Machine Learning in Radar and Remote Sensing: An Overview

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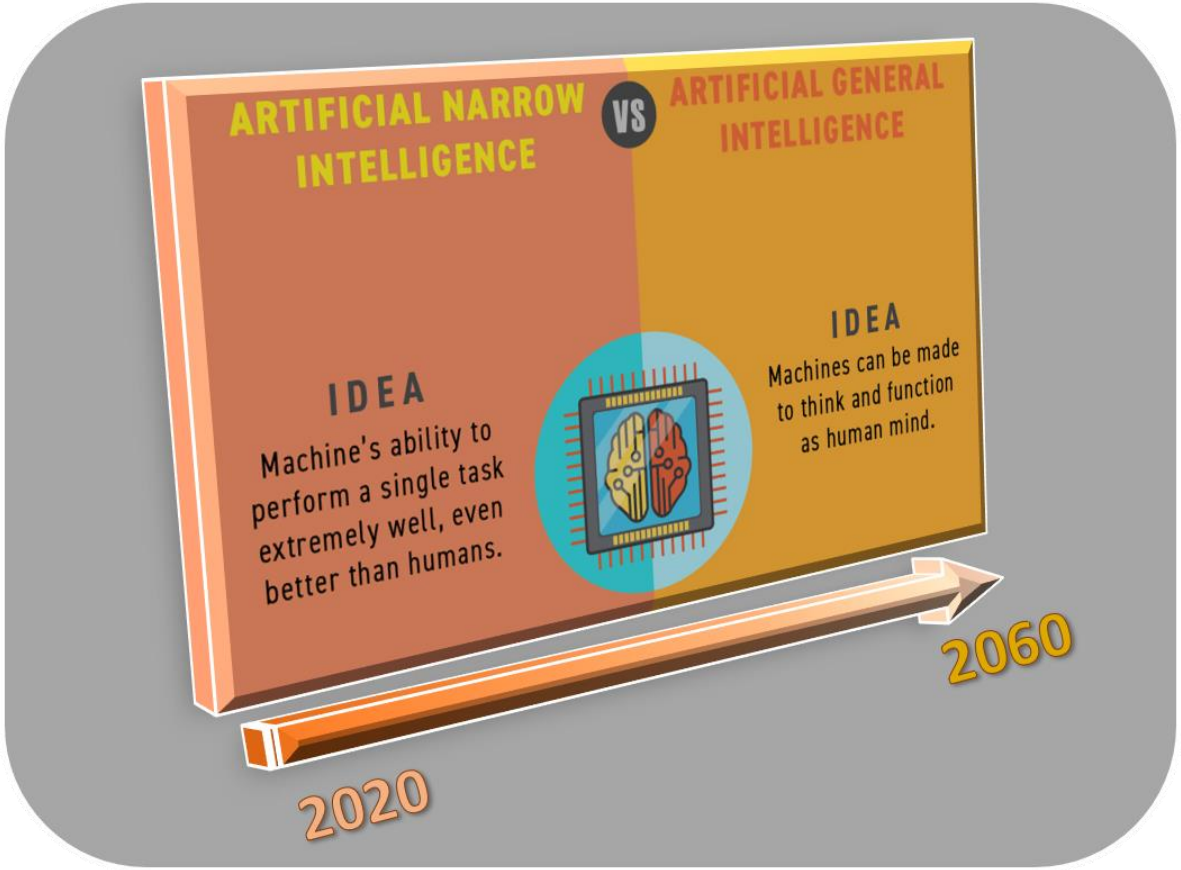
Introduction

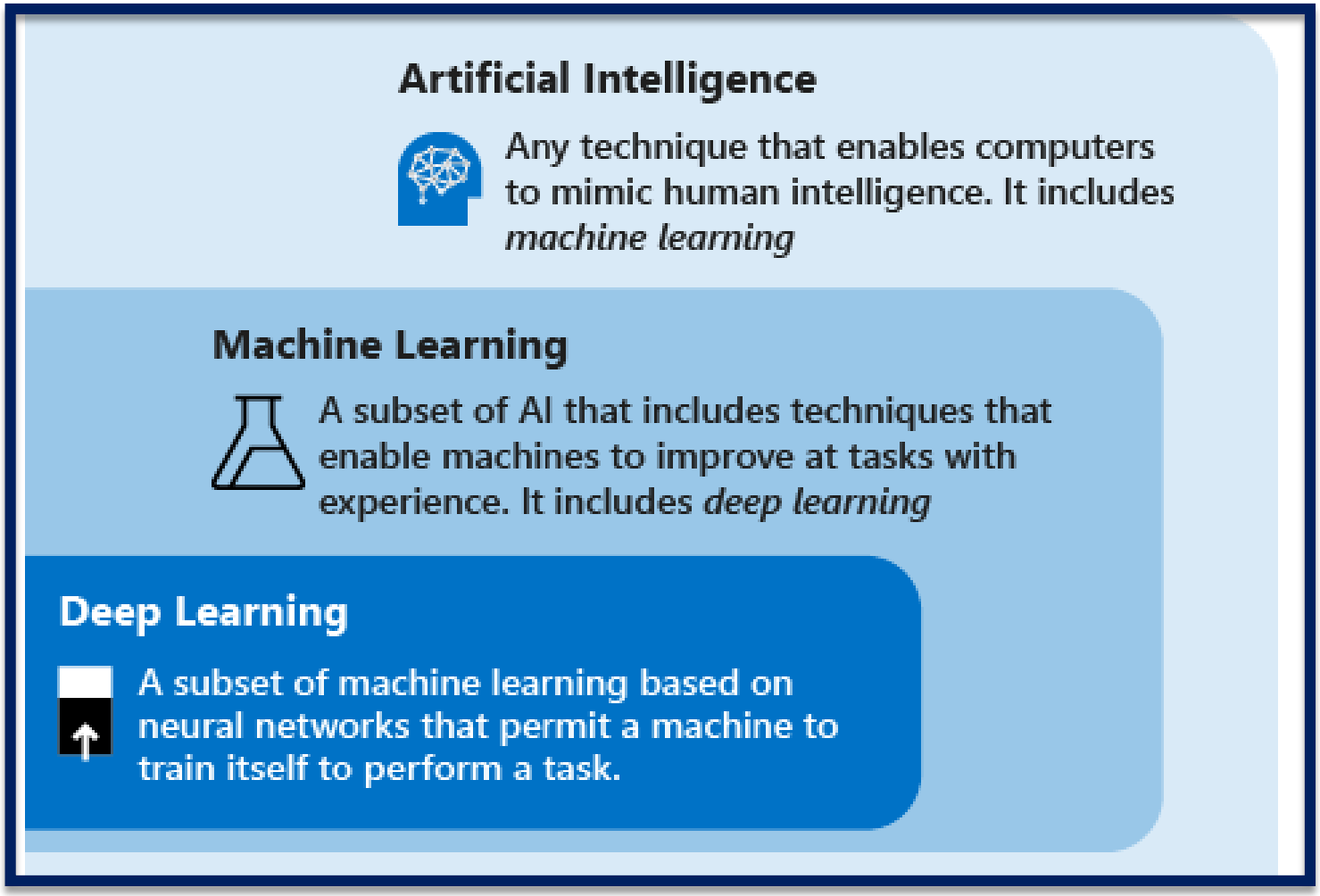
Artificial intelligence (**AI**) is intelligence demonstrated by machines.
AI is the study of "intelligent agents": any device that perceives its environment and takes actions that maximize its chance of successfully achieving its goals.
The term "artificial intelligence" is often used to describe machines that mimic "**cognitive**" functions that humans associate with the human mind, such as "**learning**" and "**problem solving**".

AI applications:

- converting speech to text
- lipreading
- face recognition
- malignant tumours recognition
- price prediction
- film to recommend (Netflix, Amazon Prime Video, etc.
- autonomous driving.



