Teaching Neural Networks to Play SET™

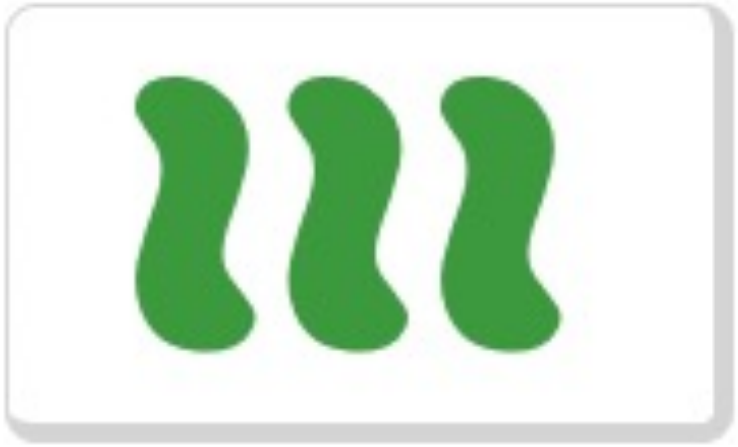
Metis DL Module Presentation

Andrei Levin • 12/3/21

SET is a Pattern-Finding Card Game

- Each card has 4 features:

Shape, Color, Number, Shading

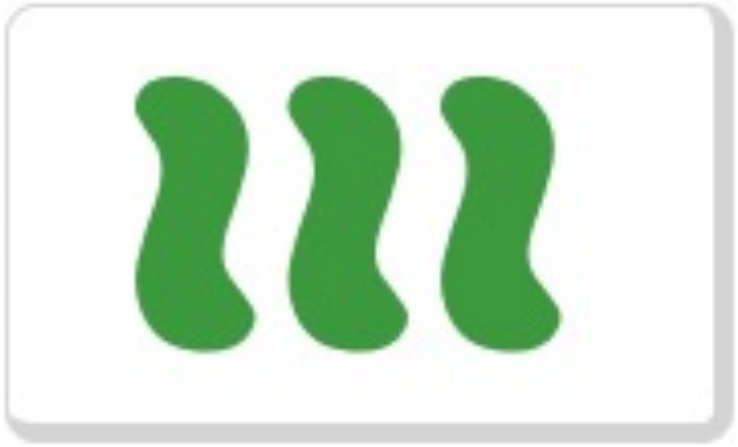


SET is a Pattern-Finding Card Game

- Each card has 4 features:

Shape, Color, Number, Shading

- Each feature has 3 classes



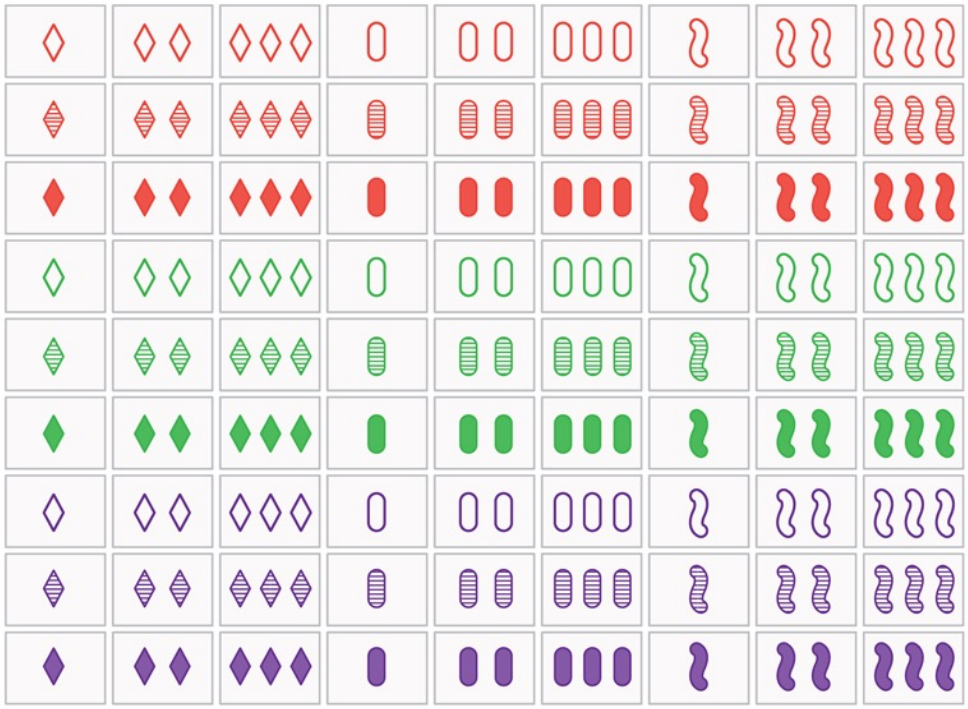
A Full Deck Has 3^4 = 81 Different Cards

- Each card has 4 features:

Shape, Color, Number, Shading

- Each feature has 3 classes

THE FULL DECK



Shape

 ovals,

 squiggles,

 or diamonds

Color

 red,

 purple,

 or green

Number

 one,

 two,

 or three

Shading

 solid,

 striped,

 or outlined

The Goal of the Game is to Find Sets

- Three cards are said to form a Set if, for each feature: the cards are all the same class OR all different classes

Shading	
Shape	
Color	
Number	
Is it a Set?	

