Developing a Deep Learning Model for Satellite-based Active Fire Detection with Better Accuracy

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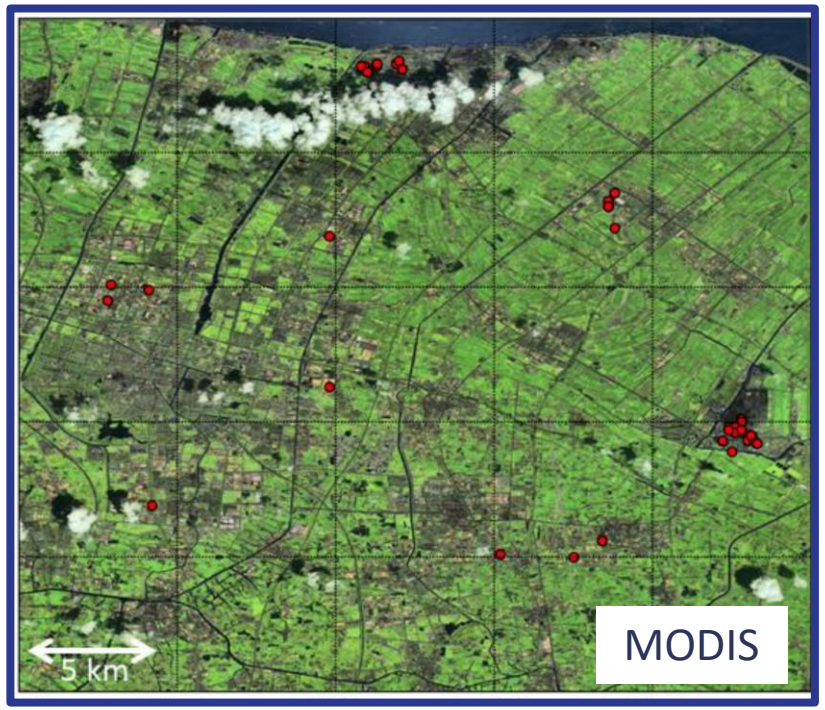
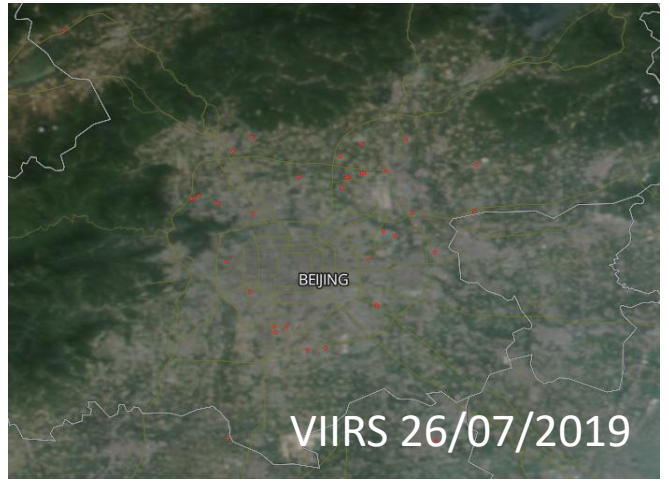
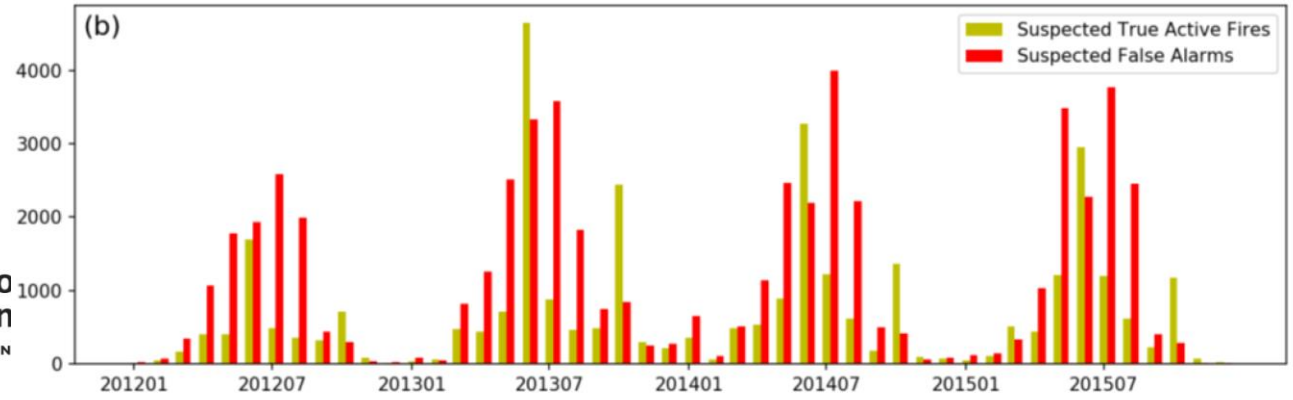
False Fire Detections from MODIS/VIIRS





Current fire products suffer 10-40% false fire detection in certain urban area of Eastern China.