Artificial Intelligence



Machine Learning in formulas

X

Machine

$$Y = f(X; \vartheta)$$

Y

ϑ

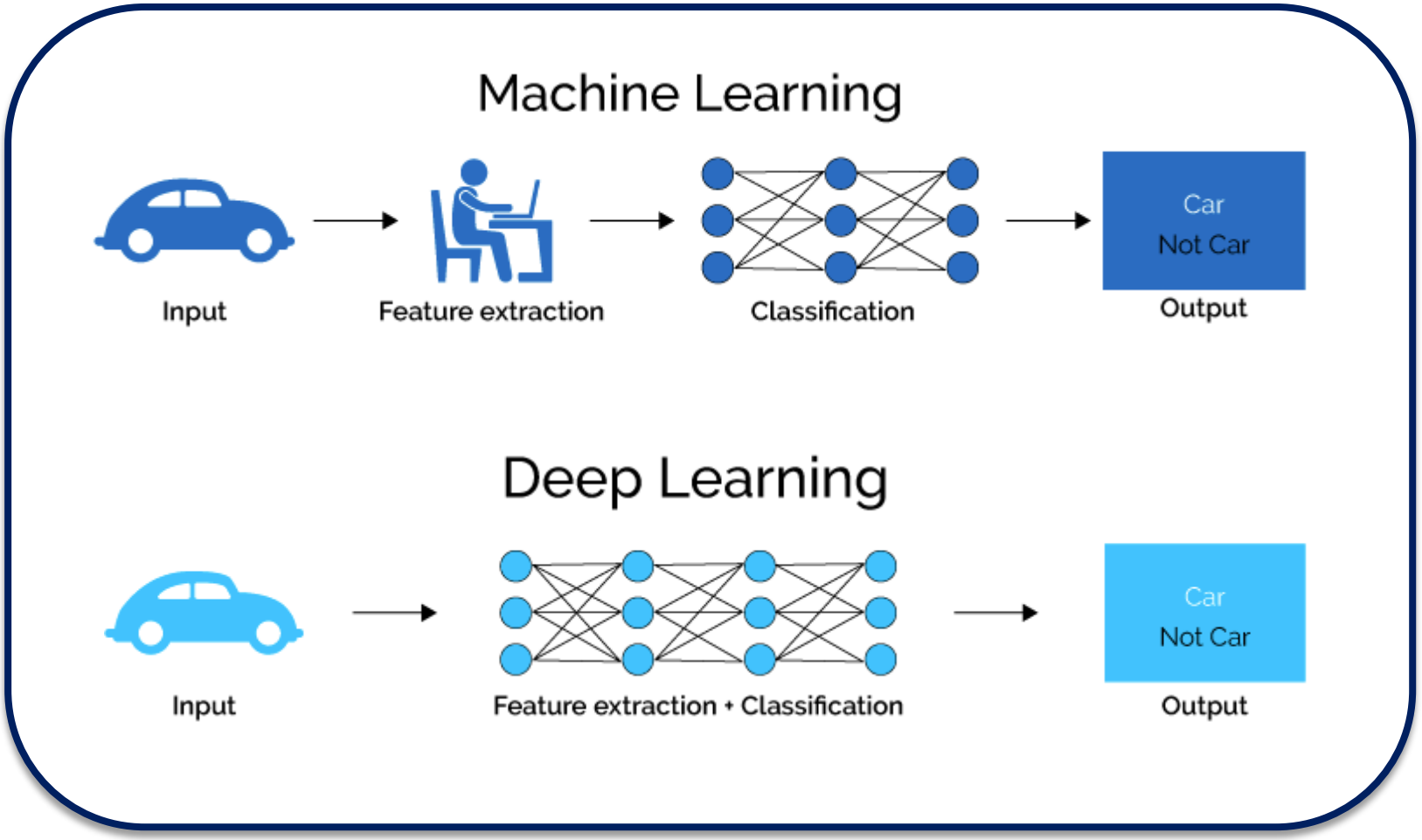
Training Set

$$\{Y_t, X_t\}_{t=1}^{N_t}$$

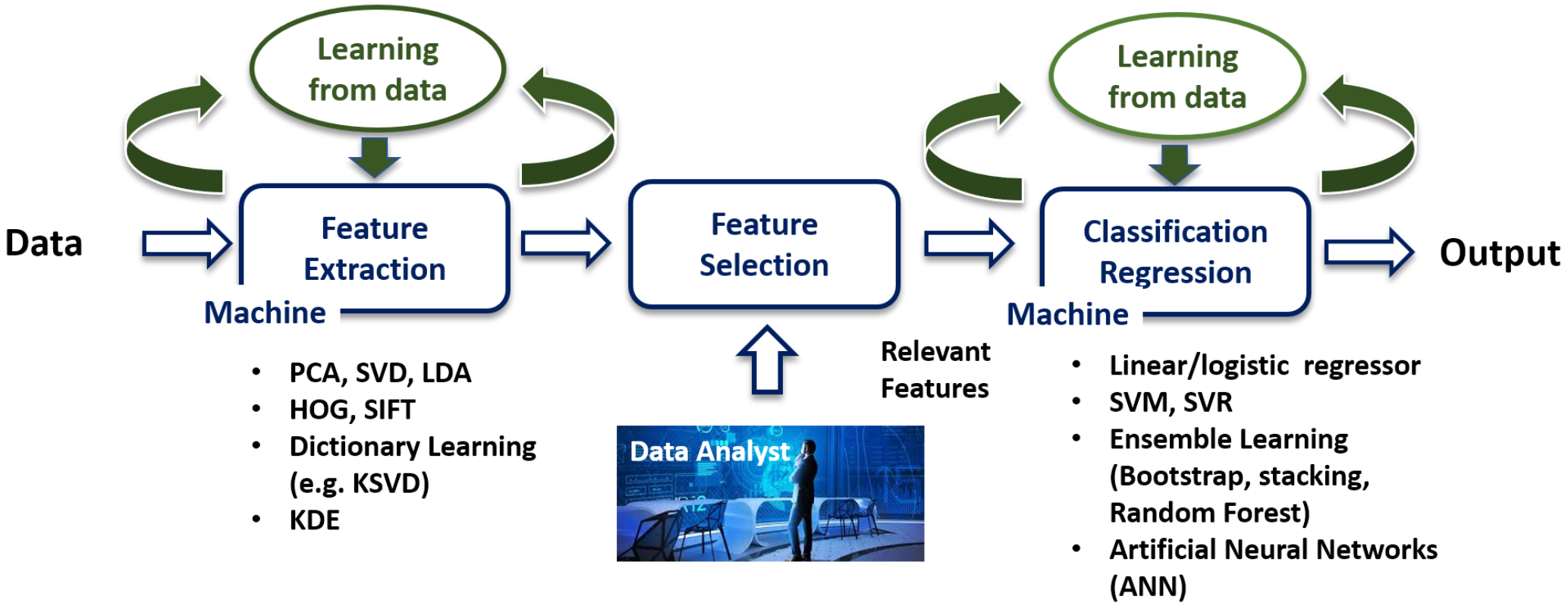
$$\vartheta = \arg\min_{\tilde{\vartheta}} loss\left[Y_t, f(X_t; \tilde{\vartheta})\right] \quad t = 1, \ldots, N_t$$

Learning

Machine Learning vs Deep Learning

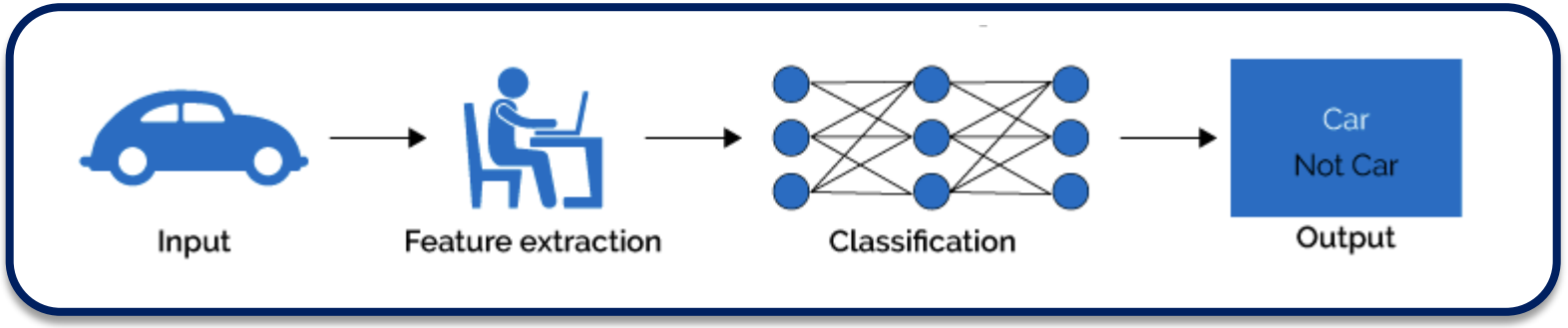


Machine Learning vs Deep Learning



- PCA, SVD, LDA
- HOG, SIFT
- Dictionary Learning (e.g. KSVD)
- KDE

- Linear/logistic regressor
- SVM, SVR
- Ensemble Learning (Bootstrap, stacking, Random Forest)
- Artificial Neural Networks (ANN)