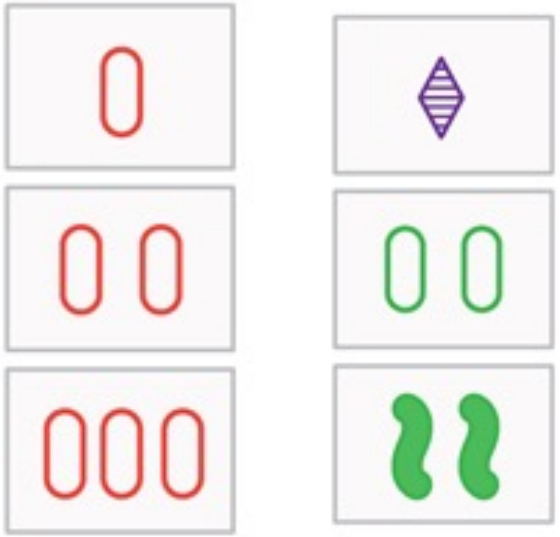
The Goal of the Game is to Find Sets

- Three cards are said to form a Set if, for each feature: the cards are all the same class OR all different classes

Shading	All same
Shape	All same
Color	All same
Number	All different
Is it a Set?	**Yes ☺**

The Goal of the Game is to Find Sets

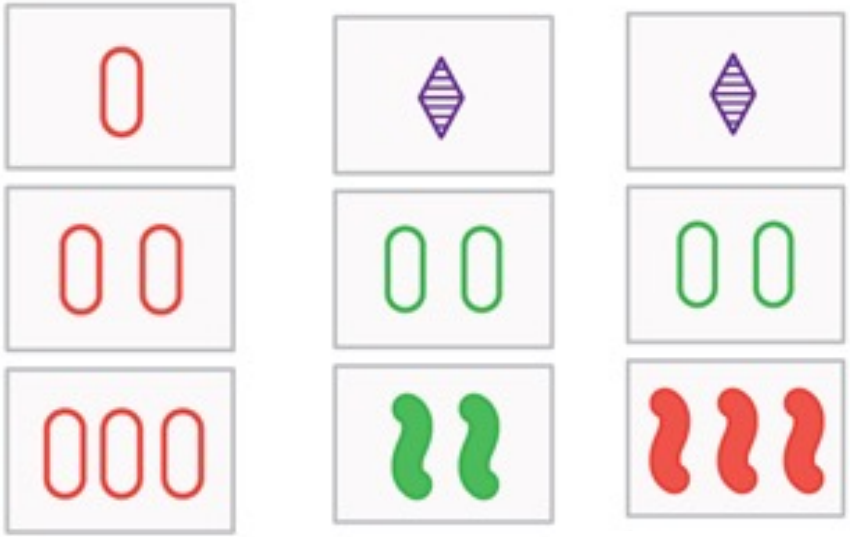
- Three cards are said to form a Set if, for each feature: the cards are all the same class OR all different classes



Shading	All same	All different
Shape	All same	All different
Color	All same	2 & 1
Number	All different	2 & 1
Is it a Set?	**Yes ☺**	**No ☹**

