Remote Sensing - Advanced Methods

AI4EO Hackathon

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Agenda

1. Introduction
2. Meet the data
3. Machine learning
4. Deep learning
5. Open problems
6. Challenge

What is artificial intelligence?

It is the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable.

John McCarthy, 2007

AI >> ML > DL

Artificial Intelligence
Mimicking human intelligence

NLP

Speech

Vision

Expert systems

Robotics

Optimization

Machine Learning
The use and development of computer systems that are able to learn

Deep Learning
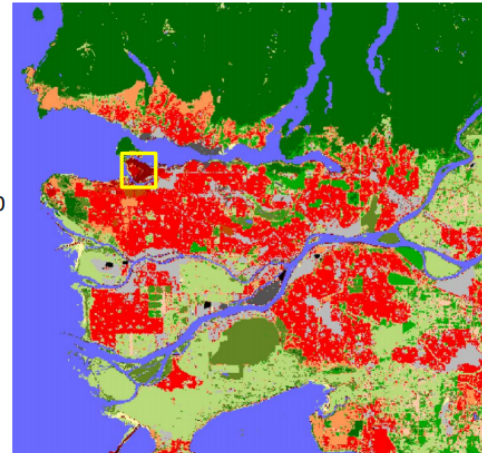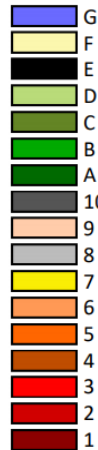*ML based on artificial neural networks that uses multiple layers to extract high-level features*
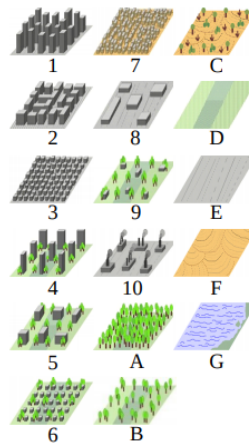
Biology

Psychology

Computer Science   Math   Philosophy

So2Sat LCZ42
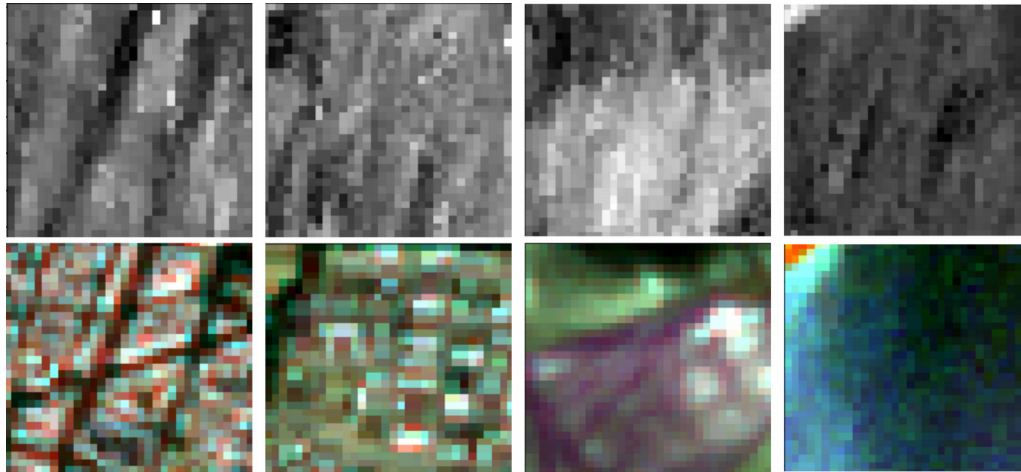
17 LCZ classes
- 10 urban
- 7 natural

42 Cities

32 Train

10 Test

Manually labeled by
10 remote sensing experts

Zhu, X.X., Hu, J., Qiu, C., Shi, Y., Kang, J., Mou, L., Bagheri, H., Haberle, M., Hua, Y., Huang, R. and Hughes, L., 2020. So2Sat LCZ42: a benchmark data set for the classification of global local climate zones [Software and Data Sets]. IEEE Geoscience and Remote Sensing Magazine, 8(3), pp.76-89.