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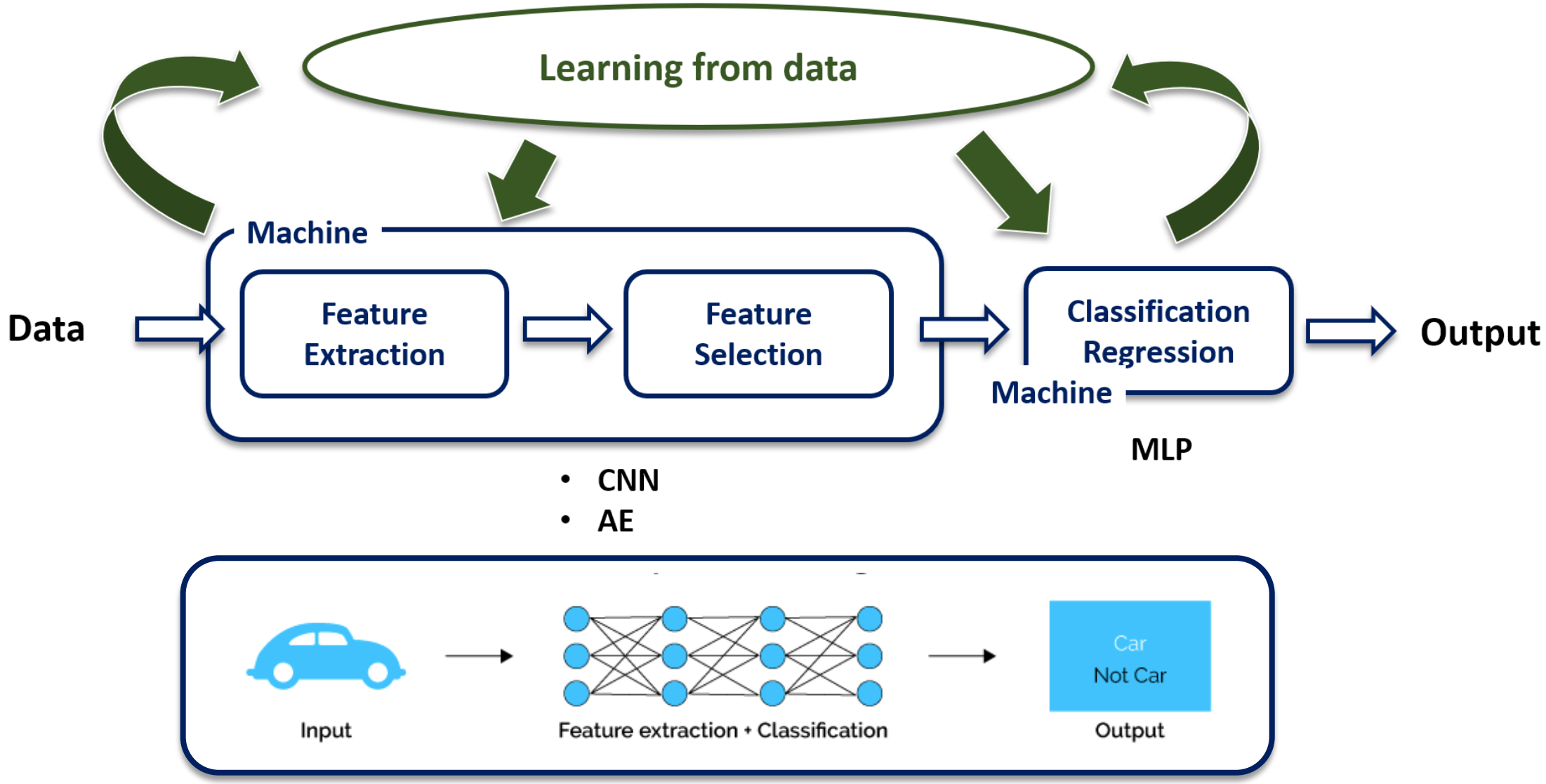
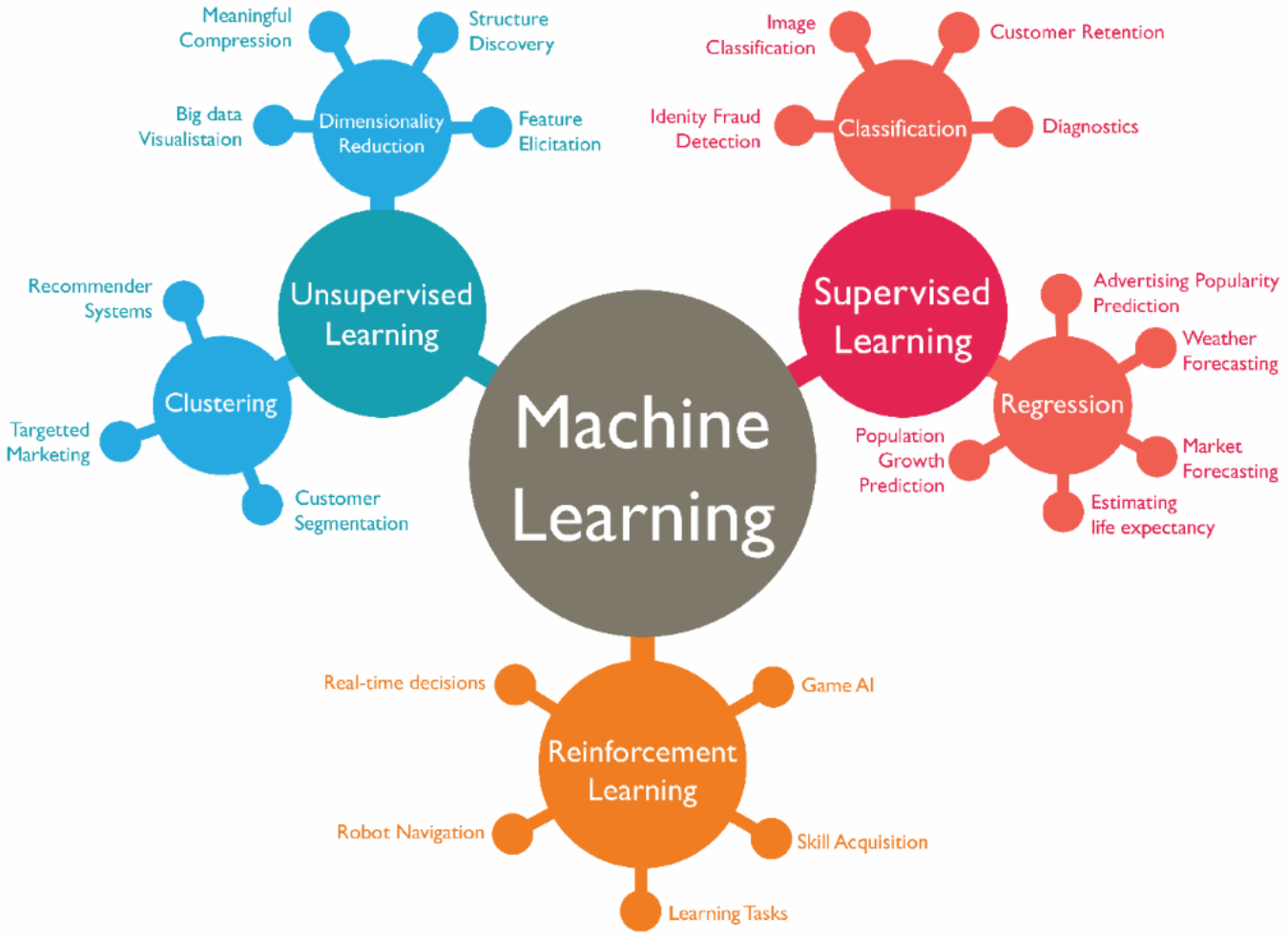