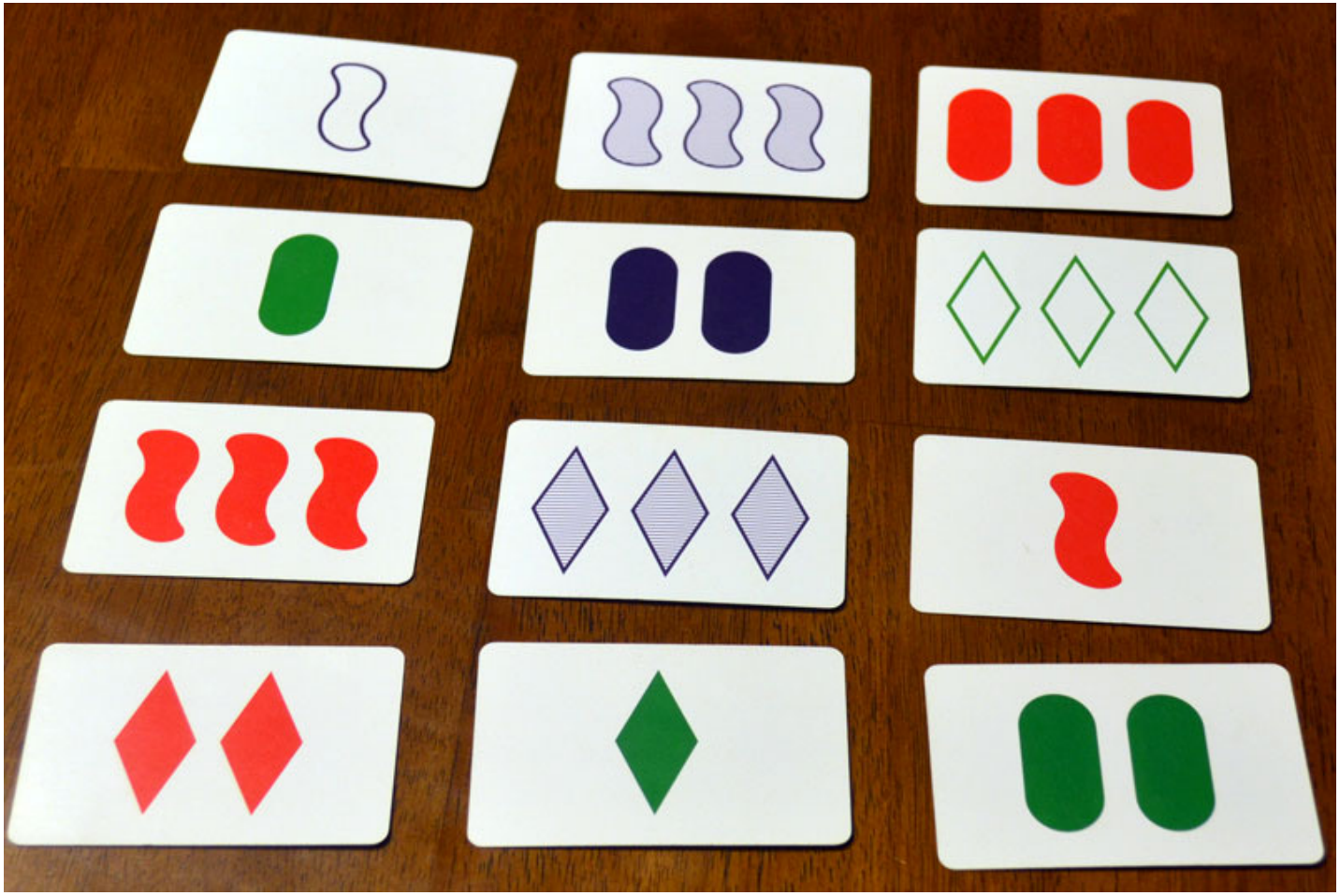
The Goal of the Game is to Find Sets

- Three cards are said to form a Set if, for each feature: the cards are all the same class OR all different classes



Shading	All same	All different	All different
Shape	All same	All different	All different
Color	All same	2 & 1	All different
Number	All different	2 & 1	All different
Is it a Set?	**Yes ☺**	**No ☹**	**Yes ☺**

Can You Find the Sets in This Hand?