So2Sat LCZ42 patches

32x32 pixels

Sentinel-1
8 real-valued bands

Sentinel-2
10 real-valued bands

2. Compact midrise   6. Open low-rise   14. Low plants   17.Water

17 one hot encoded classes

Zhu, X.X., Hu, J., Qiu, C., Shi, Y., Kang, J., Mou, L., Bagheri, H., Haberle, M., Hua, Y., Huang, R. and Hughes, L., 2020. So2Sat LCZ42: a benchmark data set for the classification of global local climate zones [Software and Data Sets]. IEEE Geoscience and Remote Sensing Magazine, 8(3), pp.76-89.
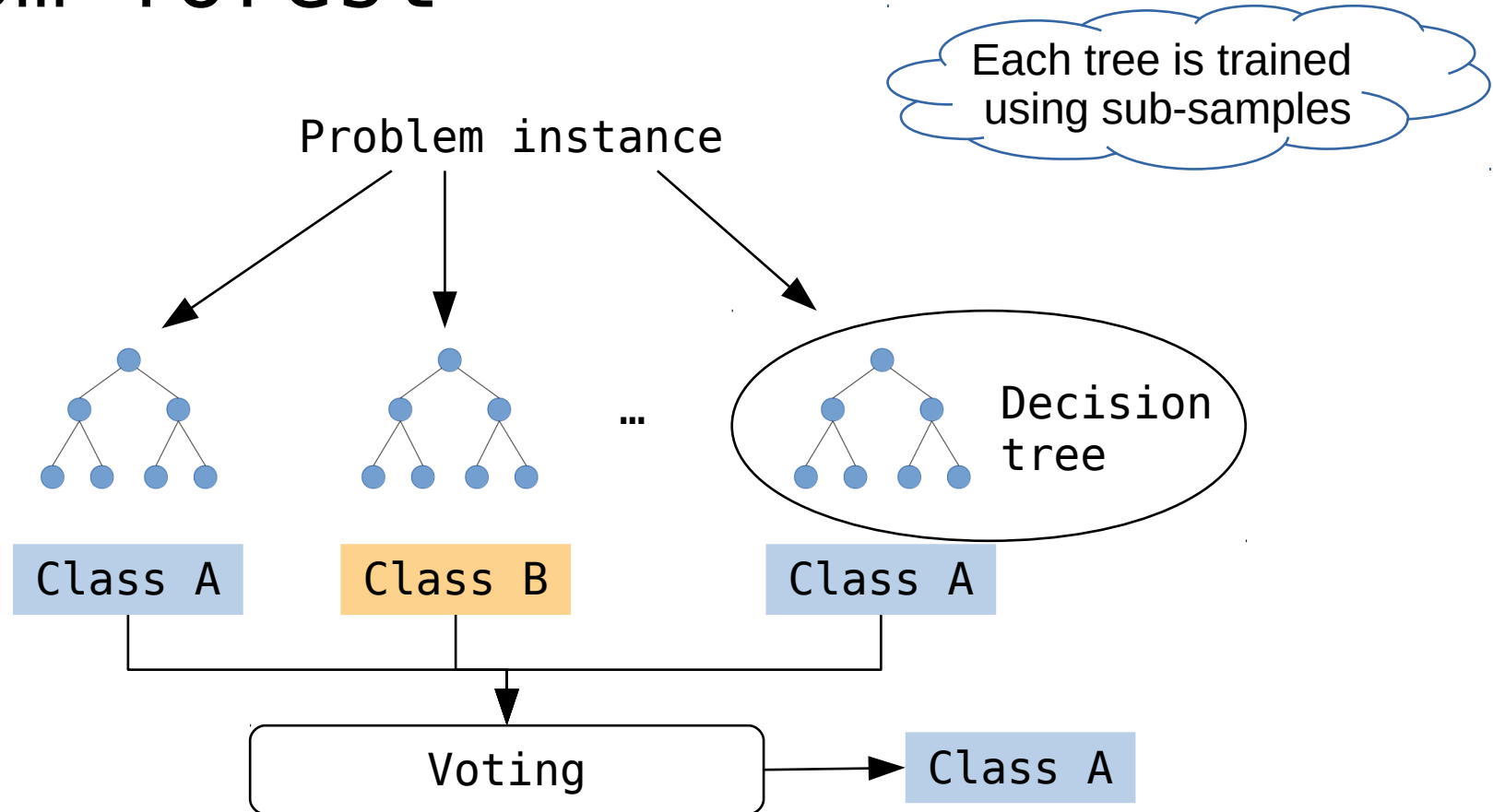
https://github.com/acamero/rsam-lcz42

Machine Learning

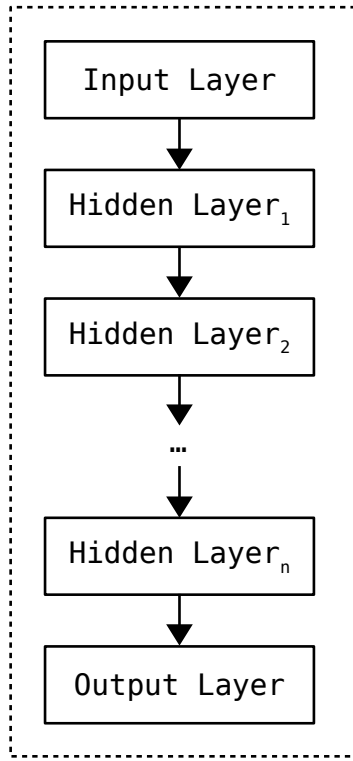A computer program is said to learn from experience *E* with respect to some task *T* and some performance measure *P*, if its performance on *T*, as measured by *P*, improves with experience *E*.