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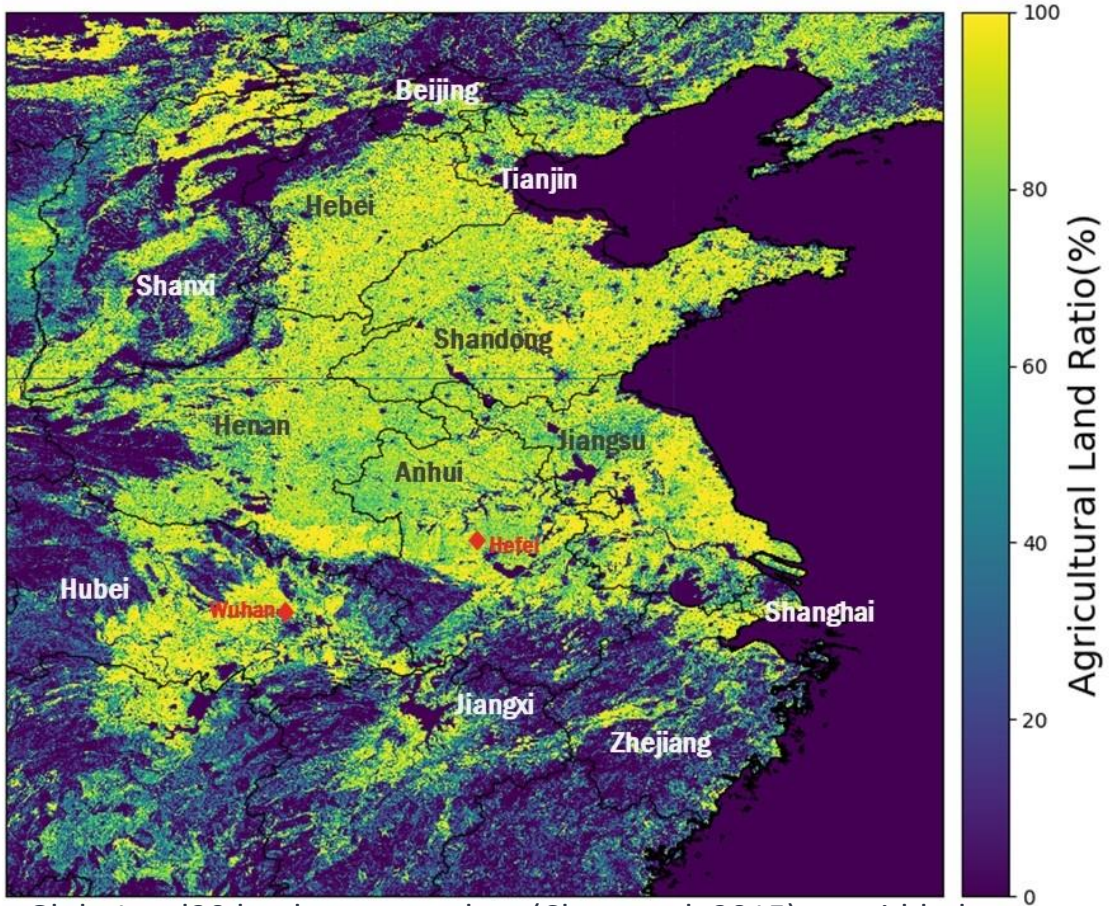
Can’t we just use landcover maps to mask them out?



GlobeLand30 land cover product (Chen et al, 2015) re-gridded to 0.01degree in eastern China (111-123° E, 27-40° N).

- Landcover map product has long delay.

The Copernicus Climate Change Service (C3S) provides global annual LC maps from 2016 to 2019. The CCI LC team is pleased to announce that the 2016, 2017 and 2018 LC maps have already been generated, and the 2016 and 2017 LC maps will be released very soon (fall 2019).

- Data not available for real-time fire detection.
- Dynamic world (urbanisation).
- Spatial & temporal resolution.

(Seasonal fire patterns vs. yearly map).

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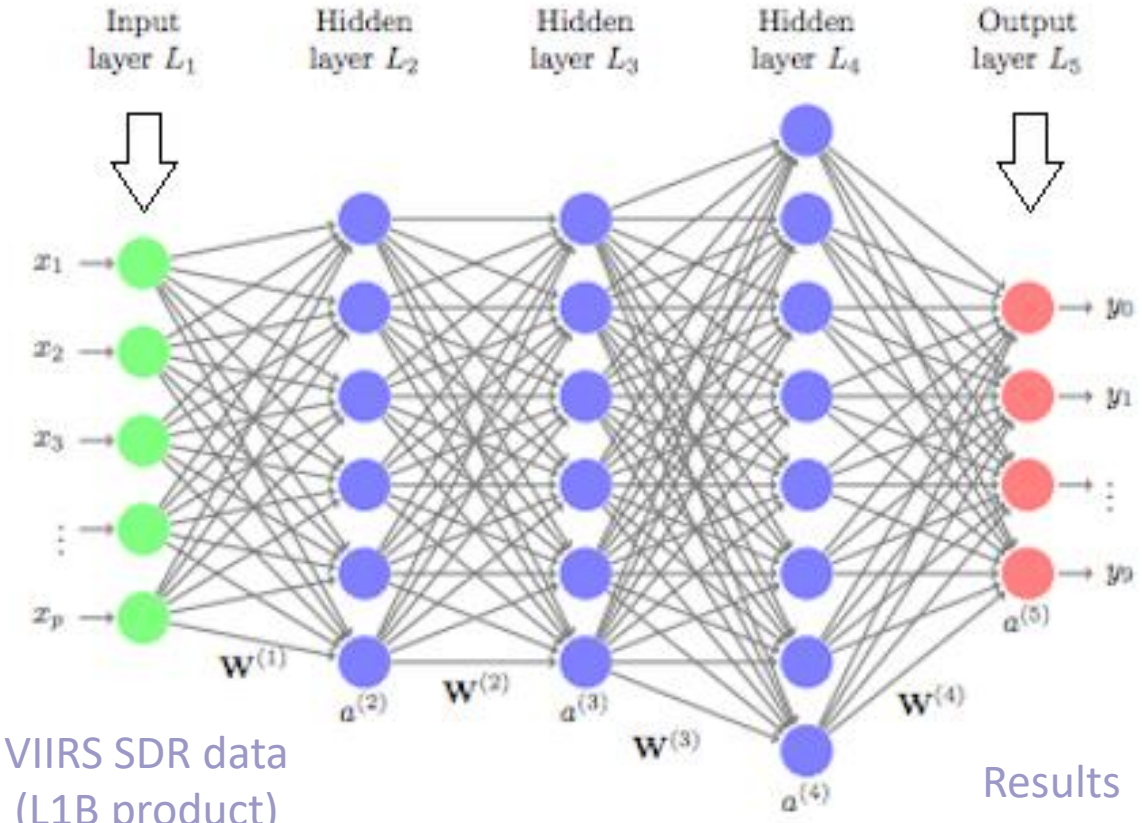
Why deep learning?

