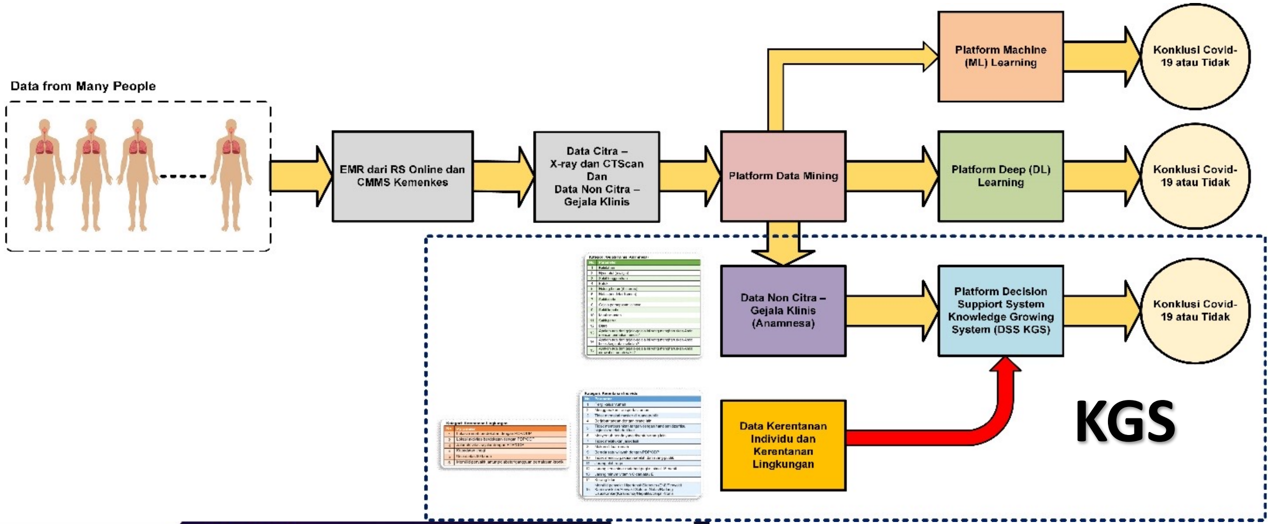
2021-2023 – KGS for Object Recognition and Identification supported by US Navy/Army/Air Force

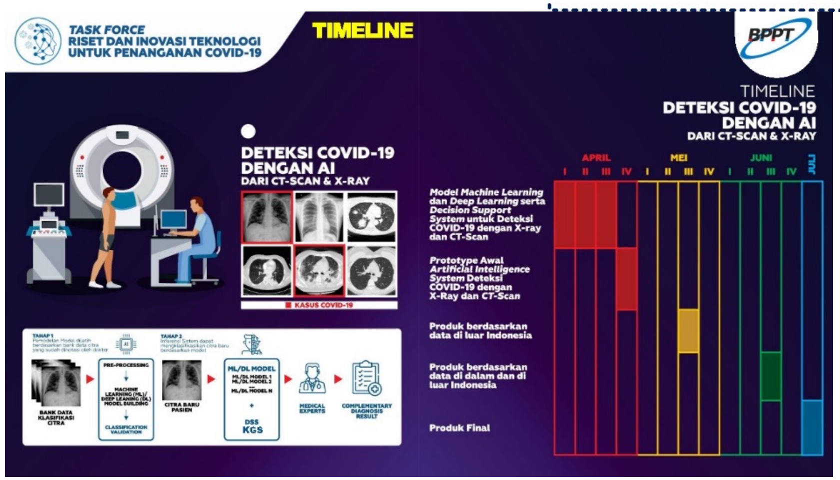
- 2008 – KGS for Military Operation Decision Making
- 2009 – KGS for Genes Behavior Analysis
- 2011 – KGS for Multi-Agent Collaborative Computation
- 2015 – Intelligent Information Fusion for Indonesian Coast Guard
- 2017 – Cognitive C4ISR
- 2018 – CAI for Humankind Published Internationally
- 2019 – KGS for Dissolve Gas Analyis
- 2019 – KGS Cognitive Countermeasure for Cyber Defense
- 2019 – KGS Intrusion Detection System (IDS) (on going)
- 2020 – Computer Application of KGS for Military Operation Decision Making (on going)
- 2020 – KGS for Face Recognition
- 2021 – Award Grant from ONRG, AOARD, and CCDC ITC (In Progress)

