Deep Learning —

Classifying Radio Galaxies with Convolutional Neural Network

Xinyu Mai
University of Iowa
Dept. of Physics & Astronomy

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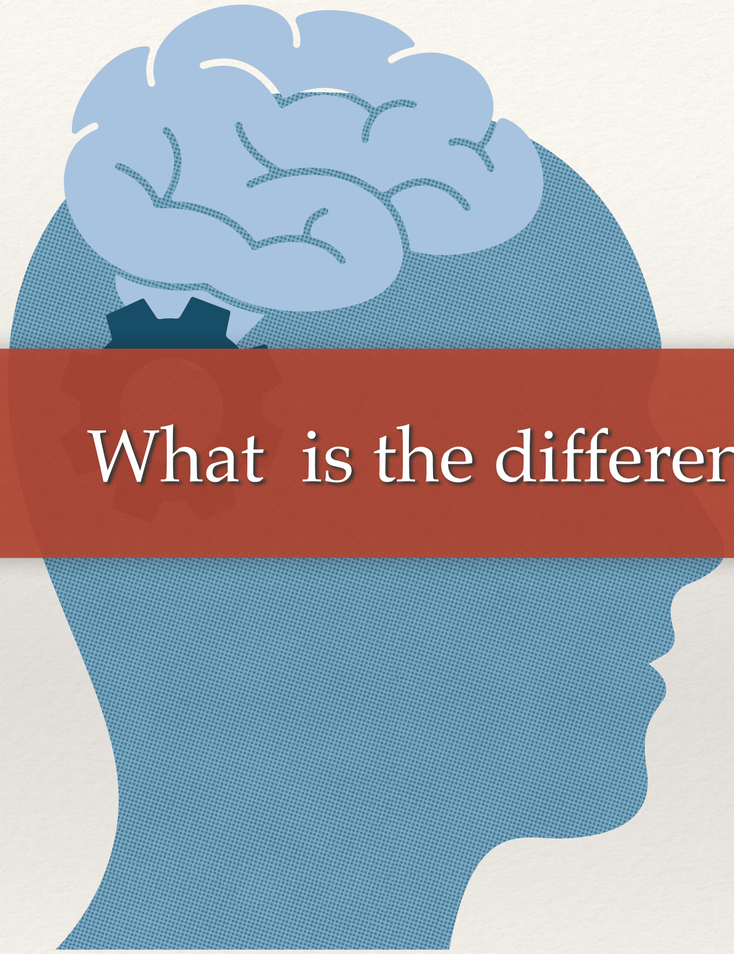
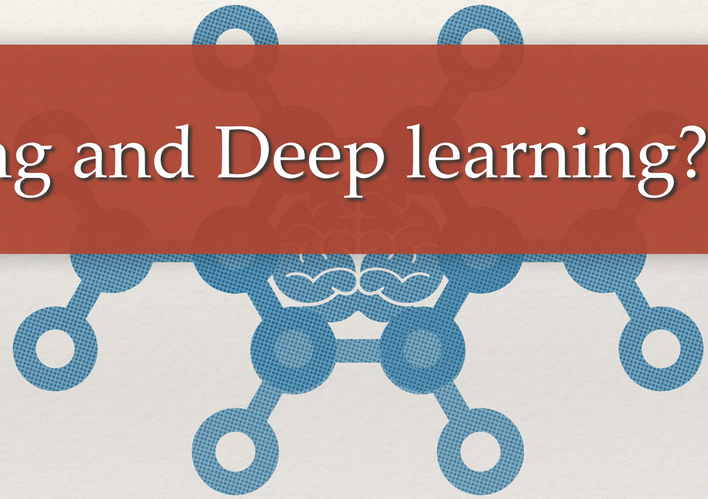
What is the difference between Machine Learning and Deep learning?