Training Stage

VIIRS SDR data
(L1B product)

Labels:
VIIRS Active Fire Product

+ Landcover Map
Vegetation Map
Cultivation Map
……



Deploying Stage

VIIRS SDR data
(L1B product)

Results

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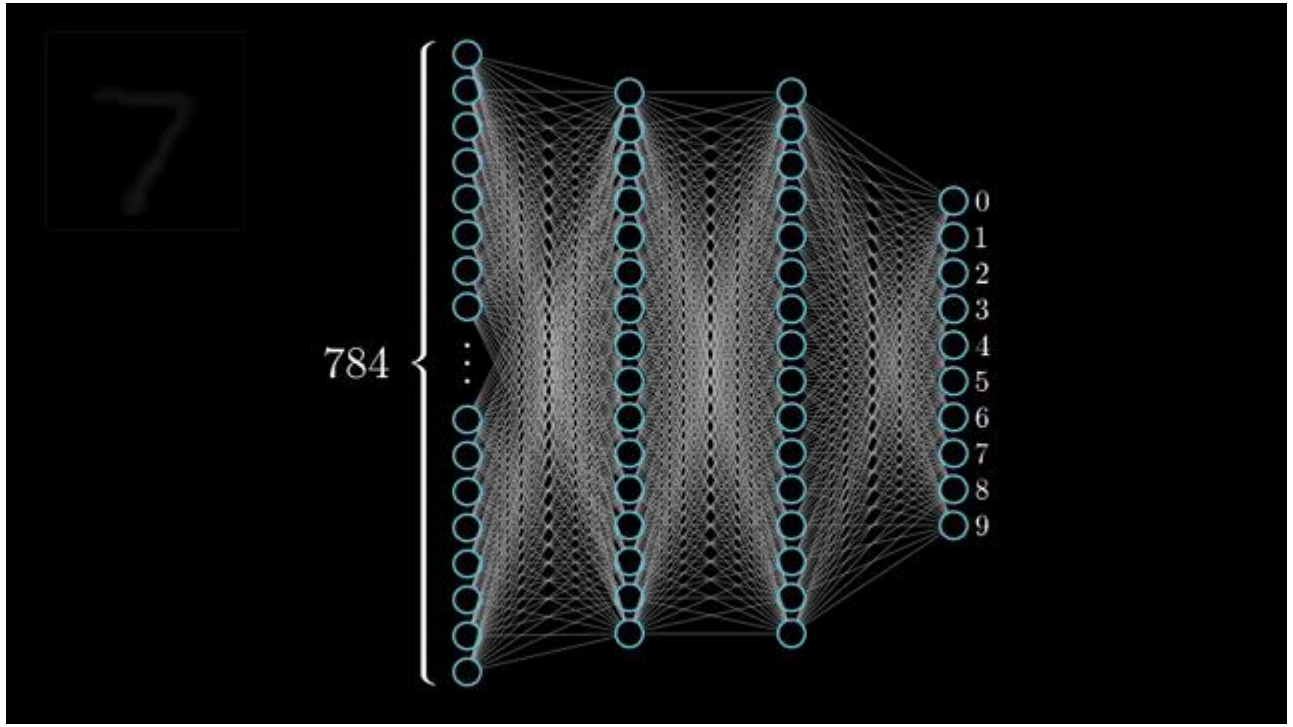
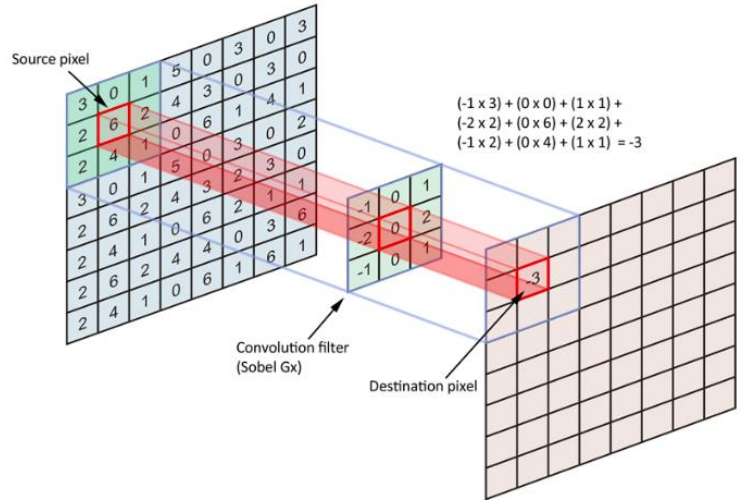
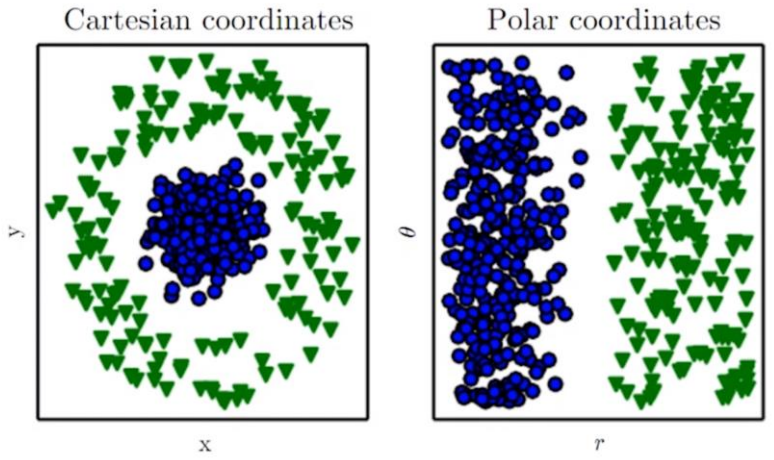
Source: University of Cincinnati

Convolutional Neural Network (CNN)







Great performance on the handwritten digits database (MNIST), 0.21 % error rate at 2016.