KGS Use-Cases

- Intelligence Analysis (Military. Maritime Security)
- Strategic/Military Decision Making
- Bioinformatics/Genetic Regulatory System
- Predictive Electrical Equipment Maintenance
- Health/Heart-Attack Prediction
- Weather Prediction
- Cognitive Processor
- Hardware Security/Cognitive Countermeasure
- Intrusion Detection System
- Pandemic Prediction
- Natural Disaster Prediction
- Face Recognition
- Energi Usage Management
- Cyber Defense/Cyberattack Prediction

KGS Contribution to Solve National Problem





Task Force for Research and Technology Innovation for COVID-19 (TFRIC-19) https://tfric-19.id/

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Septafiansyah Dwi Putra

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Researcher on Information System (Indonesia)

Baihaqi Siregar

Researcher on Brain Computing System (Indonesia)

INTRODUCTION

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31 May 2022

A fast object recognizer with a very small number of information using human cognitive-inspired computation model

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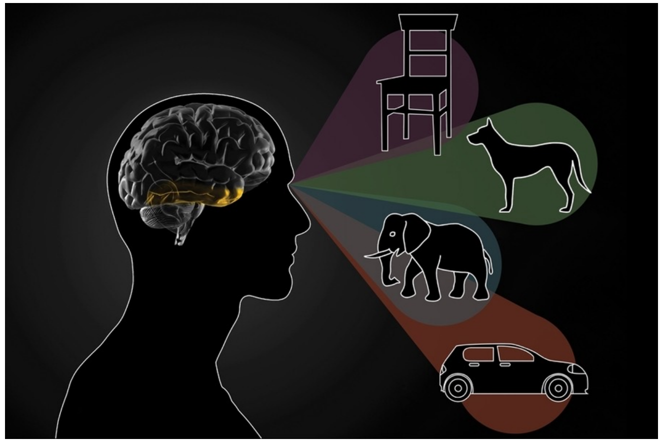
Human Recognition Ability

https://news.mit.edu/2019/inferotemporal-brain-object-recognition-0313



- Very easy for human
- Five sensors
- Need knowledge

Partial sensor =>
Partial information =>
Partial Knowledge

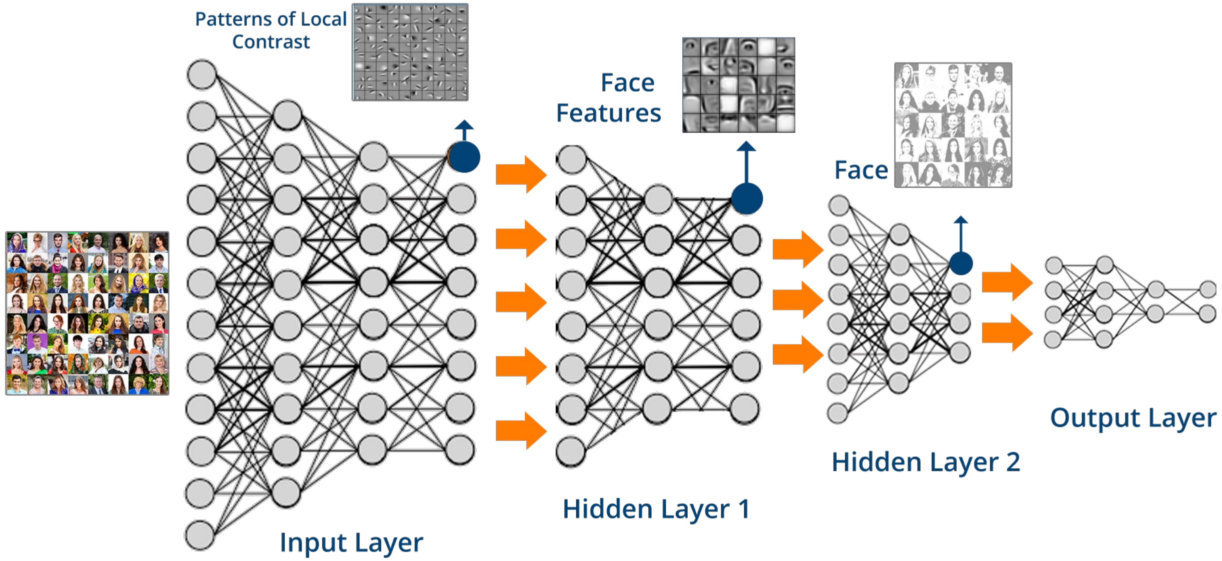
Learning from Past Data/Experience → Deep Learning