AI

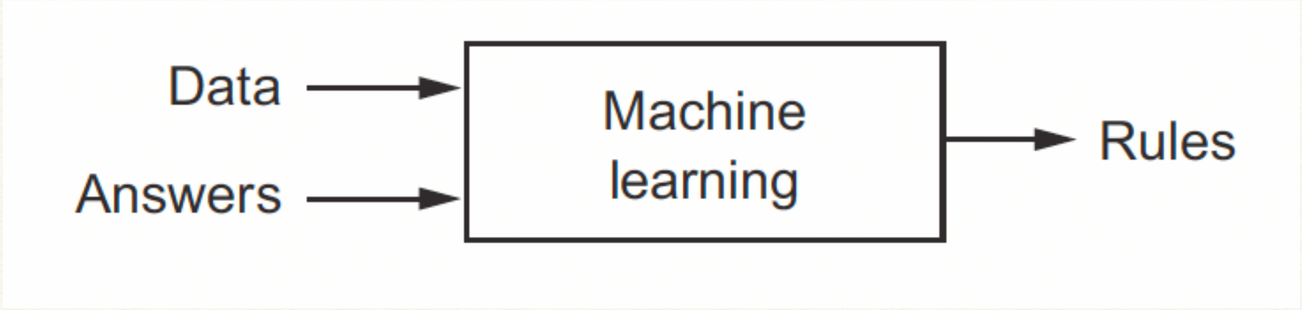
Machine Learning



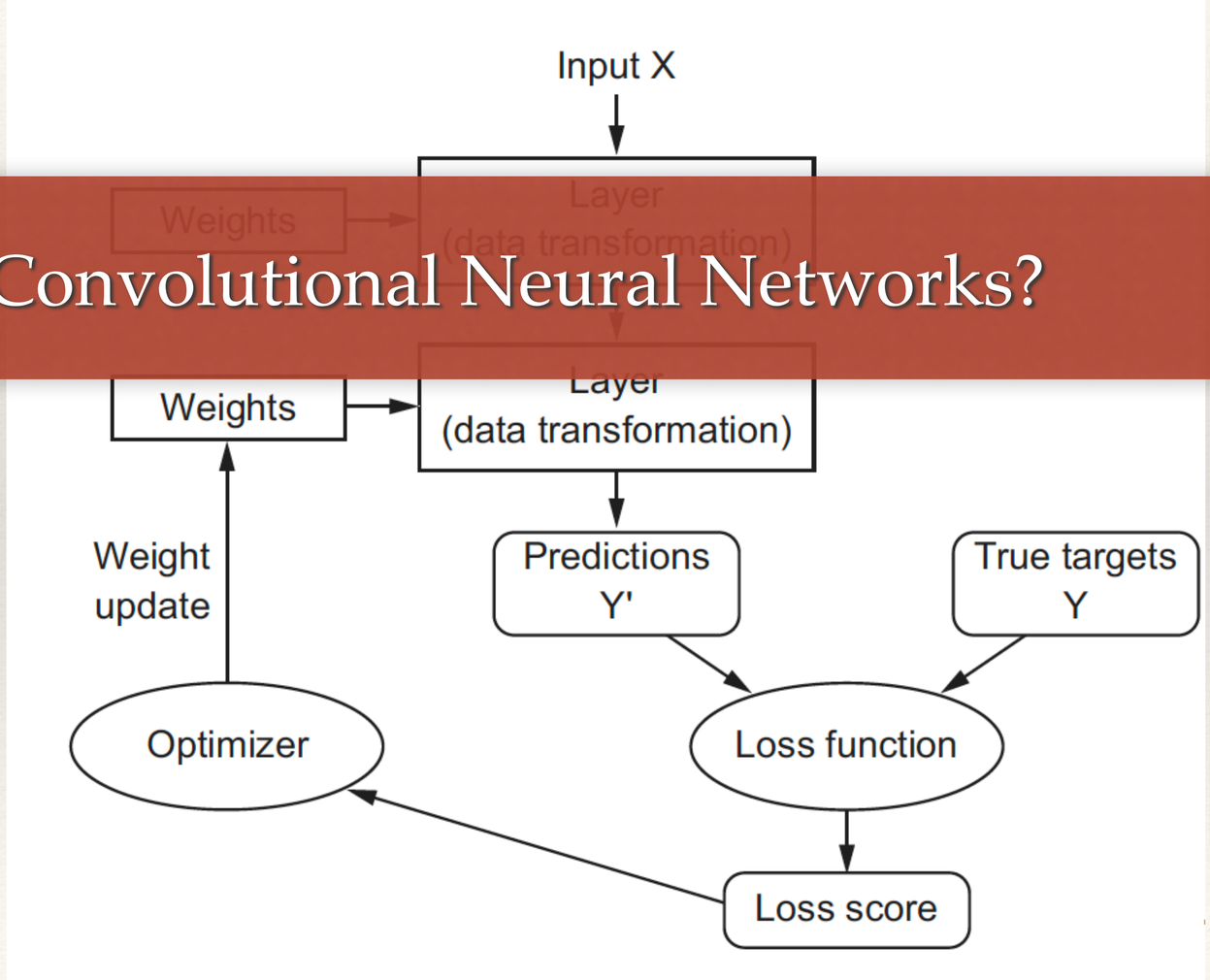
Deep Learning

What is Convolutional Neural Networks?

Machine Learning



Deep Learning



Convolutional Neural Networks

- A type of feed-forward neural network model
- Has multi-layer structure
- Has some types of specialization for being able to pick out or detect patterns
- Develops multiple feature detectors and use them to develop several feature maps — Convolutional layers