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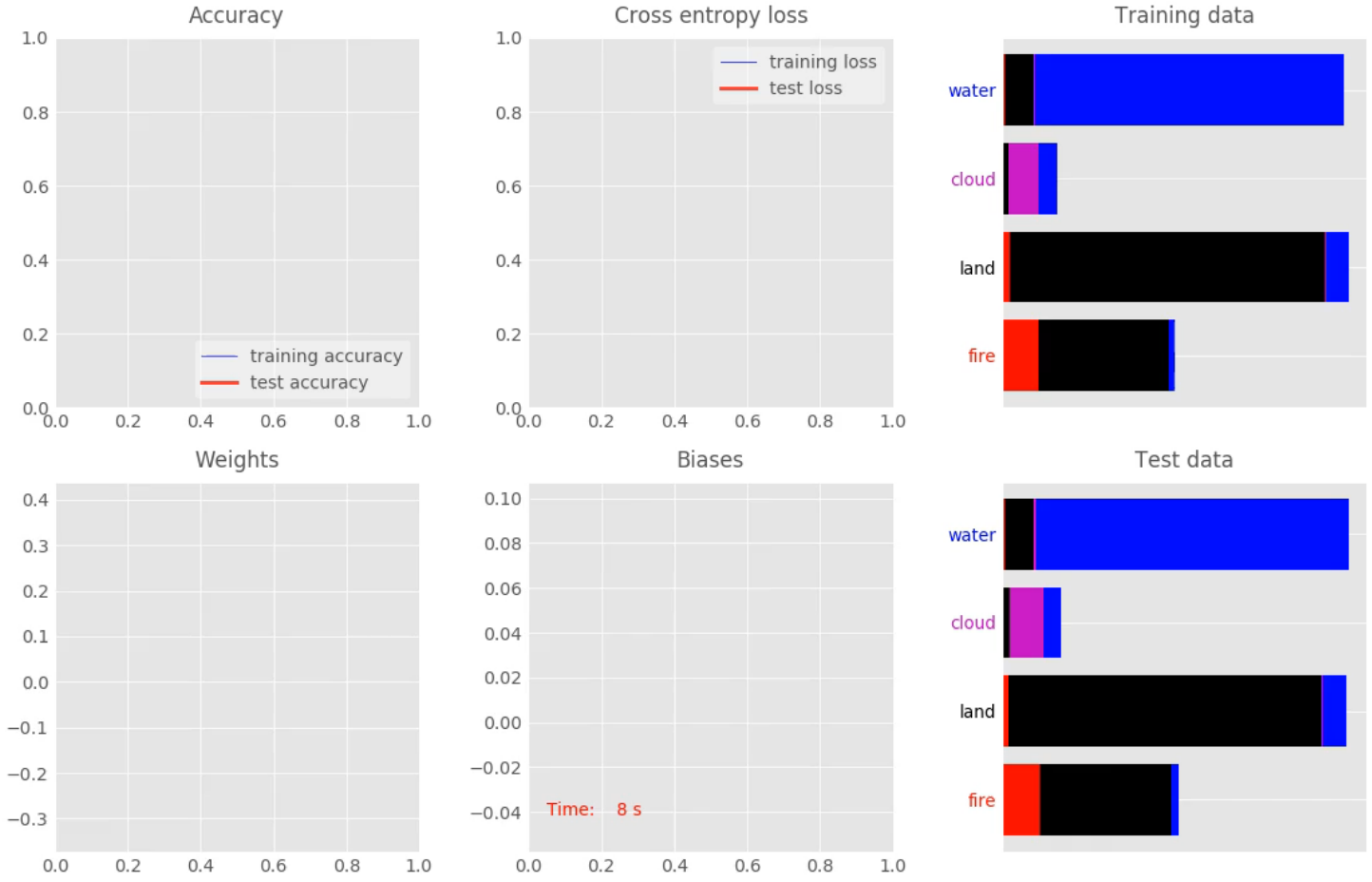
Application in Multi-spectral Remote Sensing Data

VIIRS Channels

		Band No.	Driving EDR(s)	Spectral Range (um)	Horiz Sample Interval (km) (track x Scan) Nadir	End of Scan
Reflective Bands	VisNIR	M1	Ocean Color Aerosol	0.402 - 0.422	0.742 x 0.259	1.60 x 1.58
		M2	Ocean Color Aerosol	0.436 - 0.454	0.742 x 0.259	1.60 x 1.58
		M3	Ocean Color Aerosol	0.478 - 0.498	0.742 x 0.259	1.60 x 1.58
		M4	Ocean Color Aerosol	0.545 - 0.565	0.742 x 0.259	1.60 x 1.58
		I1	Imagery EDR	0.600 - 0.680	0.371 x 0.387	0.80 x 0.789
		M5	Ocean Color Aerosol	0.662 - 0.682	0.742 x 0.259	1.60 x 1.58
		M6	Atmosph. Correct.	0.739 - 0.754	0.742 x 0.776	1.60 x 1.58
		I2	NDVI	0.846 - 0.885	0.371 x 0.387	0.80 x 0.789
		M7	Ocean Color Aerosol	0.846 - 0.885	0.742 x 0.259	1.60 x 1.58
	S/WMIR	M8	Cloud Particle Size	1.230 - 1.250	0.742 x 0.776	1.60 x 1.58
		M9	Cirrius/Cloud Cover	1.371 - 1.386	0.742 x 0.776	1.60 x 1.58
		I3	Binary Snow Map	1.580 - 1.640	0.371 x 0.387	0.80 x 0.789
		M10	Snow Fraction	1.580 - 1.640	0.742 x 0.776	1.60 x 1.58
		M11	Clouds	2.225 - 2.275	0.742 x 0.776	1.60 x 1.58
		I4	Imagery Clouds	3.550 - 3.930	0.371 x 0.387	0.80 x 0.789
		M12	SST	3.660 - 3.840	0.742 x 0.776	1.60 x 1.58
		M13	SST Fires	3.973 - 4.128	0.742 x 0.259	1.60 x 1.58
Emissive Bands	LWIR	M14	Cloud Top Properties	8.400 - 8.700	0.742 x 0.776	1.60 x 1.58
		M15	SST	10.263 - 11.263	0.742 x 0.776	1.60 x 1.58
		I5	Cloud Imagery	10.600 - 12.400	0.371 x 0.387	0.80 x 0.789
		M16	SST	11.638 - 12.488	0.742 x 0.776	1.60 x 1.58



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Results Analysis: Overfitting