Taxonomy: Learning Paradigms



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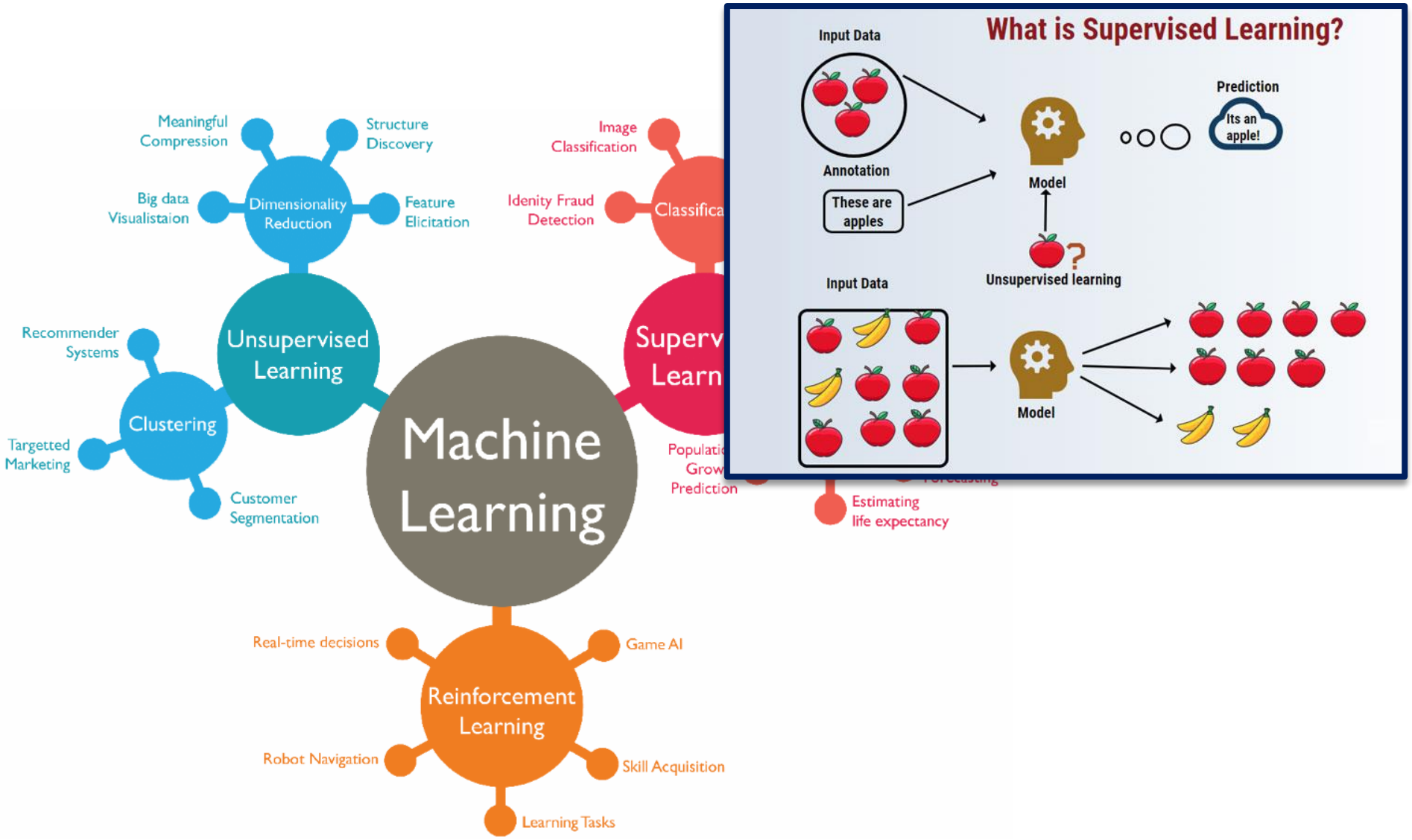

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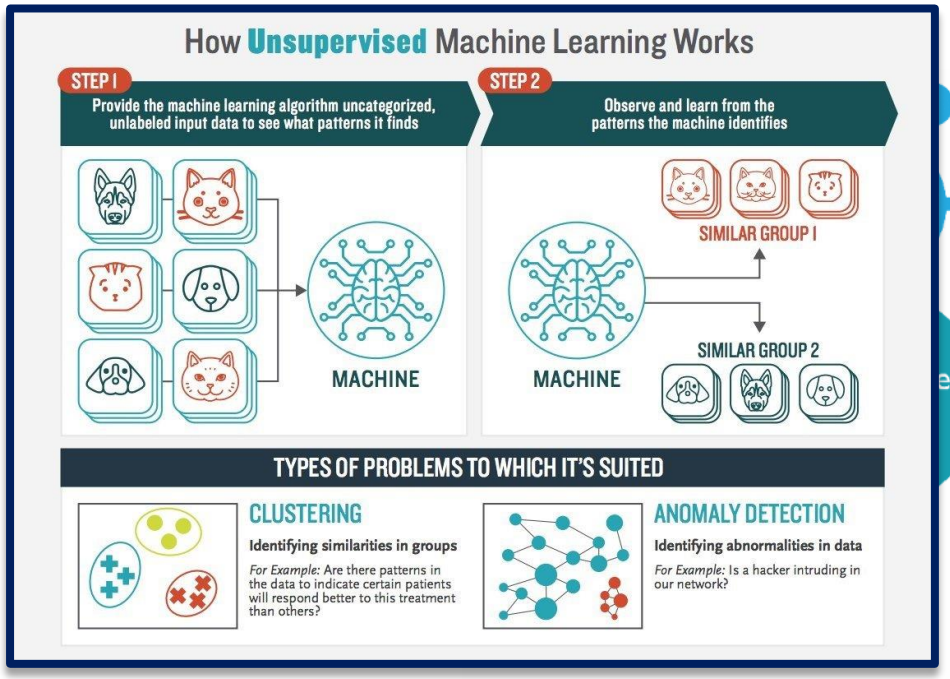