Convolutional Neural Networks

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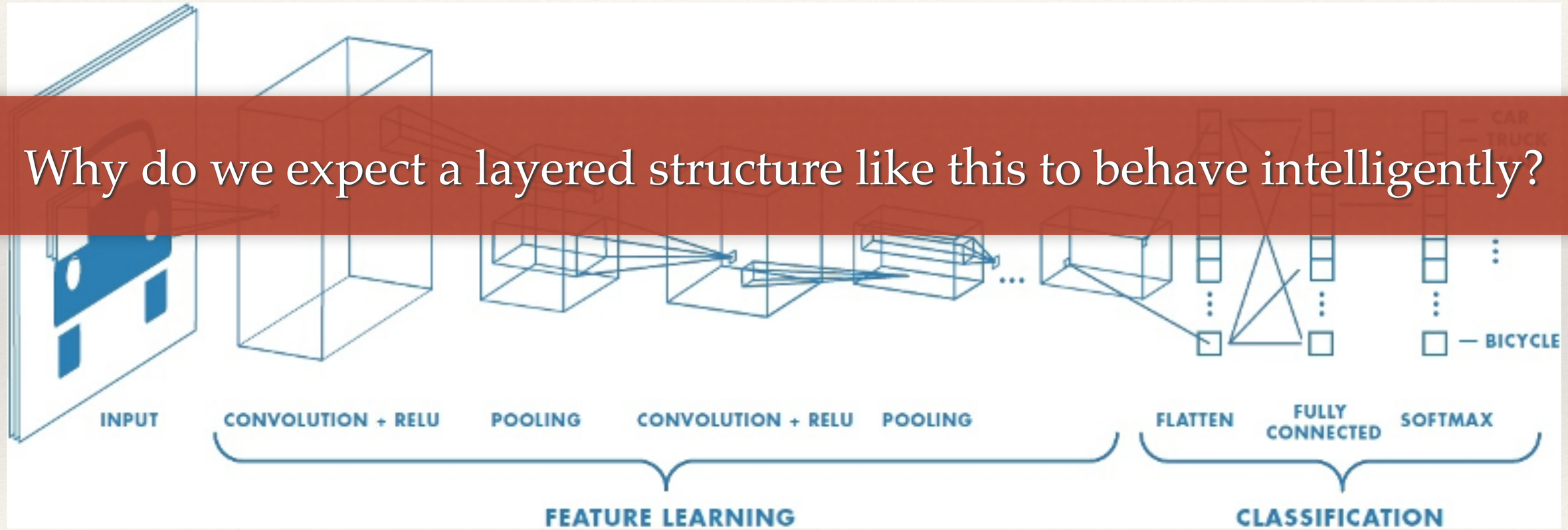
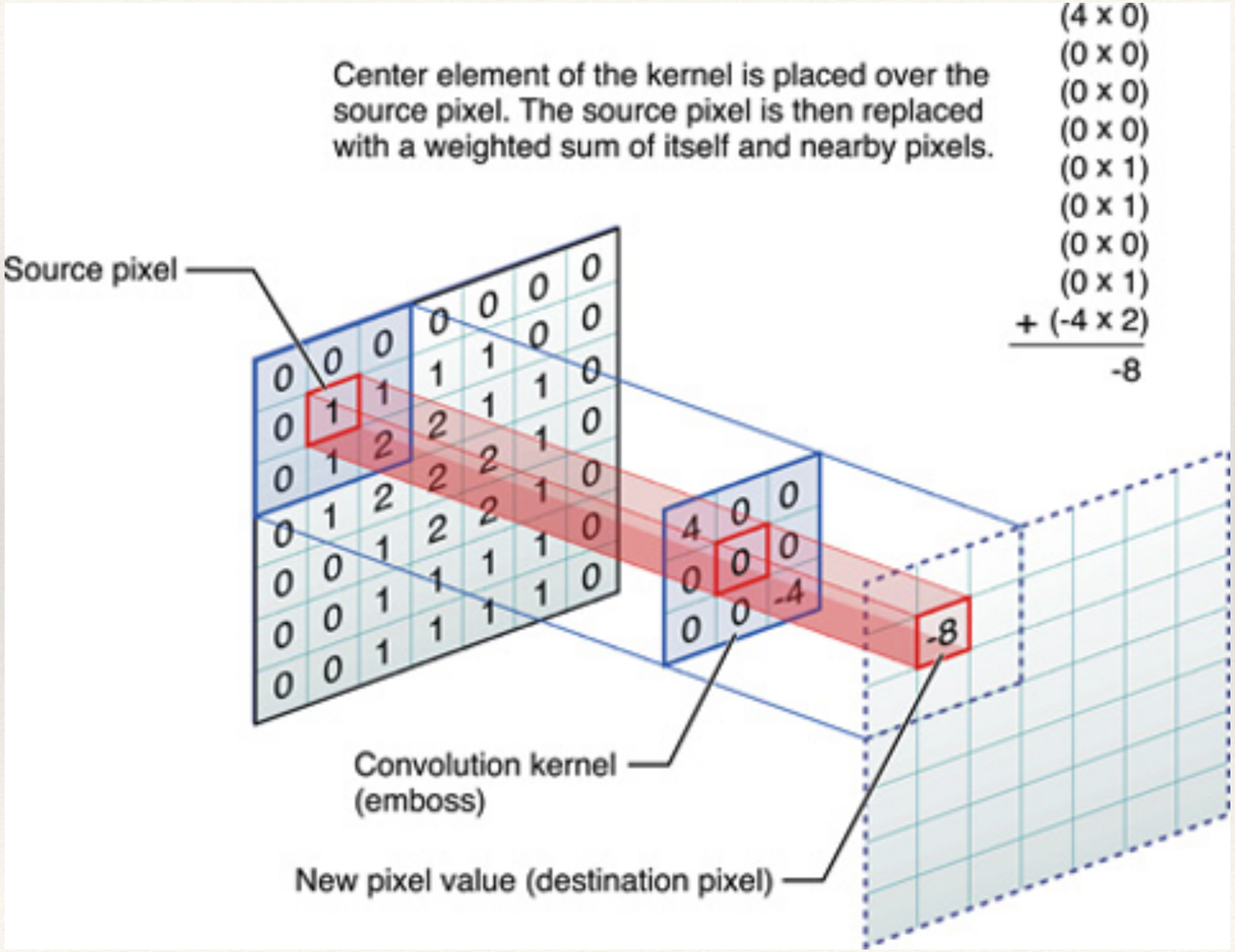
Why do we expect a layered structure like this to behave intelligently?



Convolutional Neural Networks



Convolutional Neural Networks

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Why do I care any of this? What makes it important for Radio Astronomy?