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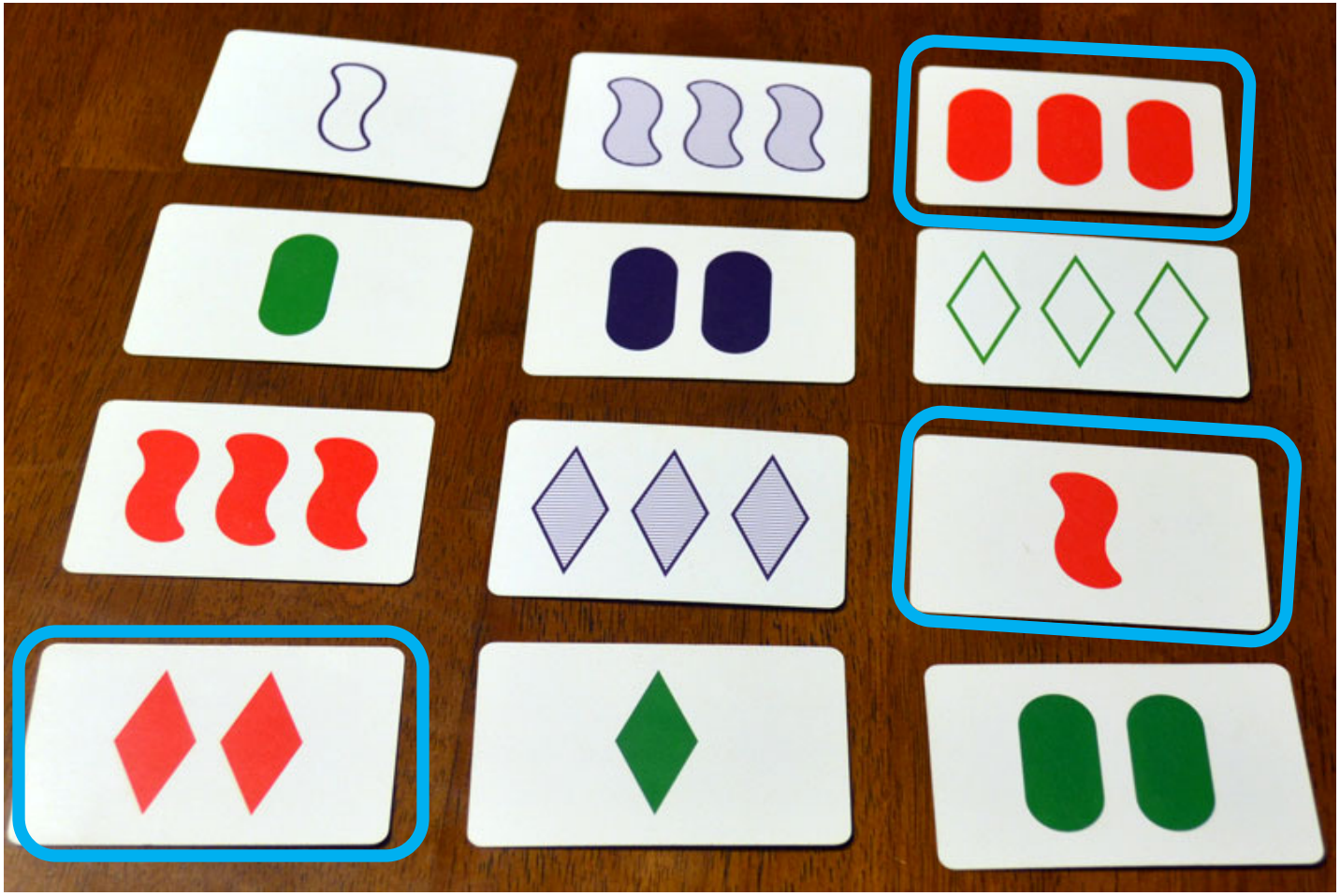