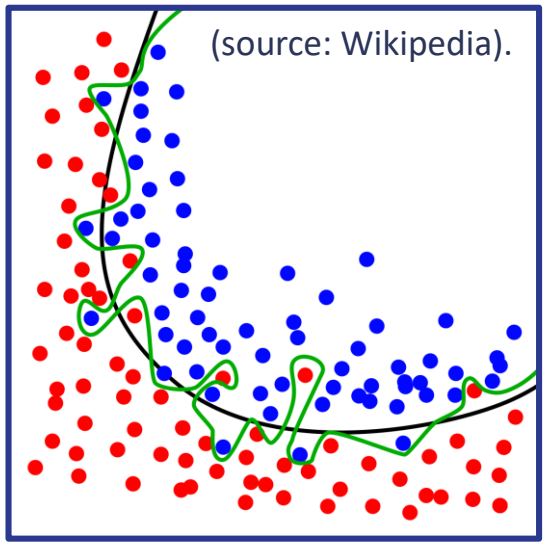


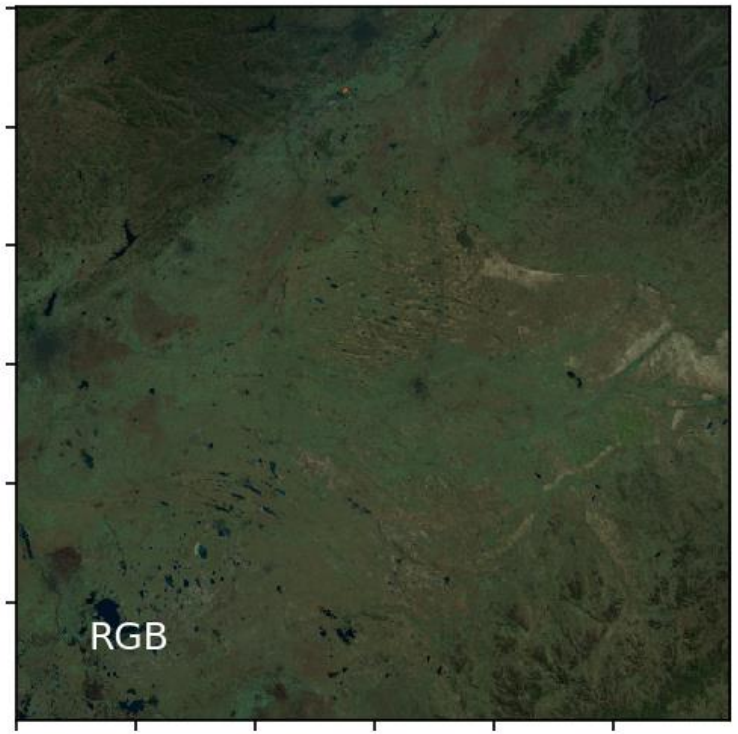
Illustration of overfitting.

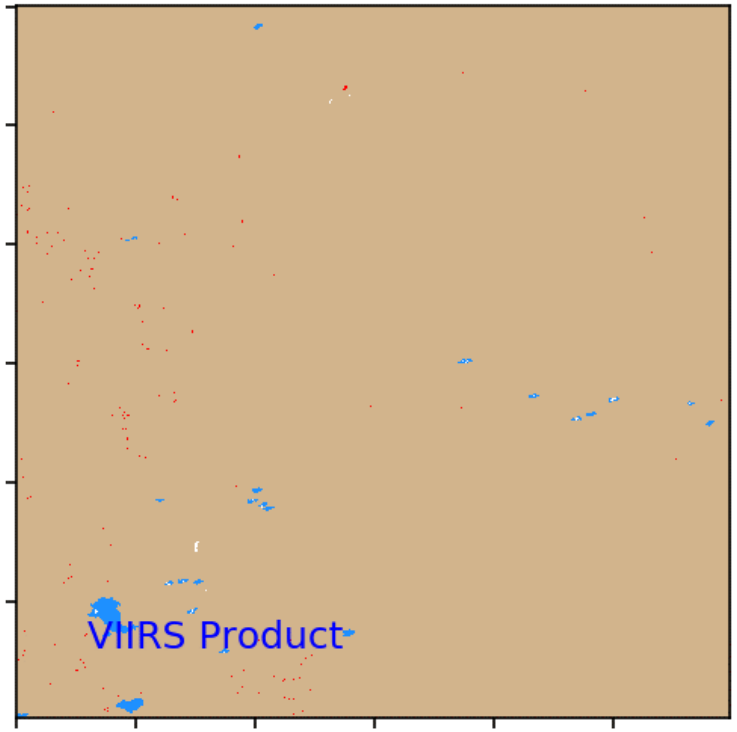
Data Scientist Solution

- More training data.
- Change model structure.
- Apply regularization.

Remote Sensing Scientist Solution

- Look into data details (geometry, seasonal/regional special pattern).
- Improve data quality by using other source/higher resolution data.