Learning by Interaction → Knowledge Growing System (KGS)

BACKGROUND AND SUPPORTING THEORIES

The Boundaries of Deep Learning

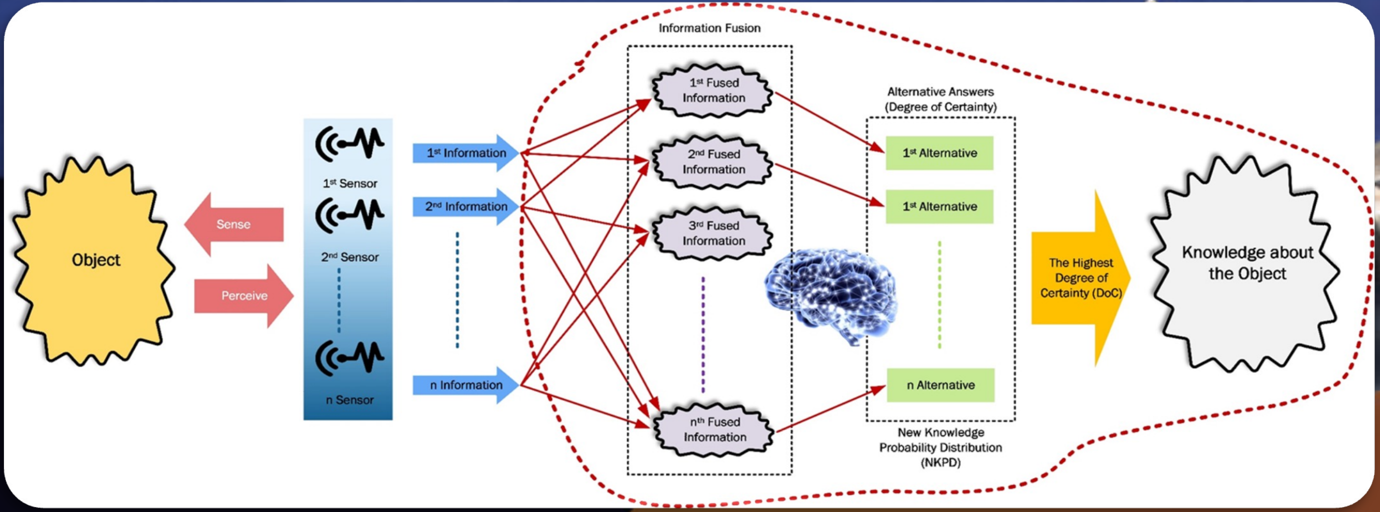
- Massive amount of data (min. 1,000 data)
- A significant time for data annotations or labels
- High computing power (TPU, GPU, VPU)
- Complex mathematical computations
- Complex network structure
- Black-box phenomenon
- Does not support fast deployment



https://thedatascientist.com/what-deep-learning-is-and-isnt/deep-neural-network-what-is-deep-learning-edureka/

Human Recognition Ability with Data-Available-at-That-Time

- Easy to recognize with **only a few observations**
- Generate or develop sufficient knowledge **with just a few trials**
- Knowledge generated by performing **interactions**
- **Cognitive psychology** approach
- Ability to **combine all information** and **extract** the combined information to become **new knowledge**
- Knowledge is **generated over time**
- Support **fast deployment**



