## Group 5 Results

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#### Outline

Our Model and its Optimization

 $\circ \, \text{Model}$ 

○ Optimization

- Further
  - Question 1 : How do you measure your network's performance? What is your reason for this choice? What other good choices are there?
  - Question 2 : What makes Class 5 stand out? How can this be addressed?
  - Question 3 : Find the galaxy images that your network performs best(worst) with. Explain why this is the case.

Primary Task: Train a neural network to classify the galaxy image's shapes

- >We use eLU for convolutional layers.
- ➤We use ReLU for dense layers.
- >We always have two sequential convolutional layers before pooling.
- >We used max pooling.
- Dense layers with many nodes.
- >Added a dropout layer with a 0.5 rate.

Layer (type)	Output Shape
input_7 (InputLayer)	[(None, 64, 64, 1)]
conv2d_28 (Conv2D)	(None, 64, 64, 16)
conv2d_29 (Conv2D)	(None, 64, 64, 16)
max_pooling2d_12 (MaxPoolin g2D)	(None, 32, 32, 16)
conv2d_30 (Conv2D)	(None, 32, 32, 32)
conv2d_31 (Conv2D)	(None, 32, 32, 32)
max_pooling2d_13 (MaxPoolin g2D)	(None, 16, 16, 32)
conv2d_32 (Conv2D)	(None, 12, 12, 64)
conv2d_33 (Conv2D)	(None, 8, 8, 64)
flatten_6 (Flatten)	(None, 4096)
dense_19 (Dense)	(None, 200)
dense_20 (Dense)	(None, 200)
dense_21 (Dense)	(None, 100)
dropout_8 (Dropout)	(None, 100)
dense 22 (Dense)	(None, 10)

### Primary Task: Optimize the model

- Reduced the learning rate to 0.0002.
- >Increased the batch size.
- Implemented early stopping to prevent overtraining.
- ≻No regularization.
- ≻Added weights.



Question 1: How do you measure your network's performance? What is your reason for this choice? What other good choices are there?

>We can see how good the network is performing by looking at the confusion matrix, which ideally would be diagonal.

The closer to that form, the better.

## Question 2: What makes Class 5 stand out? How can this be addressed?

- Class 5 has way too few samples compared to other ones by an order of magnitude of 3.
- We can address it by oversampling the class by mirroring, rotating or modifying weights.

# Question 3: Find the galaxy images that your network performs best(worst) with. Explain why this is the case.

Best class performance: Disk, Edge-on, No Bulge (class 6)
2<sup>nd</sup> best: Smooth, completely round (class 1)

Both are comparably more distinctive than other classes.

Worst class performance: Disk, Face-on, no spiral (class 0)

Class 0 gets categorized into 1 and 2

➤ Bad performance also with:

Class 8 gets mixed up with 7

Class 3 gets mixed up with 6

Disk, Face-on, No Spirel     0.46     0.13     0.16     0.001     0.01												
Smooth, Completely round     0.017     0.95     0.027     0     0.014     0     0.0084     0.0     0.016     0.015     0.016     0.015     0.016		Disk, Face-on, No Spiral	0.46	0.13	0.16	0.0061	0.03	0	0.0061	0.11	0.043	0.058
Smooth, in-between round -   0.044   0.08   0.85   0   0.005   0   0.01   0.001	True label	Smooth, Completely round	0.017	0.95	0.027		0.0014			0.0084		
Bisk, Edge-on, Rounded Bule     O<		Smooth, in-between round	0.044	0.08	0.85	0	0.0065			0.016	0.0016	0.0016
Disk, Edge-on, Rounded Bulge   00059   0   0035   0085   0   0.053   0<		Smooth, Cigar shaped	0		0.027	0.68	0.027		0.27			
Disk, Edge-on, No Bulge - 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		Disk, Edge-on, Rounded Bulge	0.0059		0.035	0.059	0.85		0.053			
Disk, Edge-on, No Bulge - 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0. 0.		Disk, Edge-on, Boxy Bulge	0				0	1	0			
Disk, Face-on, Medium Spiral - 0.046 0.038 0.031 0 0 0 0 0 0.85 0.023 0.0076 Disk, Face-on, Medium Spiral - 0.11 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		Disk, Edge-on, No Bulge	0				0.034	0	0.97			
Disk, Eace-on, Medium Spiral   010   0   0   0   0   0   0     Bisk, Edge-on, Rounded Bulge   0   0   0   0   0   0   0   0   0     Disk, Edge-on, No Spiral   Smooth, Completely round   - <td>Disk, Face-on, Tight Spiral</td> <td>0.046</td> <td>0.038</td> <td>0.031</td> <td></td> <td></td> <td></td> <td>0</td> <td>0.85</td> <td>0.023</td> <td>0.0076</td>		Disk, Face-on, Tight Spiral	0.046	0.038	0.031				0	0.85	0.023	0.0076
Disk' Eace-on, No Spiral - Smooth, Completely round - Smooth, Completely round - Smooth, Completely round - Smooth, Cigar shaped - Disk, Edge-on, Rounded Bulge - Disk, Edge-on, Rounded Bulge - Disk, Edge-on, No Bulge - Disk, Face-on, Medium Spiral - Disk, Face-on, Medium Spiral - Disk, Face-on, Loose Spiral - Disk, Face-on, Loose Spiral -		Disk, Face-on, Medium Spiral	0.11							0.16	0.66	0.071
Disk, Face-on, No Spiral - Smooth, Completely round - Smooth, in-between round - Smooth, Cigar shaped - Smooth, Cigar shaped - Disk, Edge-on, Rounded Bulge - Disk, Edge-on, Rounded Bulge - Disk, Face-on, No Bulge - Disk, Face-on, No Bulge - Disk, Face-on, No Bulge - Disk, Face-on, No Bulge -		Disk, Face-on, Loose Spiral	0.022	0.022	0.022						0.044	0.89
			Disk, Face-on, No Spiral -	Smooth, Completely round -	Smooth, in-between round -	Smooth, Cigar shaped -	)isk, Edge-on, Rounded Bulge -	Disk, Edge-on, Boxy Bulge -	Disk, Edge-on, No Bulge -	Disk, Face-on, Tight Spiral -	Disk, Face-on, Medium Spiral -	Disk, Face-on, Loose Spiral -

1.0

#### Example images of each class from Galaxy10 dataset



Smooth, Completely round



Smooth, Cigar shaped



Disk, Edge-on, Rounded Bulg



Disk, Edge-on, Boxy Bulge



Disk, Edge-on, No Bulge

Disk, Face-on, Tight Spiral



Disk, Face-on, Medium Spiral



Disk, Face-on, Loose Spiral



Galaxy10 Dataset: Henry Leung/Jo Bovy 2018, Data Source: SDSS/Galaxy Zoo