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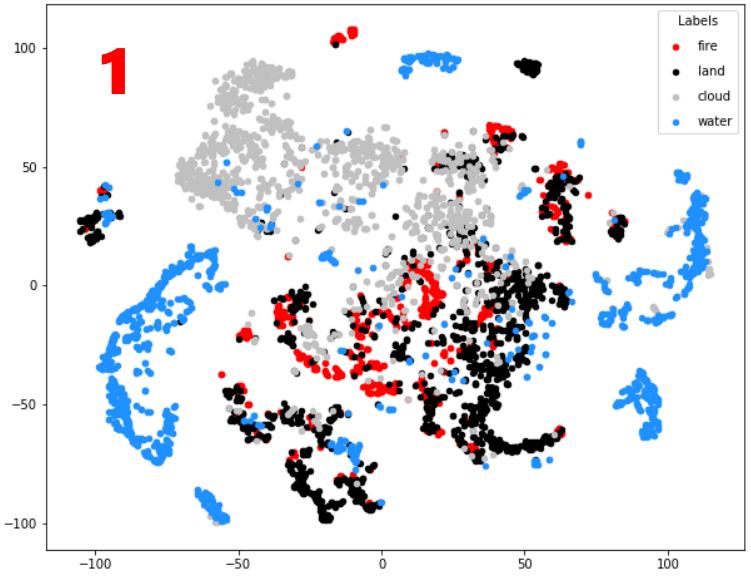
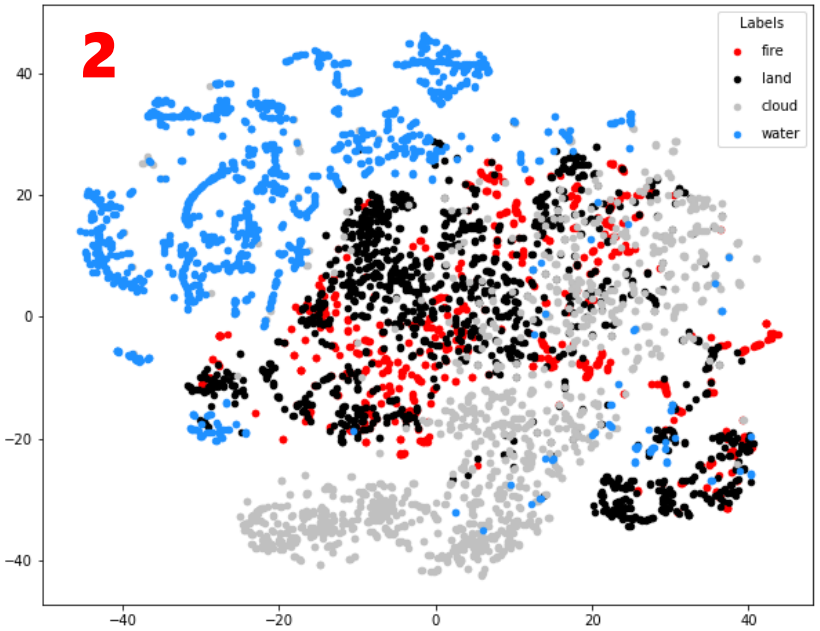
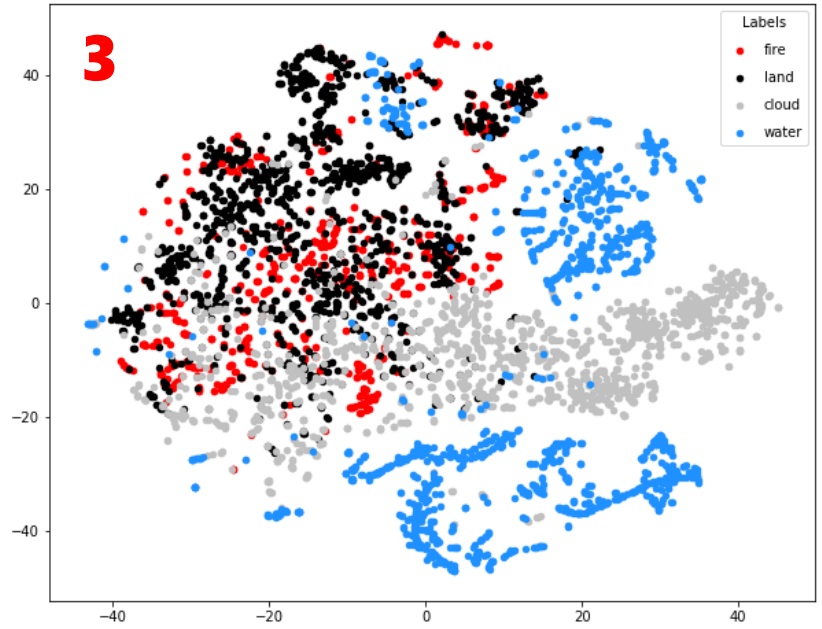
Results Analysis

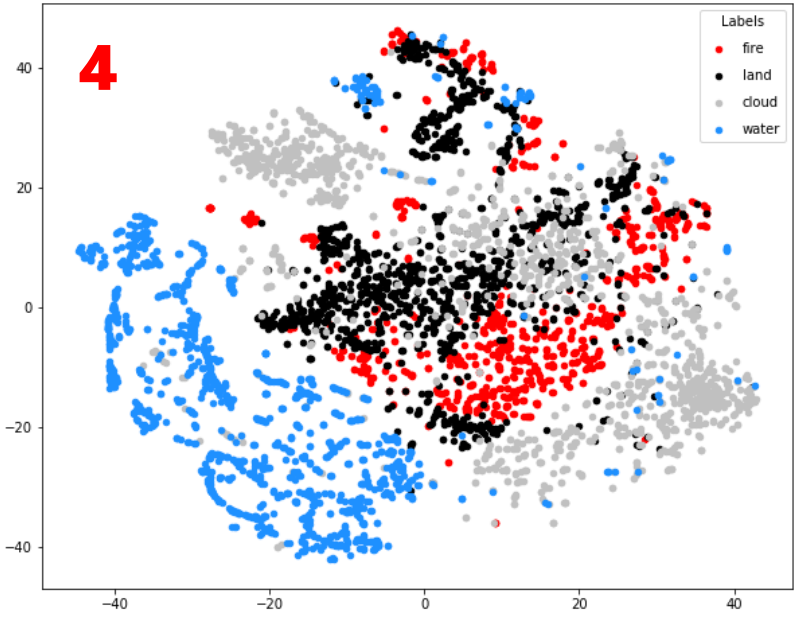
t-Distributed Stochastic Neighbor Embedding