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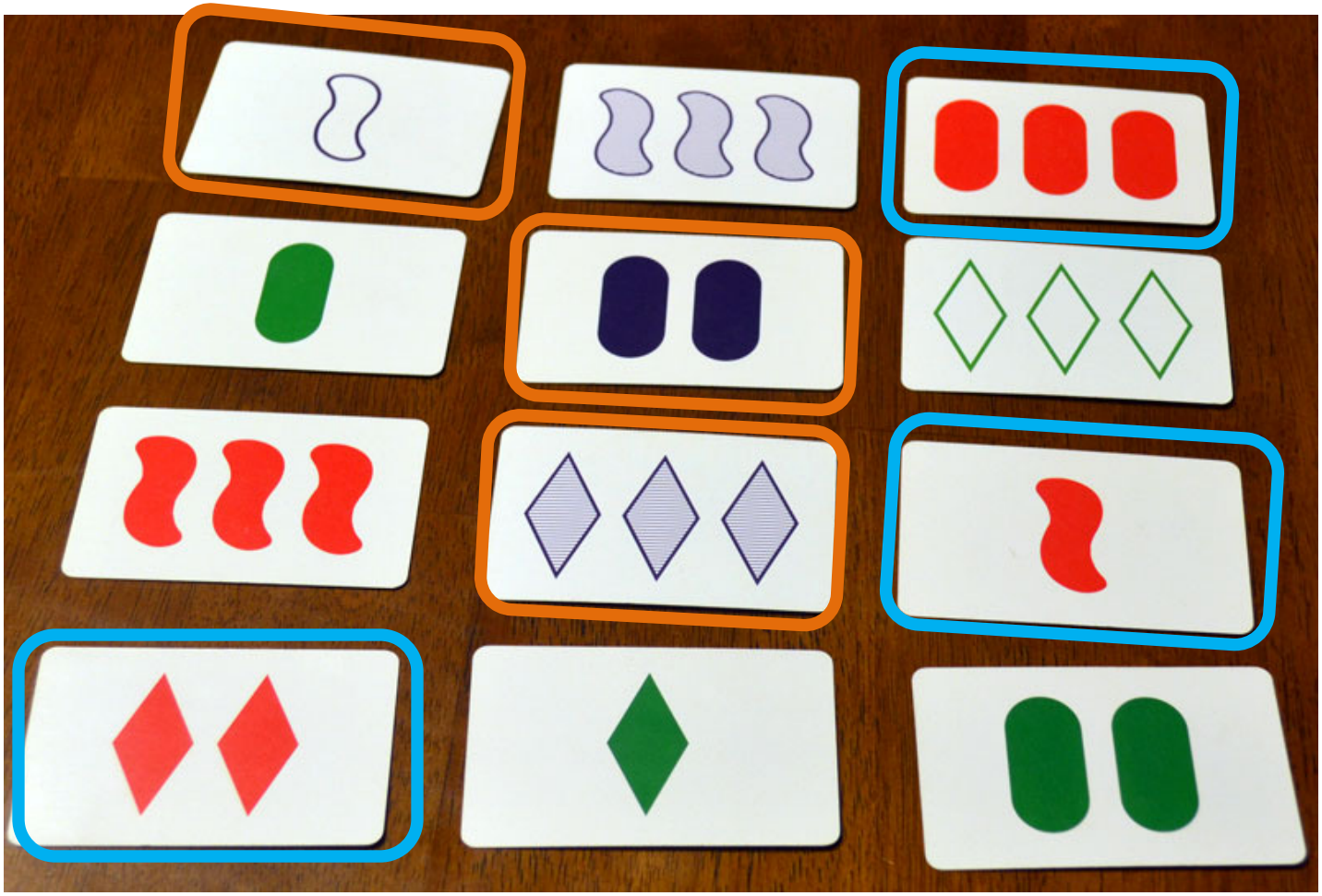
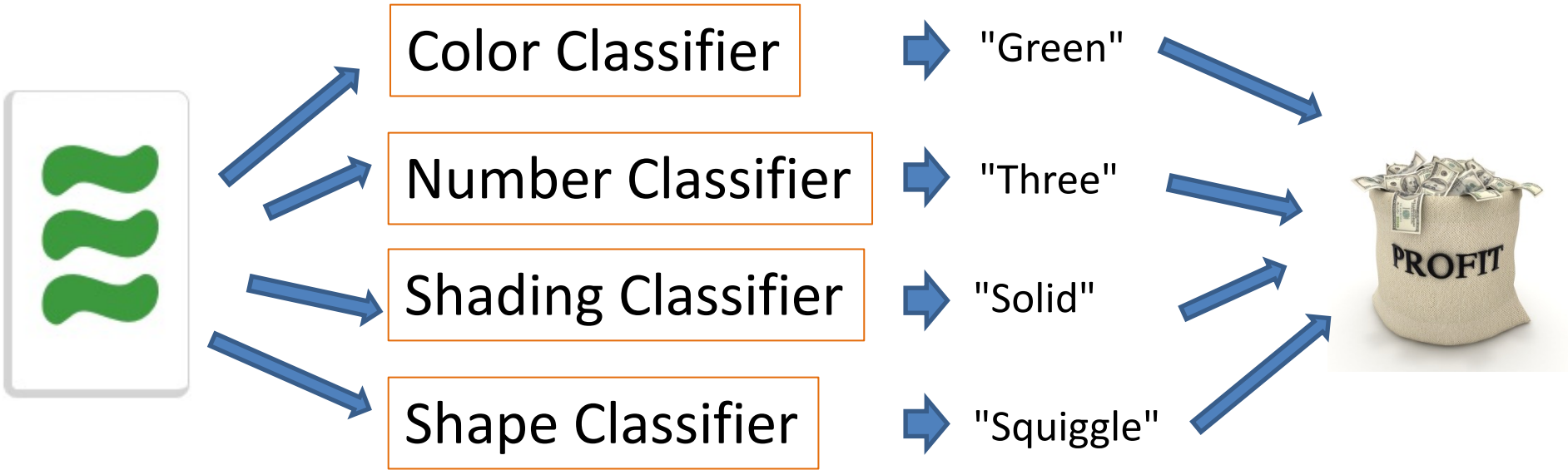


Can We Teach a Computer to Find the Sets?

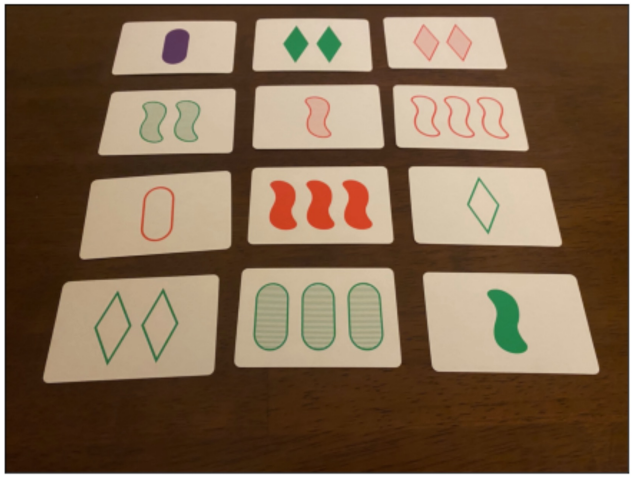
(1) Collect many card images
(different lighting, backgrounds, angles, etc.)
(2) Train four separate classifiers: one for each attribute
(3) Combine the classifiers to **fully identify** the card
(4) Exhaustive algorithm to find all Sets in a hand