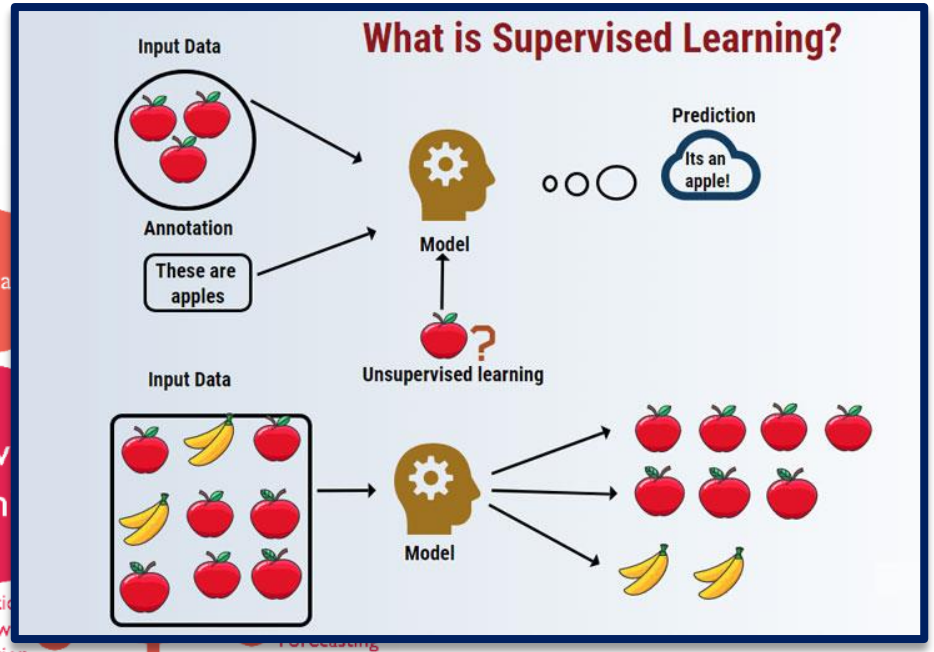

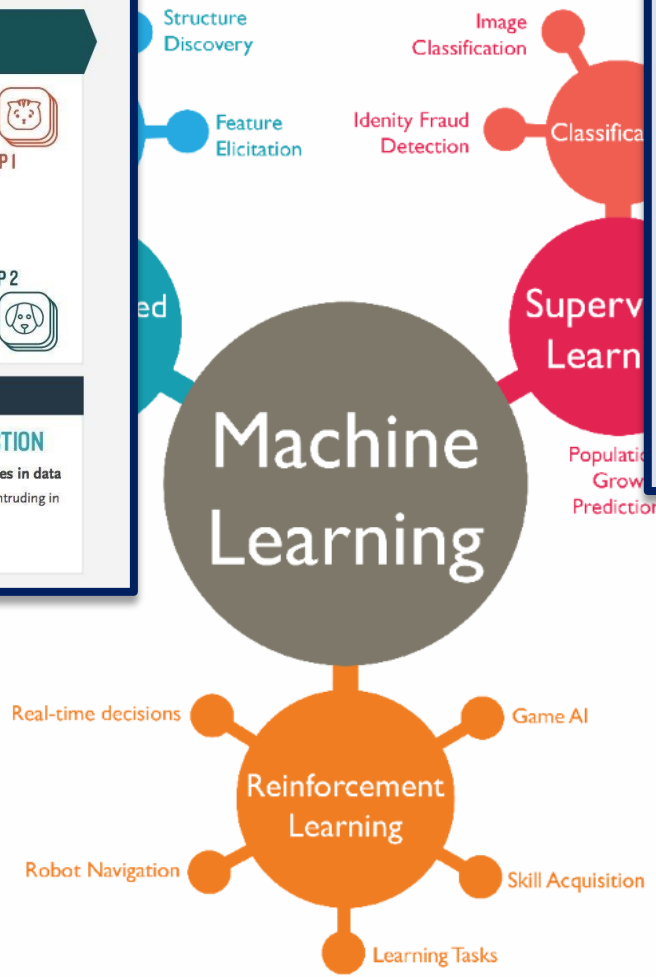

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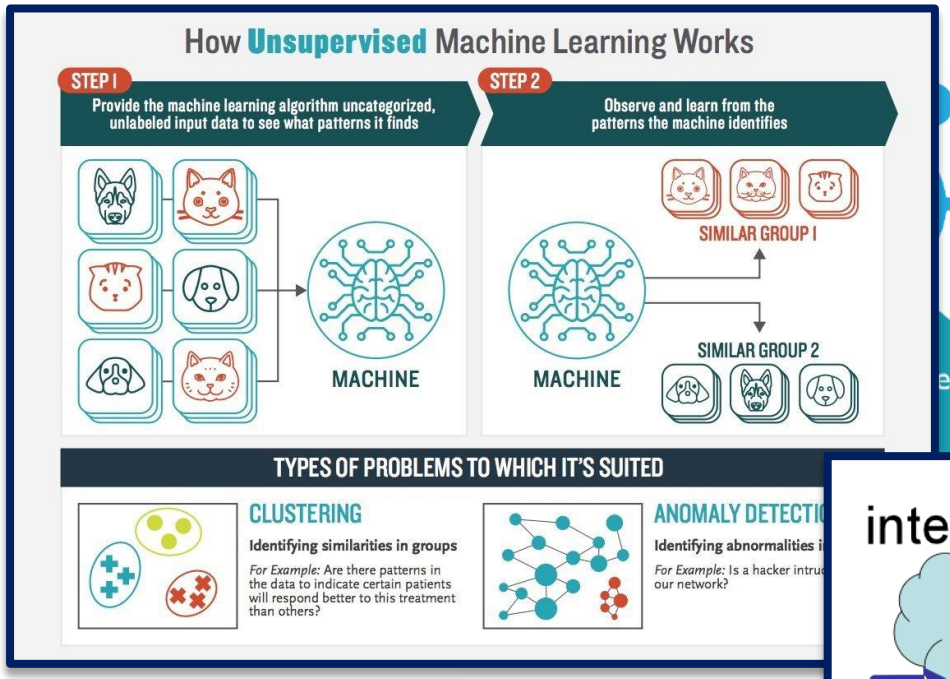