Knowledge Development Method

- $\lambda = \left(2^{\delta} - \delta\right) - 1$
- $P\left(\psi_{\tau}^{j}\right) = \frac{\sum_{j=1}^{\delta} P\left(\vartheta_{i}^{j}\right)}{\delta}$
- $P\left(\psi_{\tau}^{j}\right)_{estimate} = \odot \left[P\left(\psi_{\tau}^{j}\right)\right]$
- $P\left(\phi_{\tau}^{j}\right) = \begin{cases} 1, \ if \ \ P\left(\psi_{\tau}^{j}\right) \geq \frac{\sum_{i=1}^{\lambda} P\left(\psi_{\tau}^{i}\right)}{\lambda} \\ 0, \ if \ \ P\left(\psi_{\tau}^{j}\right) < \frac{\sum_{i=1}^{\lambda} P\left(\psi_{\tau}^{i}\right)}{\lambda} \end{cases}$
- $D_{Rj} = \left|P\left(\psi_{\tau}^{j}\right) - P\left(\psi_{R}^{j}\right)\right|$

ASSA2010
Information-Inferencing Method

IMPLEMENTING THE FAST OBJECT RECOGNIZER

Preparing Data-Available-at-That-Time

- Object will be recognized called as **object under observation (OUO)**.
- **No training phase**.
- **No annotation or data labeling**.
- The name of OUO will be informed after KGS develops the knowledge about its characteristics, called as **told-information**.
- If there are several OUOs, **learning by interaction is carried out to each OUO in some defined interaction time**.
- The **number of sensory organs** used are according to the needs.
- The OUO's order numbers are **changed to interaction time order**.

Learning by Interaction Arrangement

S	Ch	OUO1					OUO2					OUO3				
		Interaction Time for OUO1					Interaction Time for OUO2					Interaction Time for OUO3				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
S1	SL	4.80	5.10	4.60	5.30	5.00	5.70	5.70	6.20	5.10	5.70	6.70	6.30	6.50	6.20	**5.90**
S2	SW	3.00	3.80	3.20	3.70	3.30	3.00	2.90	2.90	2.50	2.80	3.00	2.50	3.00	3.40	**3.00**
S3	PL	1.40	1.60	1.40	1.50	1.40	4.20	4.20	4.30	3.00	4.10	5.20	5.00	5.20	5.40	**5.10**
S4	PW	0.30	0.20	0.20	0.20	0.20	1.20	1.30	1.30	1.10	1.30	2.30	1.90	2.00	2.30	1.80

- Iris dataset is defined into **OUO1 to OUO3**.
- Sepal Length (SL), Sepal Width (SW), Petal Length (PL), and Petal Width (PW) => **characteristics (Ch)**.
- Each characteristic is sensed and perceived by different **sensory organ (S1 to S4).**

Knowledge Growing

- The **knowledge** of each OUO or NKPD and the NKPD Estimate are generated and measured with DoC.
- Each DoC will be given **told-information** (S5).
- OUO1 has DoC = 10.04, OUO2 has DoC = 13.70, and OUO3 has DoC = 16.54.
- OUO1's name is **Setosa**, OUO2's name is **Versicolor**, and OUO3's name is **Virginica**.

		OUO1					**OUO2**					**OUO3**				
S	**Ch**	Interaction Time for OUO1					Interaction Time for OUO2					**Interaction Time for OUO3**				
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	**5**
S1	SL	4.80	5.10	4.60	5.30	5.00	5.70	5.70	6.20	5.10	5.70	6.70	6.30	6.50	6.20	**5.90**
S2	SW	3.00	3.80	3.20	3.70	3.30	3.00	2.90	2.90	2.50	2.80	3.00	2.50	3.00	3.40	**3.00**
S3	PL	1.40	1.60	1.40	1.50	1.40	4.20	4.20	4.30	3.00	4.10	5.20	5.00	5.20	5.40	**5.10**
S4	PW	0.30	0.20	0.20	0.20	0.20	1.20	1.30	1.30	1.10	1.30	2.30	1.90	2.00	2.30	**1.80**
	NKPD	9.50	10.70	9.40	10.70	9.90	14.10	14.10	14.70	11.70	13.90	17.20	15.70	16.70	17.30	**15.80**
	DoC	**10.04**					**13.70**					**16.54**				
		Told-Information														
S5	**Ear**	**Setosa**					**Versicolor**					**Virginica**				