Tom M. Michell, 1997

Random forest

Problem instance

Each tree is trained
using sub-samples

Decision
tree

...

| Class A | Class B | Class A |

Voting → Class A

Deep neural networks

Input Layer

↓

Hidden Layer$_1$

↓

Hidden Layer$_2$

↓

…

↓

Hidden Layer$_n$

↓

Output Layer

Deep-learning methods are representation-learning methods with multiple levels of representation, obtained by composing simple but non-linear modules that each transform the representation at one level (starting with the raw input) into a representation at a higher, slightly more abstract level. With the composition of enough such transformations, very complex functions can be learned.

Yann LeCun, Yoshua Bengio and Geoffrey Hinton, 2015
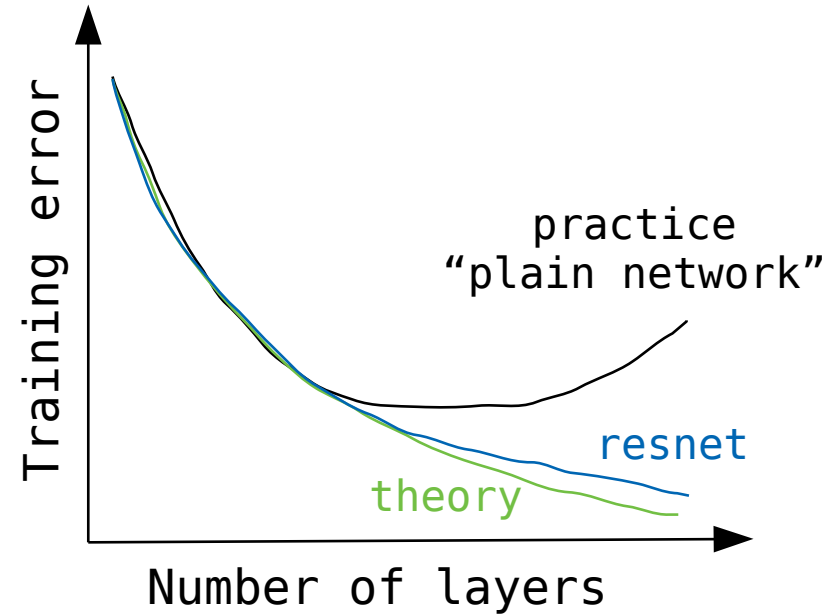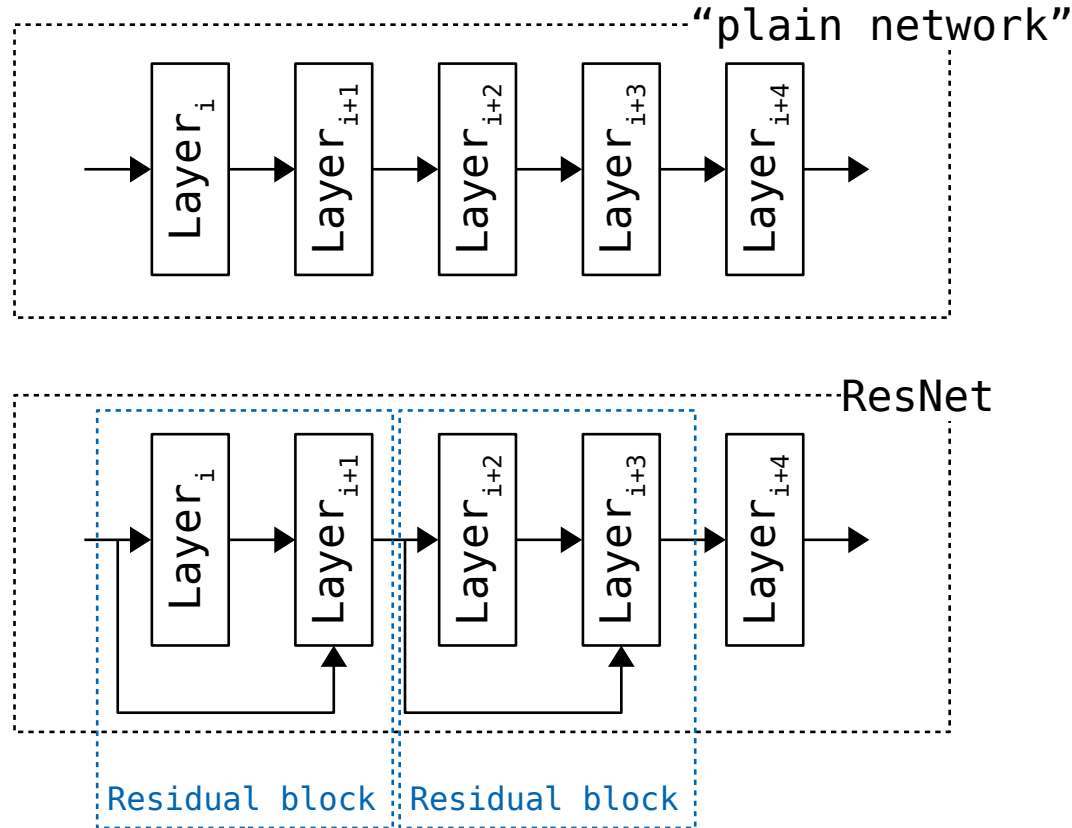
Residual block
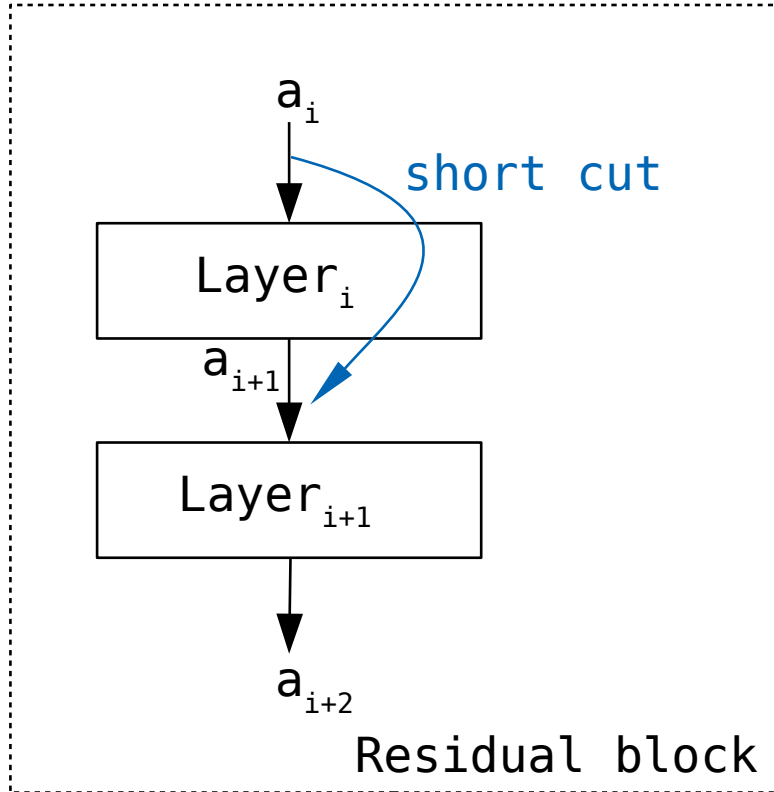
$$a_{i+1} = g(W_i \cdot a_i + b_i)$$