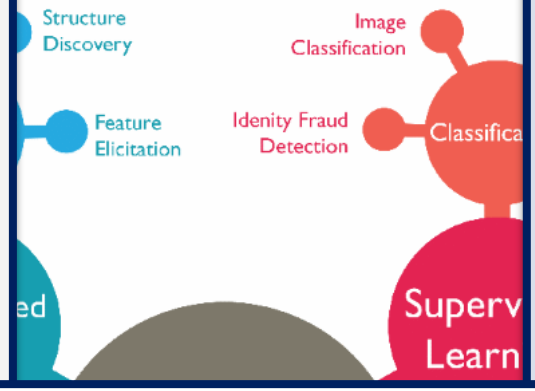
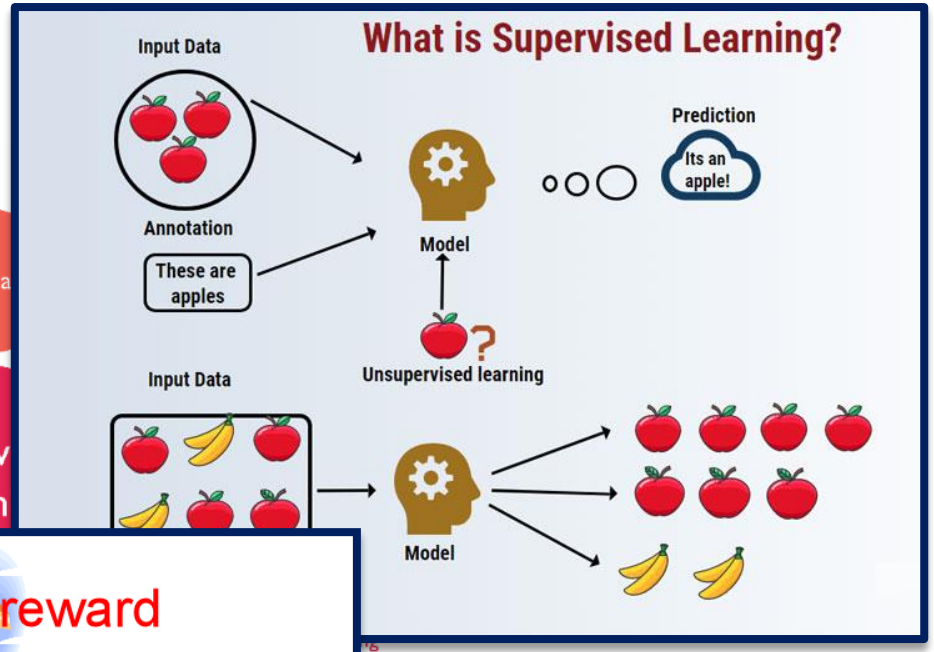
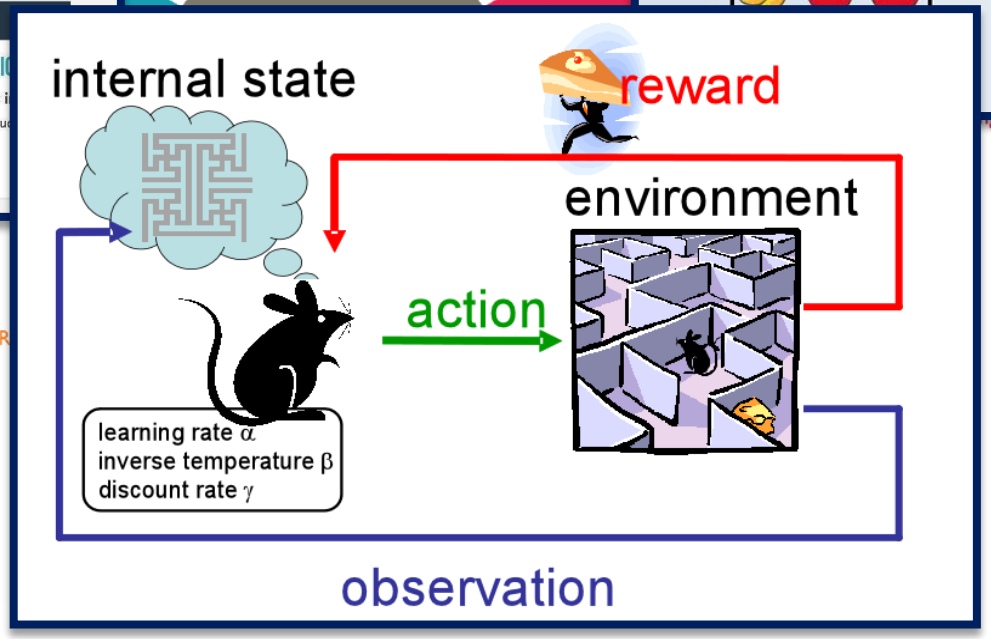
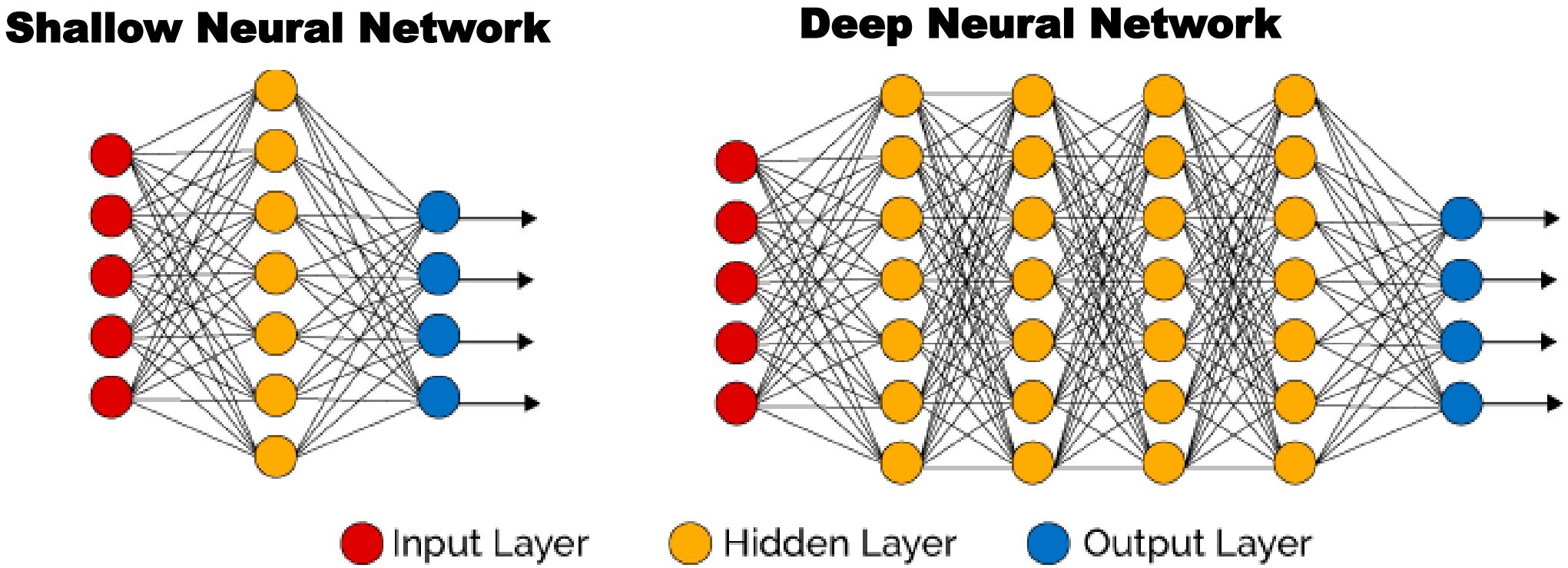