Using the Stored Knowledge for Recognition

S	Ch	OUO's Names														
		Setosa					Versicolor					**Virginica**				
		4	13	25	31	40	53	61	75	83	95	103	107	118	123	**139**
S1	SL	4.60	4.80	4.80	4.80	5.10	6.90	5.00	6.40	5.80	5.60	7.10	4.90	7.70	7.70	**6.00**
S2	SW	3.10	3.00	3.40	3.10	3.40	3.10	2.00	2.90	2.70	2.70	3.00	2.50	3.80	2.80	**3.00**
S3	PL	1.50	1.40	1.90	1.60	1.50	4.90	3.50	4.30	3.90	4.20	5.90	4.50	6.70	6.70	**4.80**
S4	PW	0.20	0.10	0.20	0.20	0.20	1.50	1.00	1.30	1.20	1.30	2.10	1.70	2.20	2.00	**1.80**
	NKPD	9.40	10.70	9.40	10.70	9.90	16.40	11.50	14.90	13.60	13.80	18.10	13.60	20.40	19.20	**15.60**
Recognized As		Setosa	Setosa	Setosa	Setosa	Setosa	Virgi-nica	Setosa	Versi-color	Versi-color	Versi-color	Virgi-nica	Versi-color	Virgi-nica	Virgi-nica	**Virgi-nica**
Comparison		**Cor-rect**	**Cor-rect**	**Cor-rect**	**Cor-rect**	**Cor-rect**	**Incor-rect**	**Incor-rect**	**Cor-rect**	**Cor-rect**	**Cor-rect**	**Cor-rect**	**Incor-rect**	**Cor-rect**	**Cor-rect**	**Cor-rect**

KGS Performance

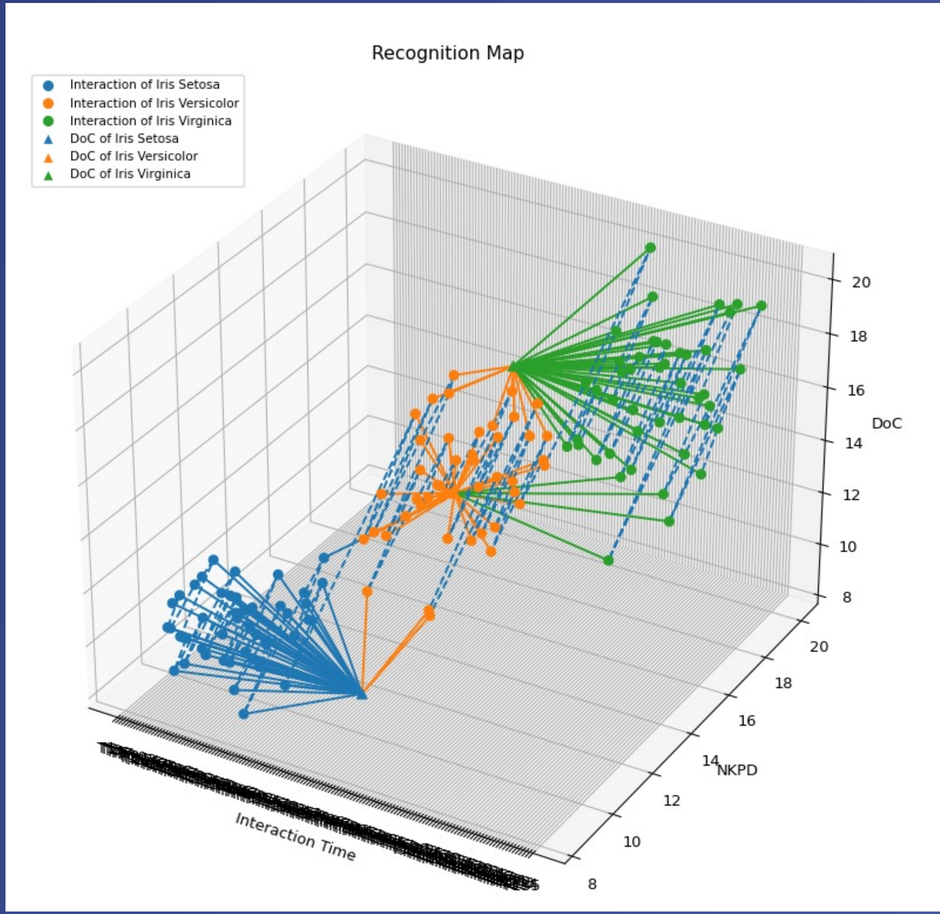
OUO Name	Setosa	Versicolor	Virginica	Total Data	Total Accuracy (%)
Correct	45	38	33	116	85.93
Incorrect	0	7	12	19	14.07
Total Data	45	45	45	135	100
				Average Accuracy	
OUO Accuracy (%)	100	84.44	73.33	85.93	