Getting the Training Data: OpenCV

1 Take Photos

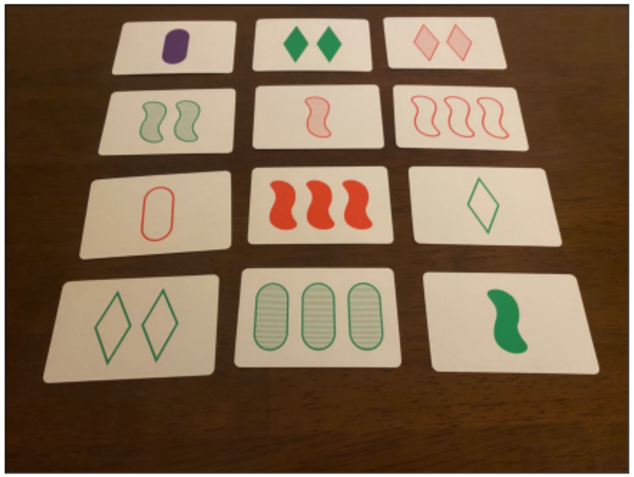
1



Getting the Training Data: OpenCV

1 Take Photos **2** Detect Contours

1



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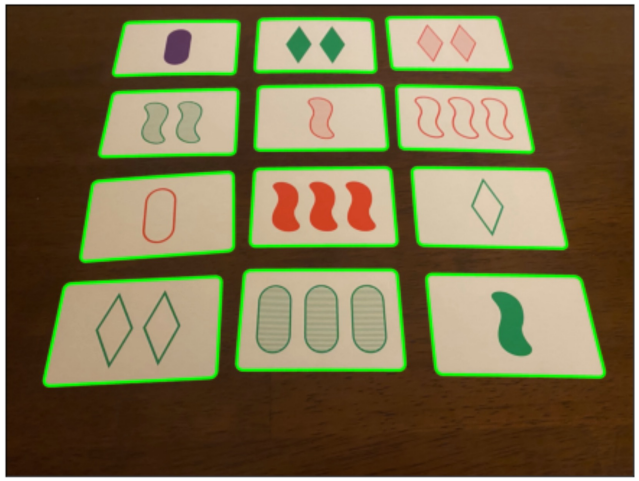
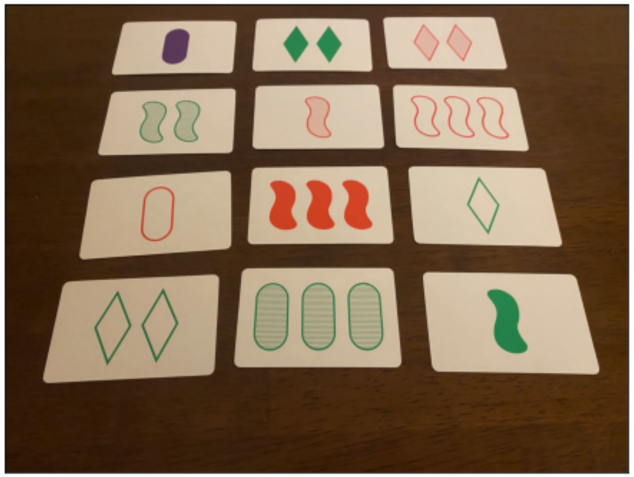


Getting the Training Data: OpenCV

1 Take Photos **2** Detect Contours **3** Extract Cards

1



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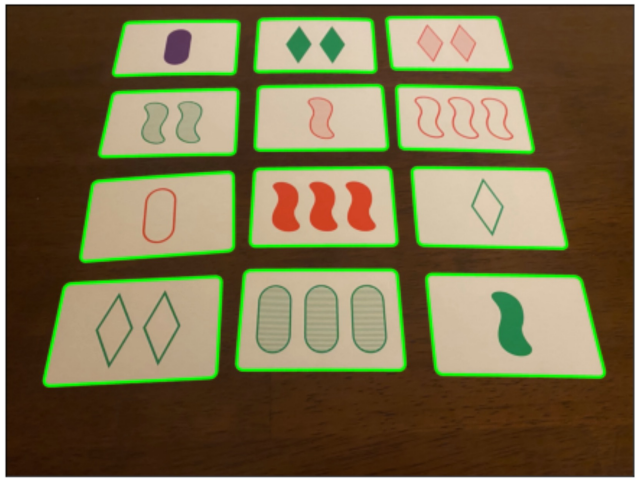