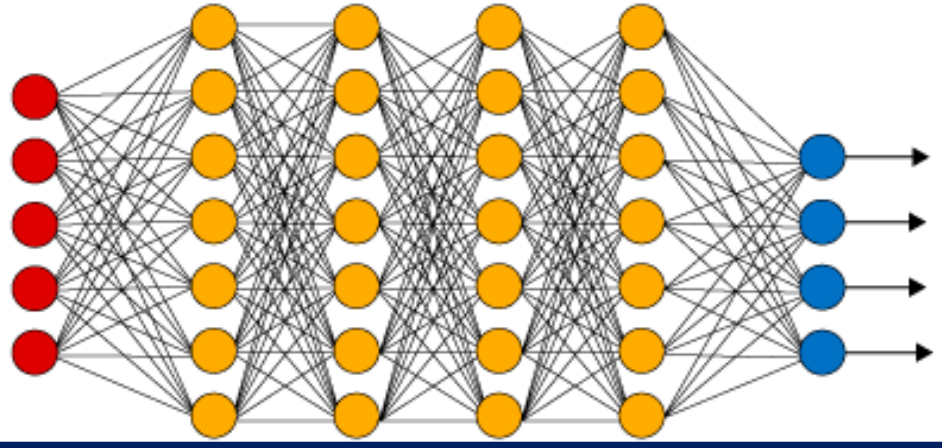


Taxonomy: Depth

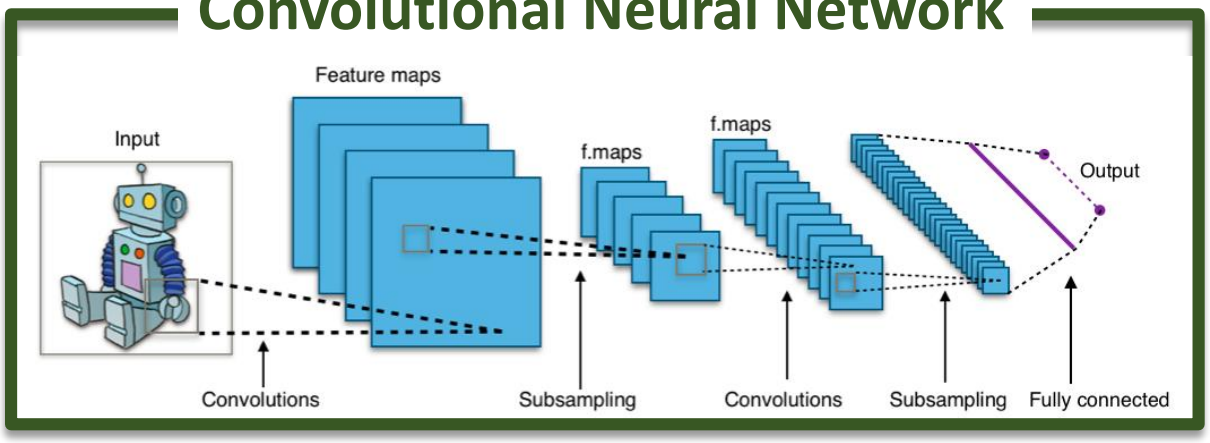


Taxonomy: Architectures

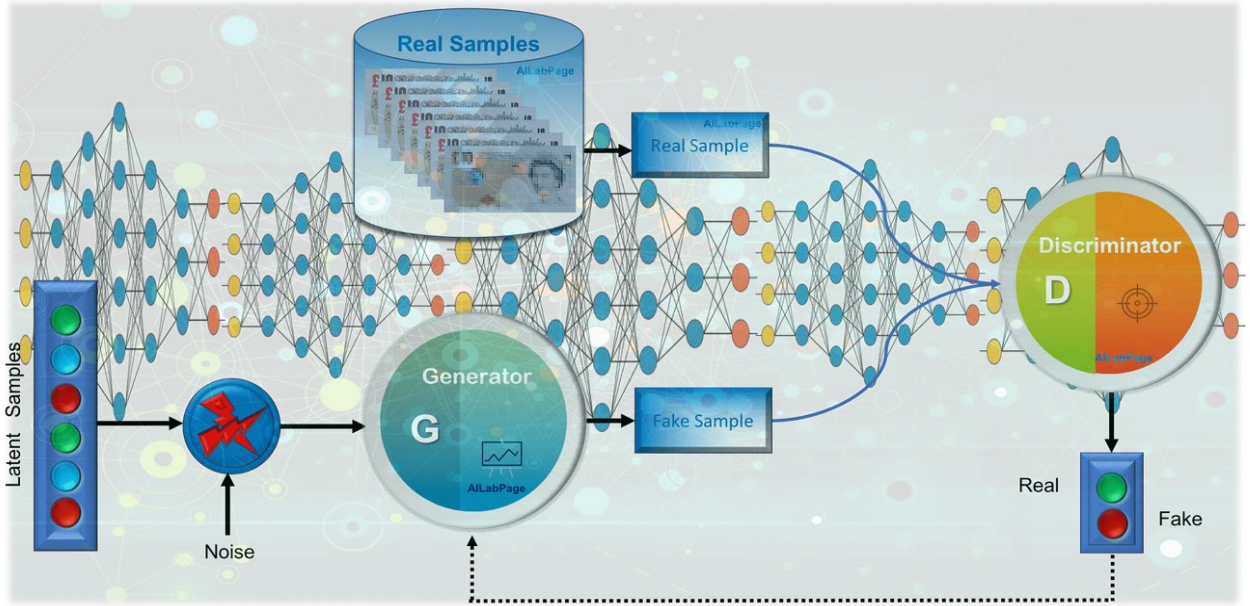
Feedforward Neural Network



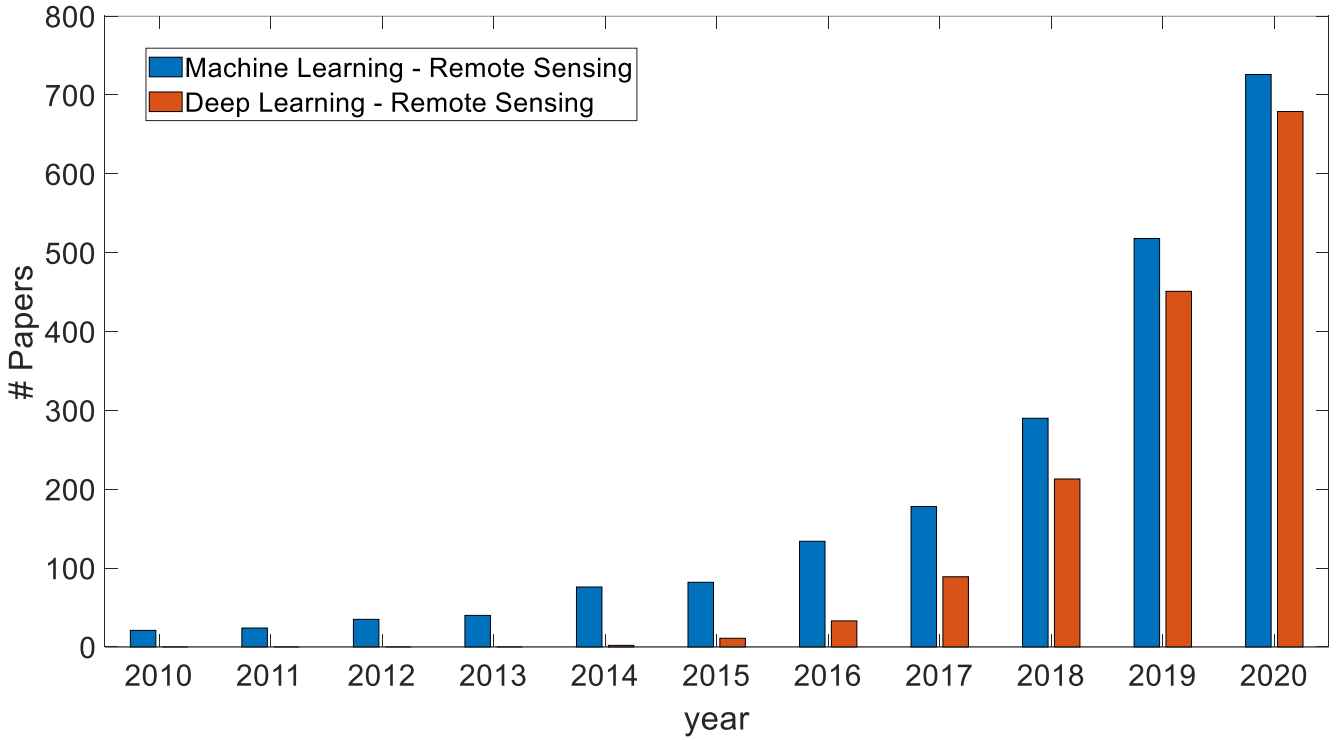
Convolutional Neural Network



Generative Adversarial Network



ML/DL: Remote Sensing



Machine Learning

Source	No of Papers
Remote Sensing	360
ISPRS Journal of Photogrammetry and remote sensing	118
IEEE Journal Of Selected Topics In Applied Earth Observations And Remote Sensing	118
Remote Sensing of Environment	91
International Journal of Remote Sensing	78
IEEE Transactions On Geoscience And Remote Sensing	76
IEEE Geoscience And Remote Sensing Letters	38

Deep Learning

Source	No of Papers
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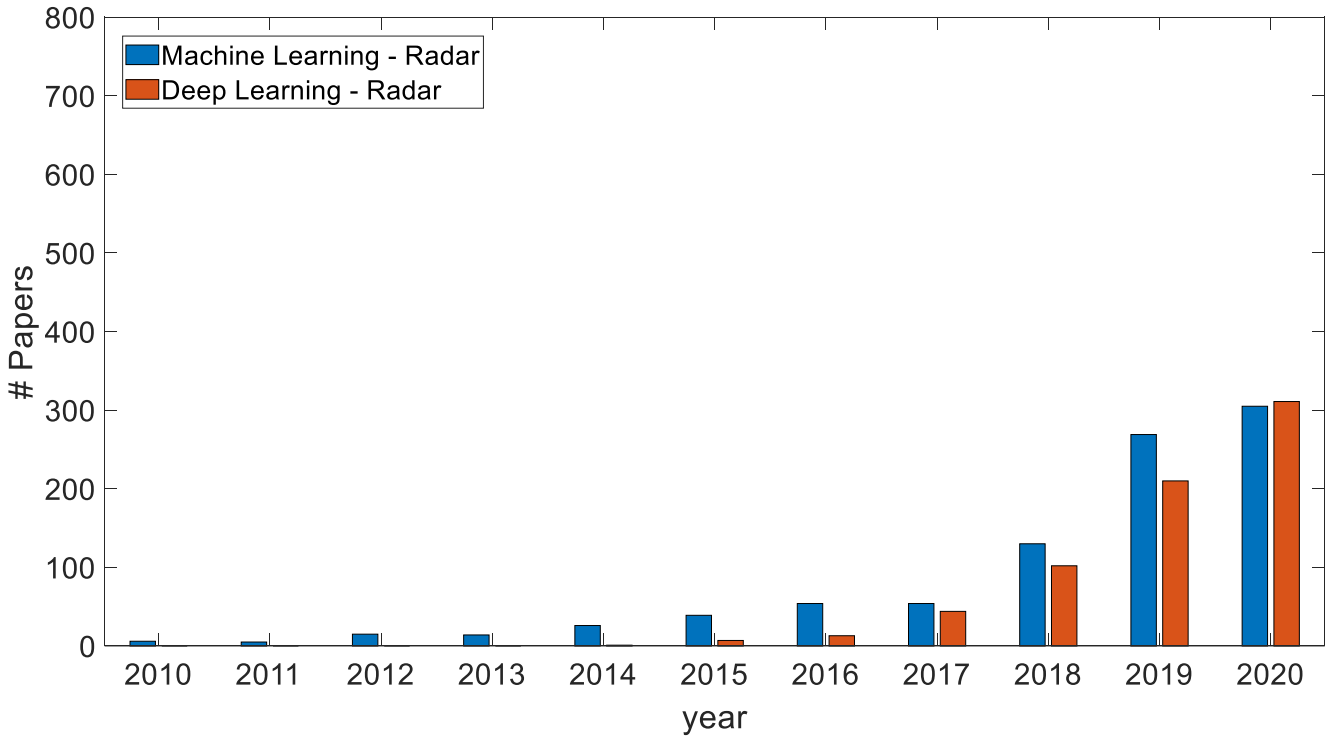
IEEE Geoscience And Remote Sensing Letters	81
IEEE Access	60