Example of KGS' Learning By Interaction

Recognition Dataframe

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	...	T126	T127	T128	T129	T130	T131	
SepalLengthCm	5.1	5.2	4.7	4.8	5.4	5.2	5.5	4.9	5.0	4.9	...	6.8	5.7	5.8	6.4	6.5	7.7	
SepalWidthCm	3.5	3.5	3.2	3.1	3.4	4.1	4.2	3.1	3.2	3.1	...	3.0	2.5	2.8	3.2	3.0	2.6	
PetalLengthCm	1.4	1.5	1.6	1.6	1.5	1.5	1.4	1.5	1.2	1.5	...	5.5	5.0	5.1	5.3	5.5	6.9	
PetalWidthCm	0.2	0.2	0.2	0.2	0.4	0.1	0.2	0.1	0.2	0.1	...	2.1	2.0	2.4	2.3	1.8	2.3	
NKPD	10.2	10.4	9.7	9.7	10.7	10.9	11.3	9.6	9.6	9.6	...	17.4	15.2	16.1	17.2	16.8	19.5	
Closest DoC	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	9.6	...	16.92	14.04	16.92	16.92	16.92	16.92	
Recognized As	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	...	Iris Virginica	Iris Versicolor	Iris Virginica	Iris Virginica	Iris Virginica	Iris Virginica	Ve
Given Value	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	Iris Setosa	...	Iris Virginica	Iris Virginica	Iris Virginica	Iris Virginica	Iris Virginica	Iris Virginica	V
Result	True	True	True	True	True	True	True	True	True	True	...	True	False	True	True	True	True	

```
True :   118
False :   17
Accuracy :   87.4074074074074
```



CONCLUSION

CONCLUSION

- Mimicking human capability in recognizing objects with **just a few trials faced to the small number of data and low computing power** has been a challenge for deep learning techniques.
- KGS only uses five data for each object for generating the knowledge or **10% of each group of data and can achieve recognition accuracy up to 85.93% in average**.
- It can be said that **with only a few interaction times with a small computing power, KGS can perform itself as a fast object recognizer** .
- **The combination of KGS and deep learning can emulate the knowledge generation in human's brain**, that is, learning by interaction and learning by experience.

The Differences between KGS and Deep Learning

Measuring Parameter	KGS	Deep Learning
Foundation Science	Cognitive Psychology	Neuroscience
Approach	Emulate Brain Mechanism when Human Thinks	Emulate Brain's Neural Network Works
Knowledge Generation Paradigm	Learning by Interaction	Learning by Experience
The Way of Generating Knowledge	Information-Inferencing Fusion	Updating Synapse Weights
Knowledge Generation Method	ASSA2010	Various Neural-like Computation depended on Problem
Knowledge Generation Time	Very Short	Very Long
Knowledge Generation Paradigm	Unsupervised with Told-Information at the End	Supervised
Mathematical Models	Simple	Complex
Number of Data	Very Little	Massive
Data Annotation	No Required	Required
Data Collection	No Required	Required
Computing Power	Low	High
Training Phase	No Required	Required
Re-trained	No	Yes
Architecture Structure	Simple	Complex
Fast Deployment	Yes	No

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Further Works

- **Improving** single object recognition accuracy as well as total accuracy for multiple object recognition.
- We have seen **some possible approaches** that we can use to improve KGS performance.
- We also **already have other datasets with more features** that are prospective for improving KGS performance.

Thank You !

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