Big Data

- Karl G . Jansky Very Large Array Sky Survey (VLASS)
- Australian Square-Kilometre-Array Pathfinder (ASKAP)
- Square Kilometre Array (SKA)

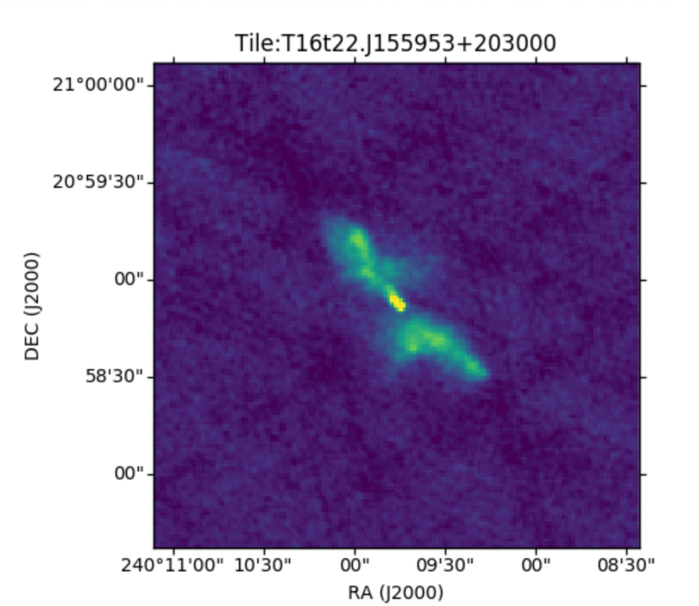
VLASS Summary	
Frequency	2-4GHz
Resolution	2.5 arcsec
Sky coverage	All Sky North of Dec. -40 deg. (33885 deg^2)
Sensitivity per epoch	120 μJy RMS
Combined (3 epoch) sensitivity	69 μJy RMS
Polarization	I,Q,U
Cadence	3 epochs separated by 32 months
Start Date	September 15 2017
Expected number of sources	~5,000,000

Radio Galaxies

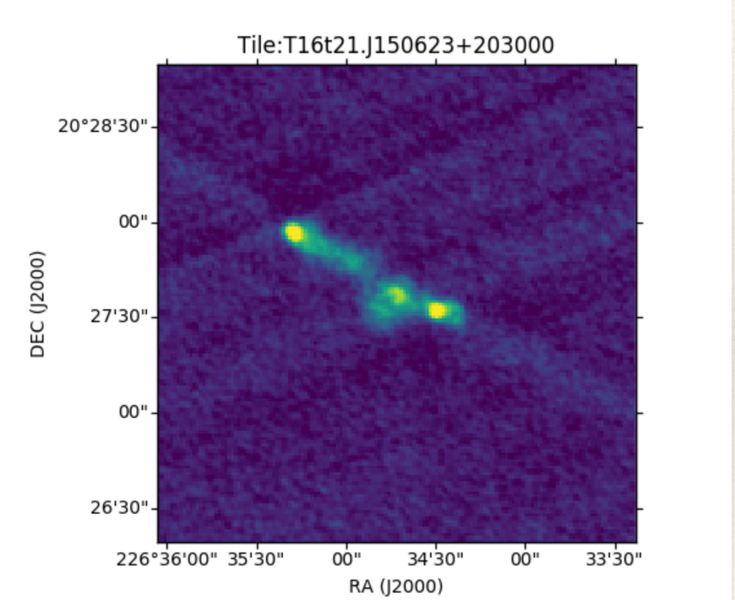
- Due to the supermassive blackhole in the center of the galaxy, a large amount of energy is emitted as the form of radio, this radio emitter is characterized as radio galaxies.
- Radio galaxies are traditionally classified into two classes:

  Fanaroff-Riley Class I (FRI) and Class II (FRII)