ML/DL: Radar



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Deep Learning

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IEEE Transactions On Geoscience And Remote Sensing	29
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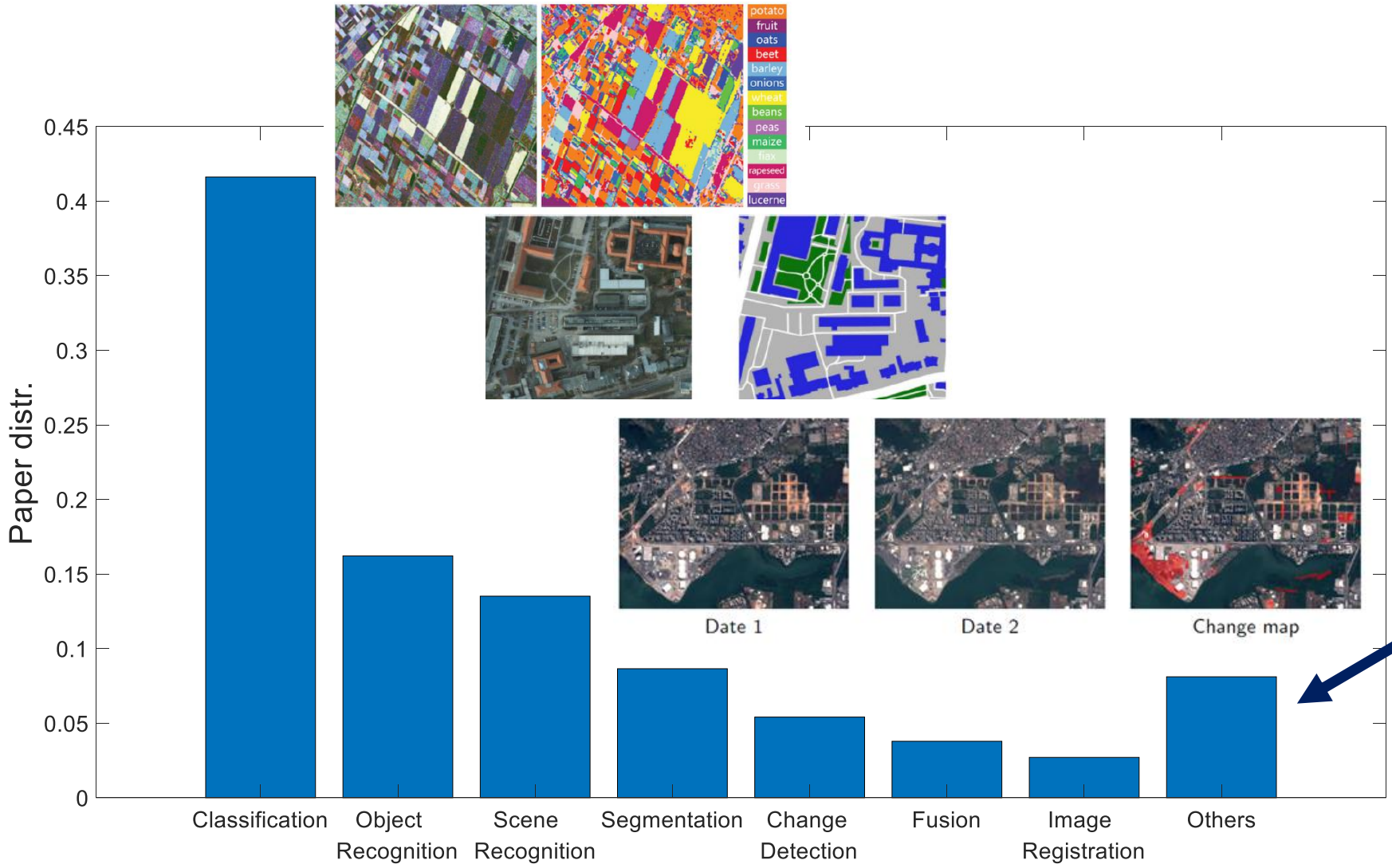
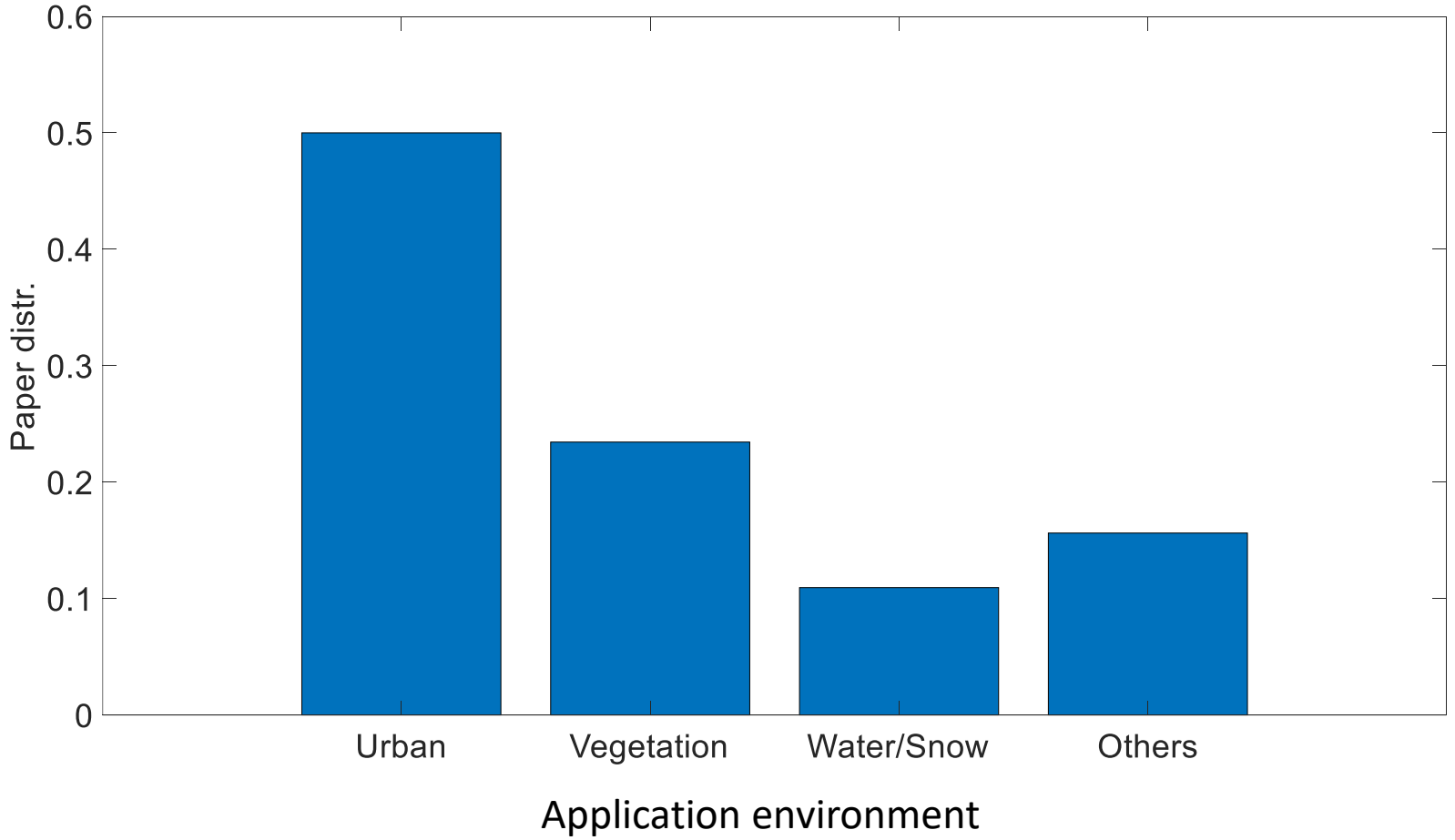
ML/DL: Radar & Remote Sensing



Super-resolution
Atmospheric compensation, etc.

L. Ma, Y. Liu, X. Zhang, Y. Ye,G. Yi, B. A. Johnson, *Deep learning in remote sensing applications: A meta-analysis and review*, IPRS Journal of Photogrammetry and Remote Sensing, Elsevier, Vol. 152, pp. 166-177, June 2019

ML/DL: Radar & Remote Sensing



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Conclusions

Definition of specific design rules for ML\DL algorithms

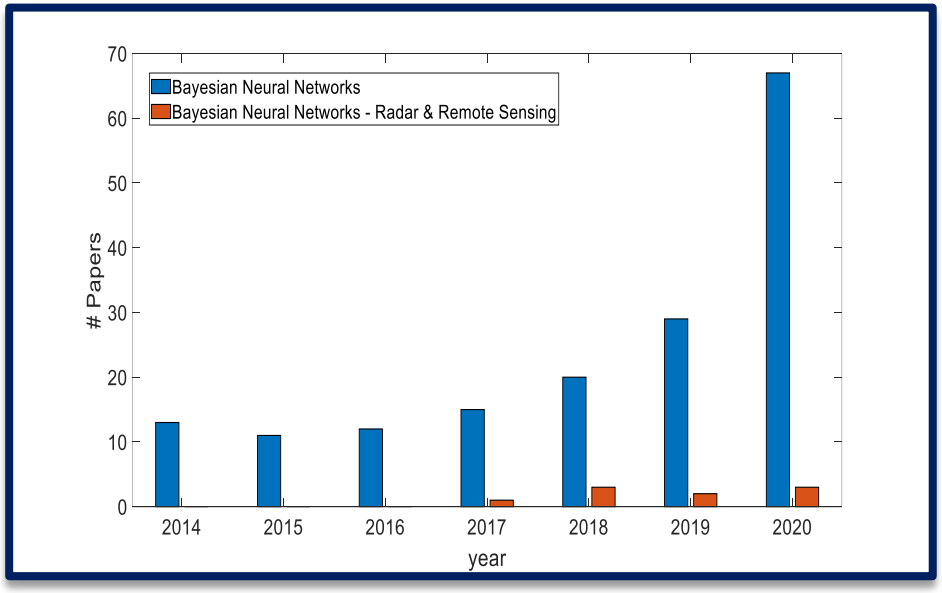
Experience ⇨ Knowledge

Explainable Artificial Intelligence (XAI)

Data sets for ML\DL algorithms training in radar and remote sensing applications

Bayesian Neural Networks

Leverage the strenghts of Machine Learning and Stochastic modeling



Interesting reviews

- G. Camps-Valls, Machine Learning in remote sensing data processing, 2009 IEEE International Workshop on Machine Learning for Signal Processing, Grenoble, 2009, pp. 1-6, doi: 10.1109/MLSP.2009.5306233.
- D.J. Lary, A.H. Alavi, A.H. Gandomi, A. L. Walker, Machine learning in geosciences and remote sensing, Geoscience Frontiers, Vol. 7, No. 1, pp. 3-10, Jan. 2016.
- X.X. Zhu, D. Tuia, L. Mou, G.-S. Xia, L. Zhang, F. Xu, F. Fraundorfer, Deep Learning in Remote Sensing: A Comprehensive Review and List of Resources, in *IEEE Geoscience and Remote Sensing Magazine*, vol. 5, no. 4, pp. 8-36, Dec. 2017.
- L. Ma, Y. Liu, X. Zhang, Y. Ye,G. Yi, B. A. Johnson, Deep learning in remote sensing applications: A meta-analysis and review, IPRS Journal of Photogrammetry and Remote Sensing, Elsevier, Vol. 152, pp. 166-177, June 2019
- W. Shi, M. Zhang, R. Zhang, S. Chen, Z. Zhan, Change detection based on artificial intelligence: State-of-the-art and challenges, Remote Sensing, Vol. 12, No. 11, May 2020.
- P. Lang, X. Fu, M. Martorella, J. Dong, R. Qin, X. Meng, M. Xie, A Comprehensive Survey of Machine Learning Applied to Radar Signal Processing, arXiv:2009.13702