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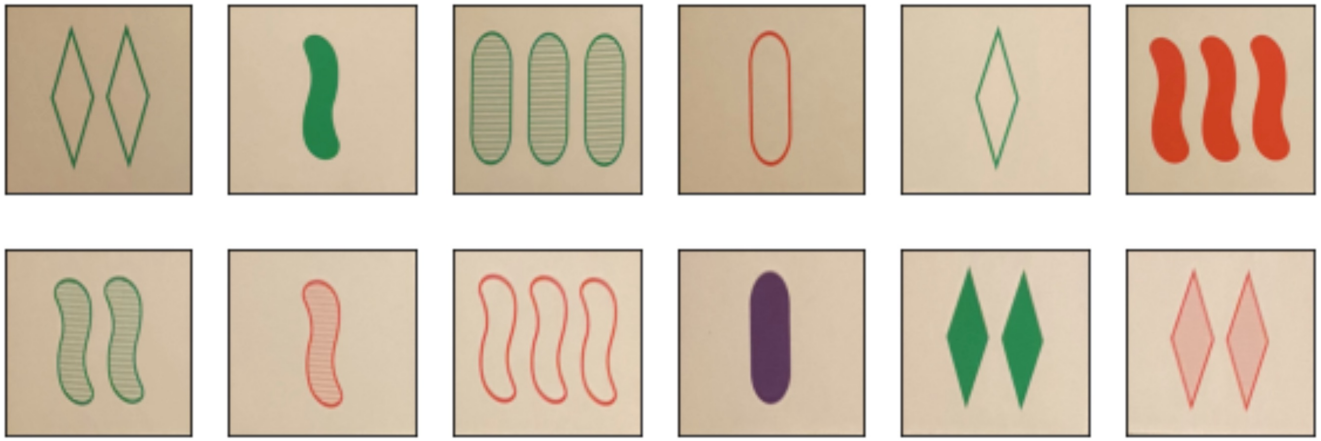
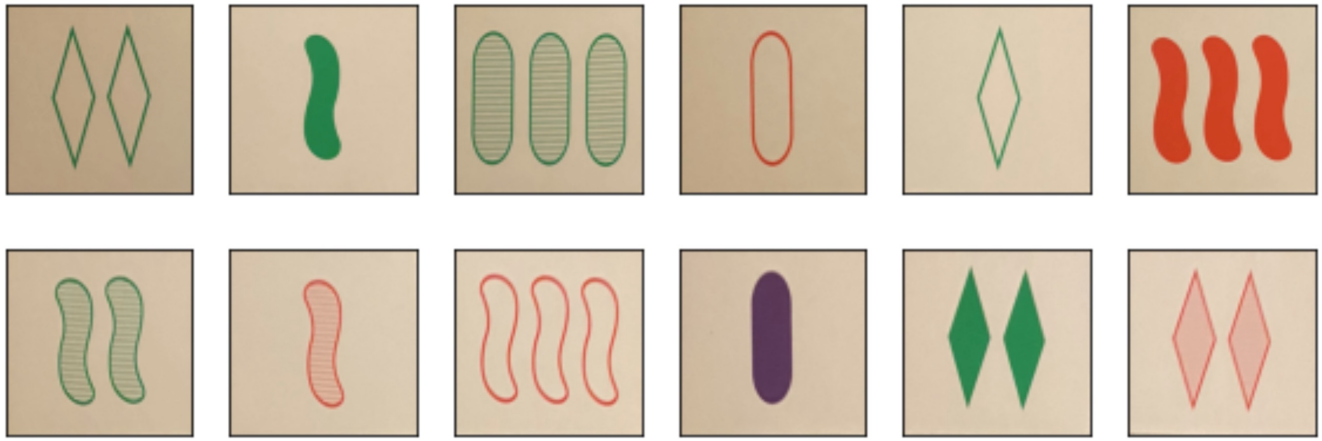


Data Augmentation

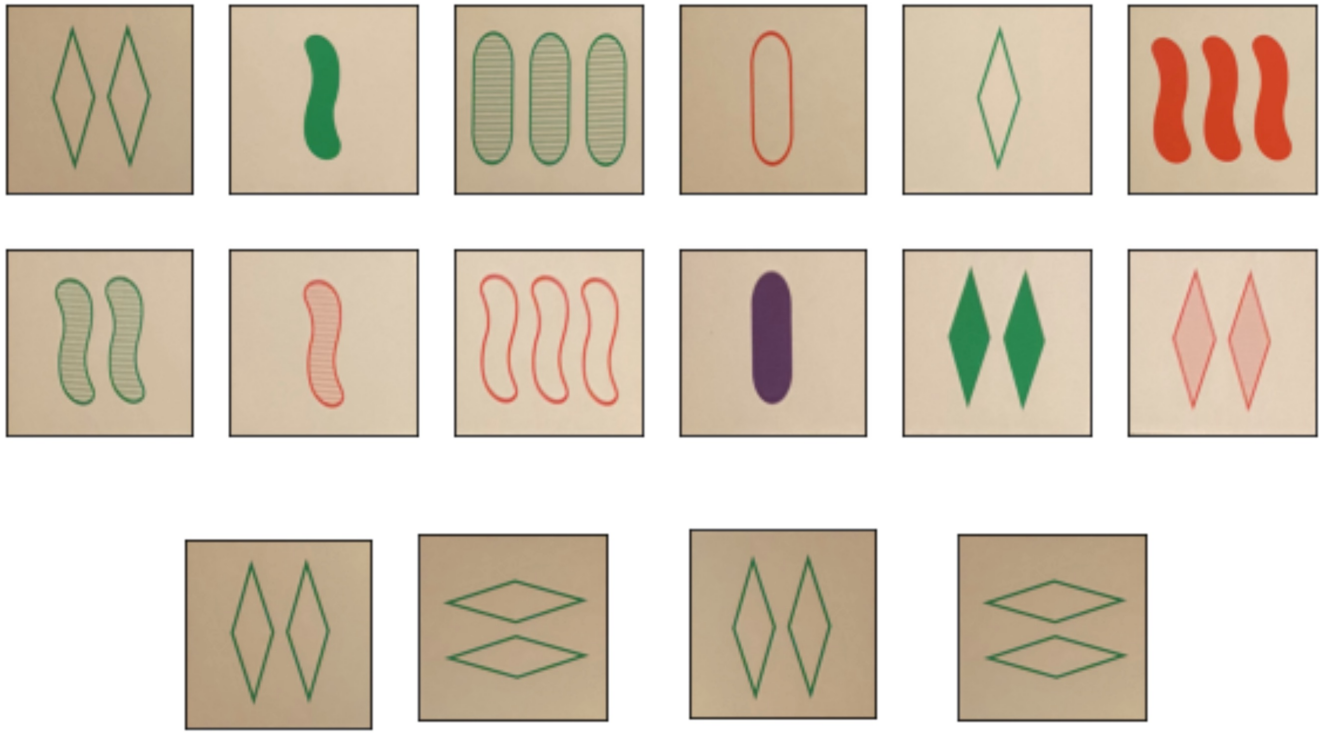
- Collected 540 unique images (140 per class)