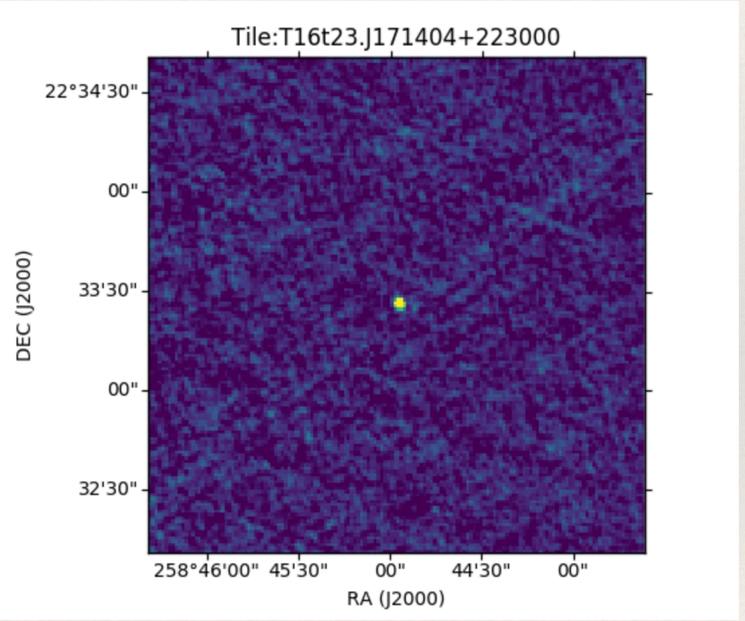
- # FRI
  - Bright energy jet in the center



- # FRII
  - Faint jets but bright hotspots at the end of lobes

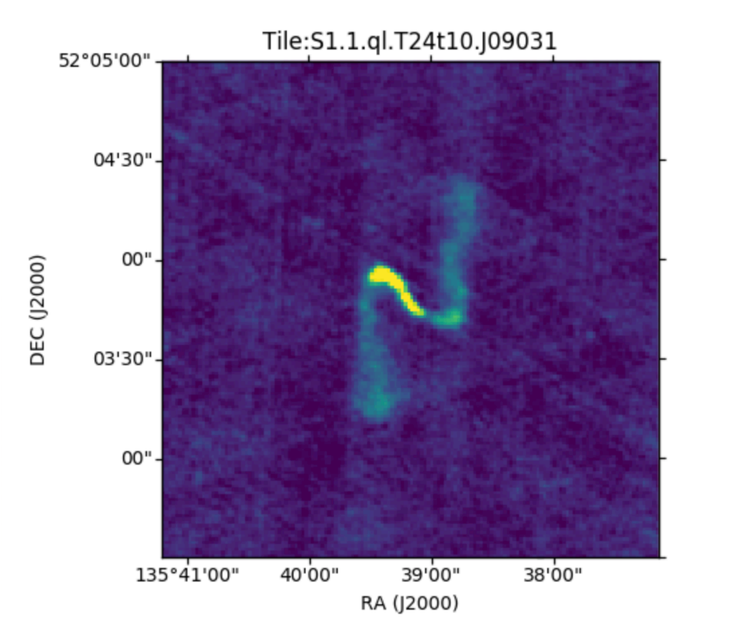


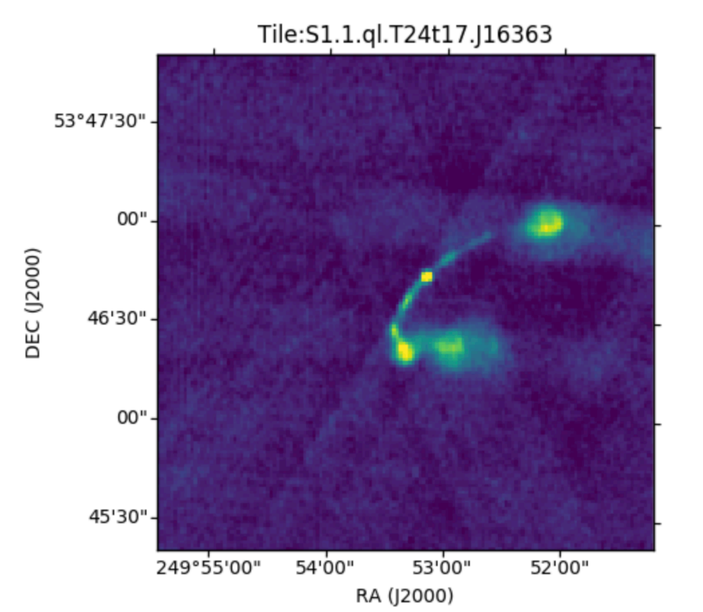
- # Compact
  - Unresolved sources has single non diffuse component