$$a_{i+2} = g(W_{i+1} \cdot a_{i+1} + b_{i+1}) \quad \text{"Plain network"}$$

$$a_{i+2} = g(W_{i+1} \cdot a_{i+1} + b_{i+1} + a_i) \quad \text{"Short cut"}$$

Residual network: ResNet

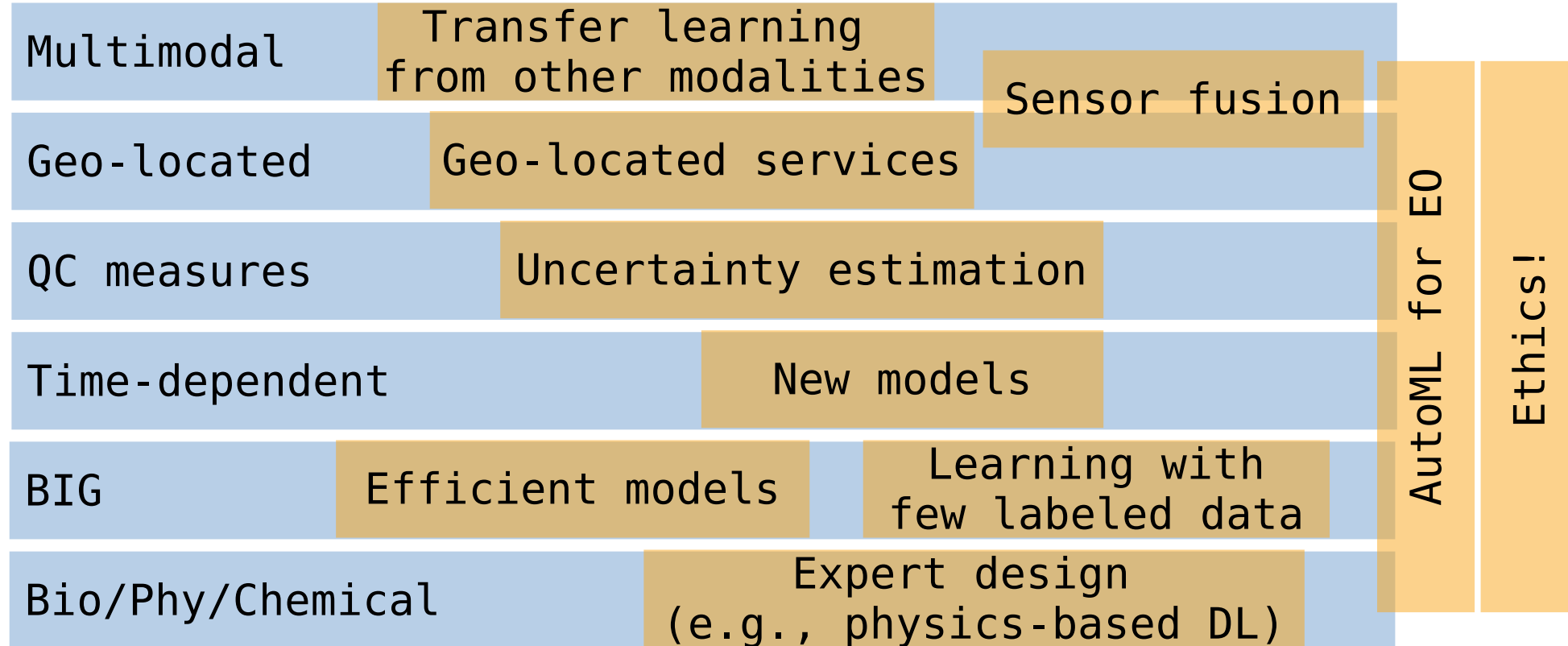# Remote sensing data is…

Multimodal

Geo-located

QC measures

Time-dependent

BIG

Bio/Phy/Chemical

Thus, requires…

Multimodal	Transfer learning from other modalities	
		Sensor fusion
Geo-located	Geo-located services	
QC measures	Uncertainty estimation	
Time-dependent	New models	
BIG	Efficient models	Learning with few labeled data
Bio/Phy/Chemical	Expert design (e.g., physics-based DL)	

AutoML for EO

Ethics!

DLR TUM

Propose the best DL model to predict LCZ!

You may…

- ✓ start from the simple model or the ResNet50,
- ✓ use Sentinel-1 and/or 2,
- ✓ modify the architecture by adding/removing/modifying layers,
- ✓ changing the optimizer parameters, ...

References

1. He, K., Zhang, X., Ren, S. and Sun, J., 2016. Deep residual learning for image recognition. In Proceedings of the IEEE conference on computer vision and pattern recognition (CVPR) (pp. 770-778).
2. LeCun, Y., Bengio, Y. and Hinton, G., 2015. Deep learning. nature, 521(7553), pp.436-444.
3. McCarthy, J., 2007. What is artificial intelligence?
4. Mohri, M., Rostamizadeh, A. and Talwalkar, A., 2018. Foundations of machine learning. MIT press.
5. Zhu, X.X., Hu, J., Qiu, C., Shi, Y., Kang, J., Mou, L., Bagheri, H., Haberle, M., Hua, Y., Huang, R. and Hughes, L., 2020. So2Sat LCZ42: a benchmark data set for the classification of global local climate zones [Software and Data Sets]. IEEE Geoscience and Remote Sensing Magazine, 8(3), pp.76-89.
6. Zhu, X.X., Tuia, D., Mou, L., Xia, G.S., Zhang, L., Xu, F. and Fraundorfer, F., 2017. Deep learning in remote sensing: A comprehensive review and list of resources. IEEE Geoscience and Remote Sensing Magazine, 5(4), pp.8-36.