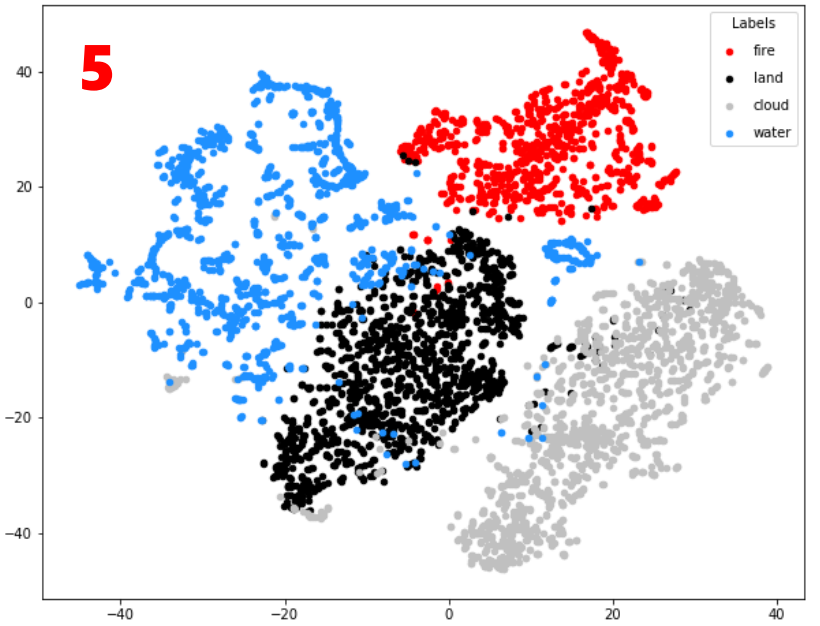
Nonlinear dimensionality reduction technique for embedding high-dimensional data for visualization in a low-dimensional space.











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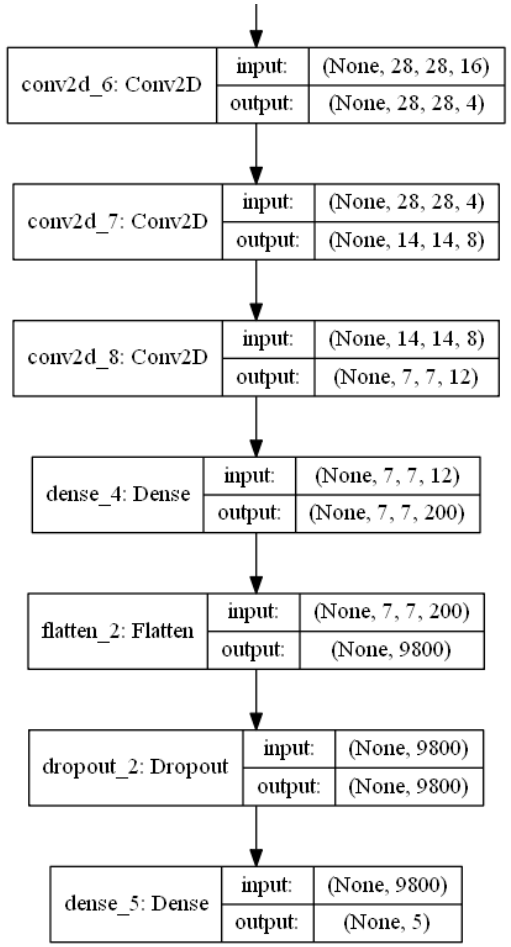
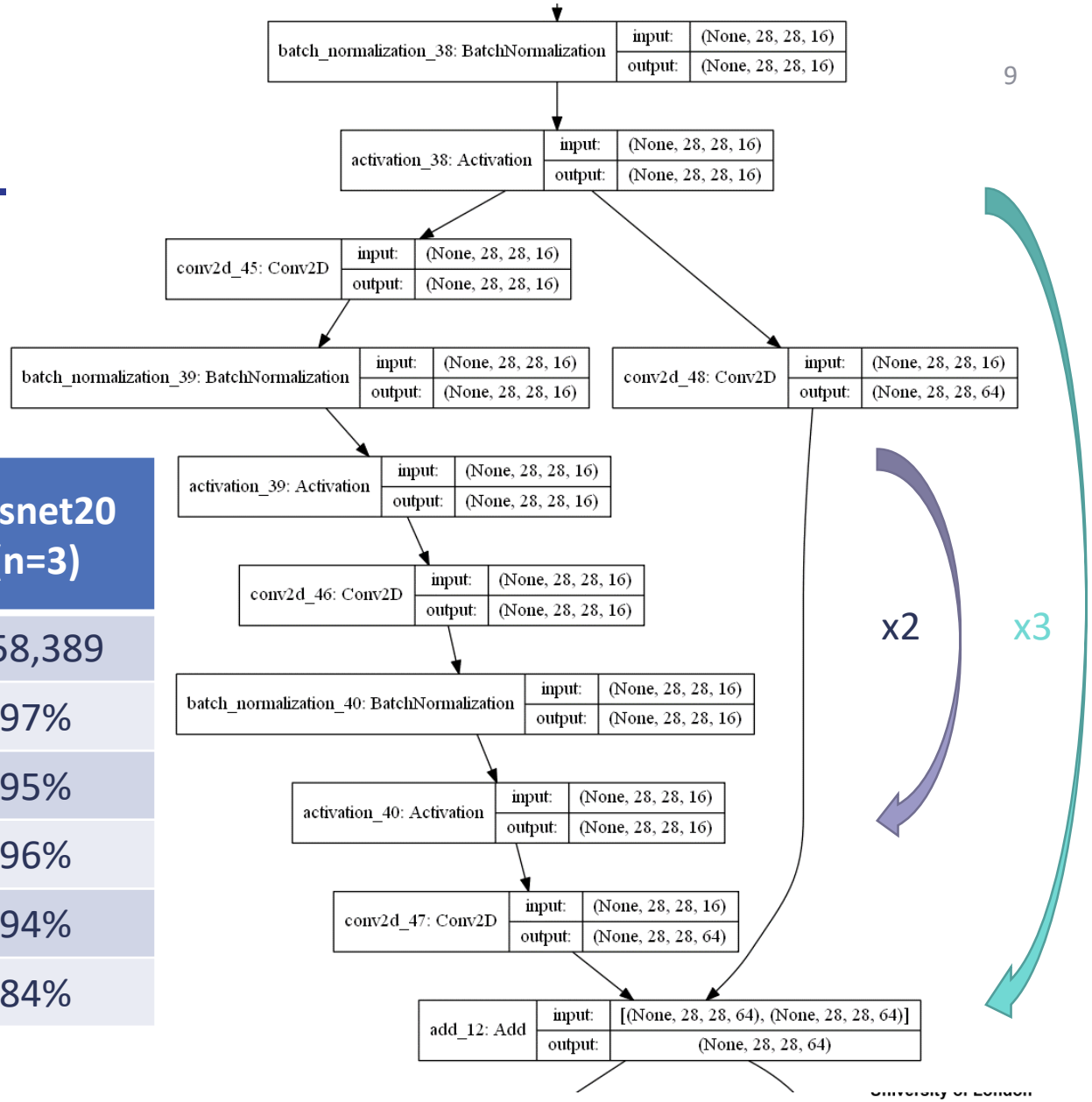
Deep or Deeper