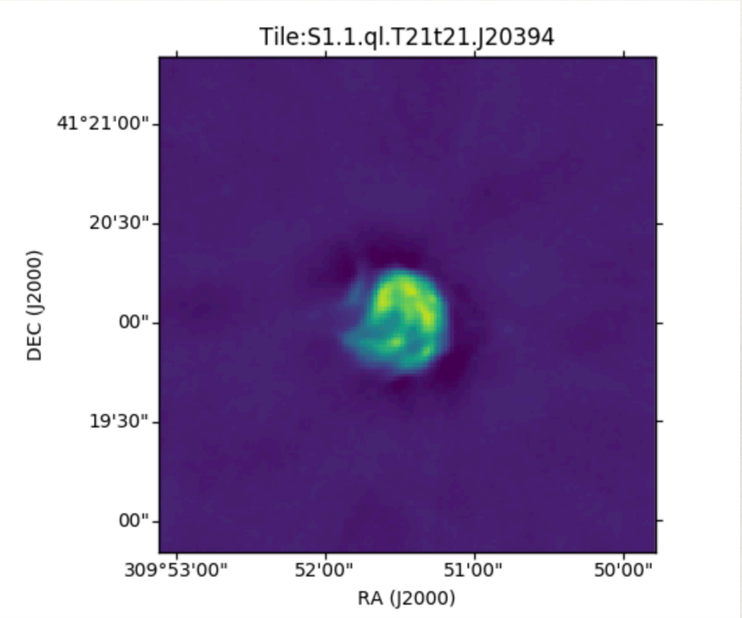


Interesting Source

- Unresolved sources







Classifying Radio Galaxies

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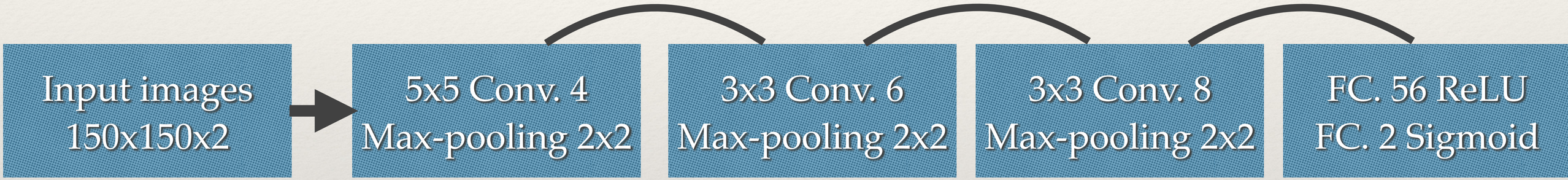
- Our group is using sources in the VLASS Quicklook images to train convolutional neural networks to automatically identify a variety of source classes
- We identified them by hands into categories of ‘Boring’ source (Compact & artifacts) and ‘Interesting’ source (FRII & tailed / diffuse sources)
-

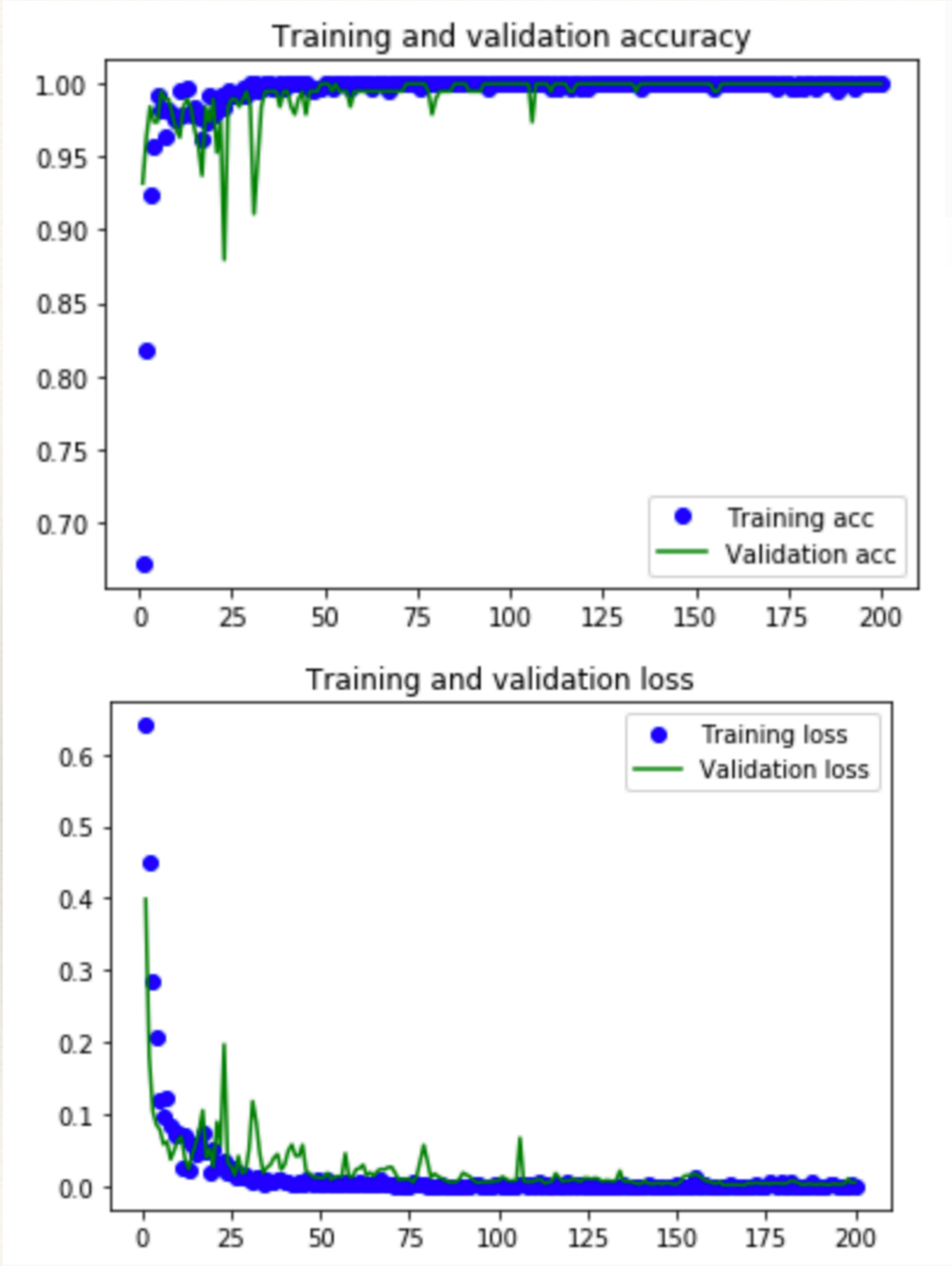
Type	Sample #	Train	Val
Interesting Source	833	762	191
Boring Source	120	762	191

Simple Neural Network Training Architecture



Model Evaluation

- The model was trained on radio galaxies images of 2 classes for 200 epochs.
- The training accuracy achieved an overall accuracy of ~99% and a loss of ~0.03% for training and validation.



Challenges & What we need to do next…

- Testing Model performance on testing dataset
- Unbalanced number of sample images.
  - More data is needed
  - Data augmentation by flipping and rotating images to generate sufficient data

Thank you!

Reference

- Chollet, F. (2017). *Deep Learning with Python* . Manning. ISBN: 9781617294433
- Alhassan, Wathela, A R Taylor, and Mattia Vaccari. “The FIRST Classifier: Compact and Extended Radio Galaxy Classification Using Deep Convolutional Neural Networks.” Monthly Notices of the Royal Astronomical Society 480.2 (2018): 2085–2093. Crossref. Web.
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- Karl G . Jansky Very Large Array Sky Survey (VLASS) Quick look images
- Autokeras, Tensorflow, https://science.nrao.edu/science/surveys/vlass