Params/Accuracy	Simple DL	Resnet20 (n=3)
Params	55,565	858,389
Fire	97%	97%
Land	95%	95%
Cloud	88%	96%
Water	92%	94%
False Fire	67%	84%



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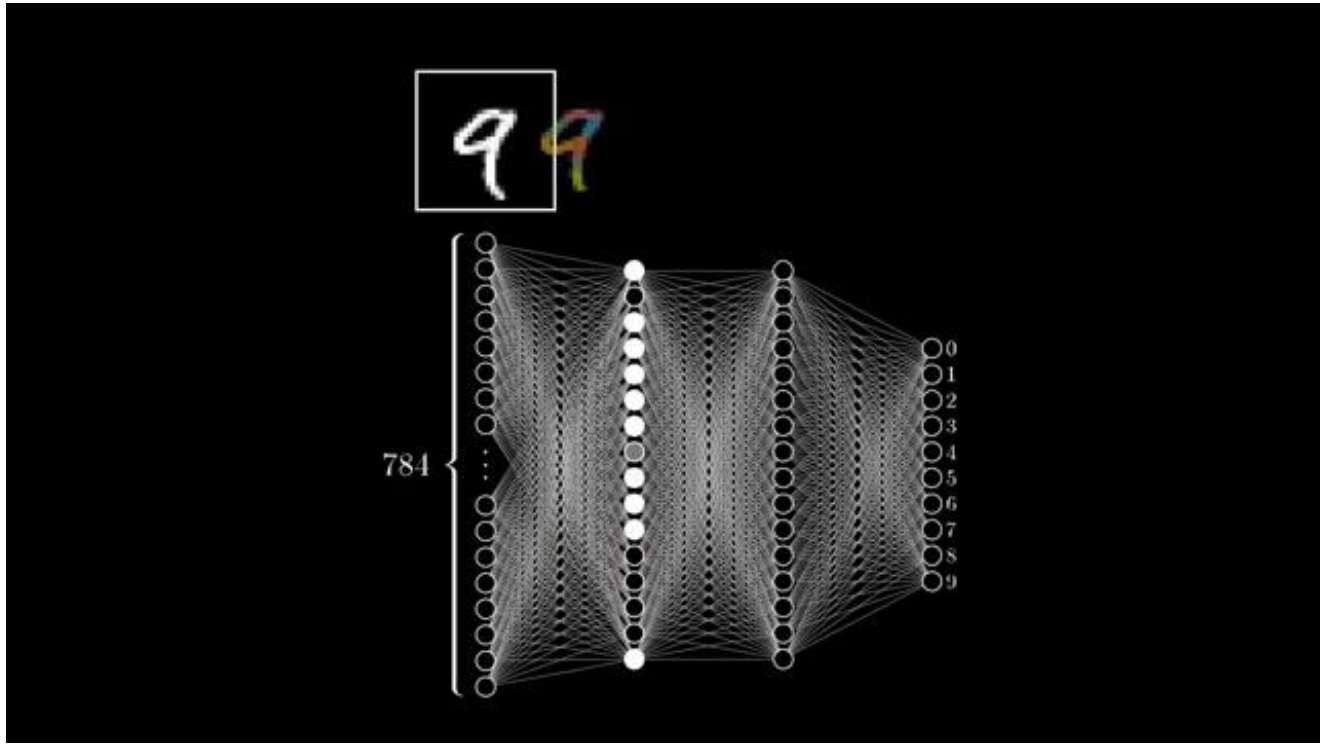
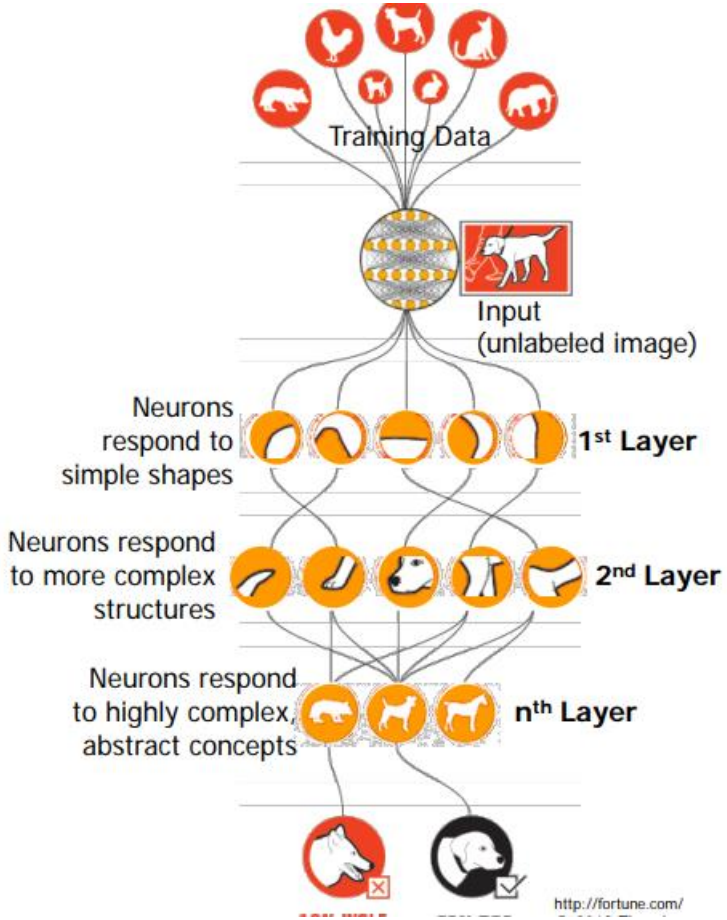
Future: Explainable Artificial Intelligence (XAI)





Hurry up! We are racing with computer/data scientists!

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