- images
  - color
    - test
    - train
      - green
      - purple
      - red
  - number
    - test
    - train
      - one
      - three
      - two
  - shading
    - test
    - train
      - empty
      - solid
      - striped
  - shape
    - test
    - train
      - diamond
      - oval
      - squiggle

Data Augmentation

- Collected 540 unique images (140 per class)
- 420 unique training images
  → 4-fold augmentation (90 degree rotations)
  → **1680** naturally augmented training images



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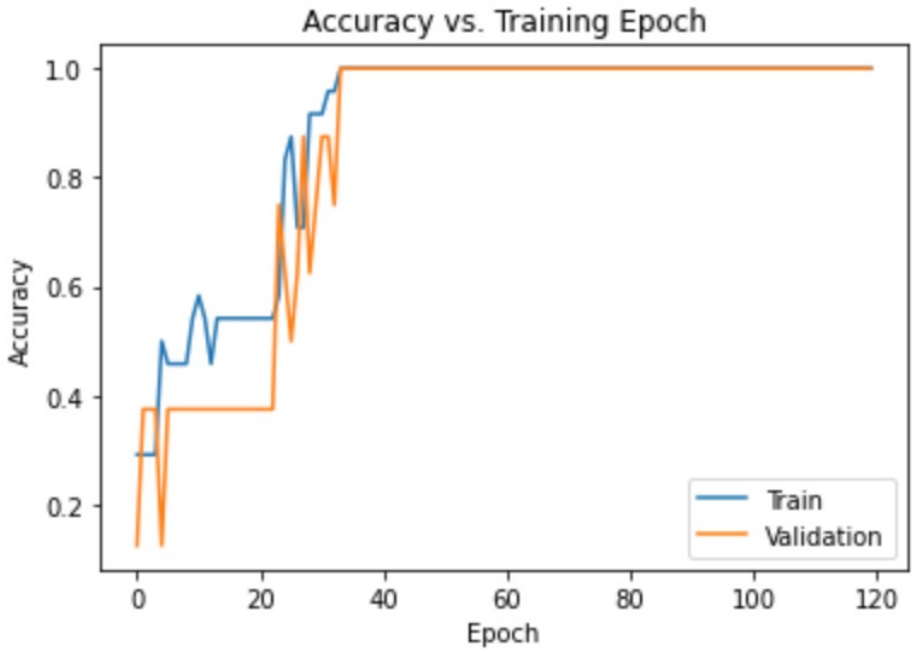
Number Classifier: 100% Train/Valid/Test Accuracy!

Layer (type)	Output Shape	Param #
conv2d_118 (Conv2D)	(None, 100, 100, 16)	160
max_pooling2d_110 (MaxPoolin	(None, 50, 50, 16)	0
conv2d_119 (Conv2D)	(None, 50, 50, 32)	4640
max_pooling2d_111 (MaxPoolin	(None, 25, 25, 32)	0
conv2d_120 (Conv2D)	(None, 25, 25, 48)	13872
max_pooling2d_112 (MaxPoolin	(None, 12, 12, 48)	0
flatten_34 (Flatten)	(None, 6912)	0
dense_228 (Dense)	(None, 10)	69130
dense_229 (Dense)	(None, 3)	33

Total params: 87,835
Trainable params: 87,835
Non-trainable params: 0



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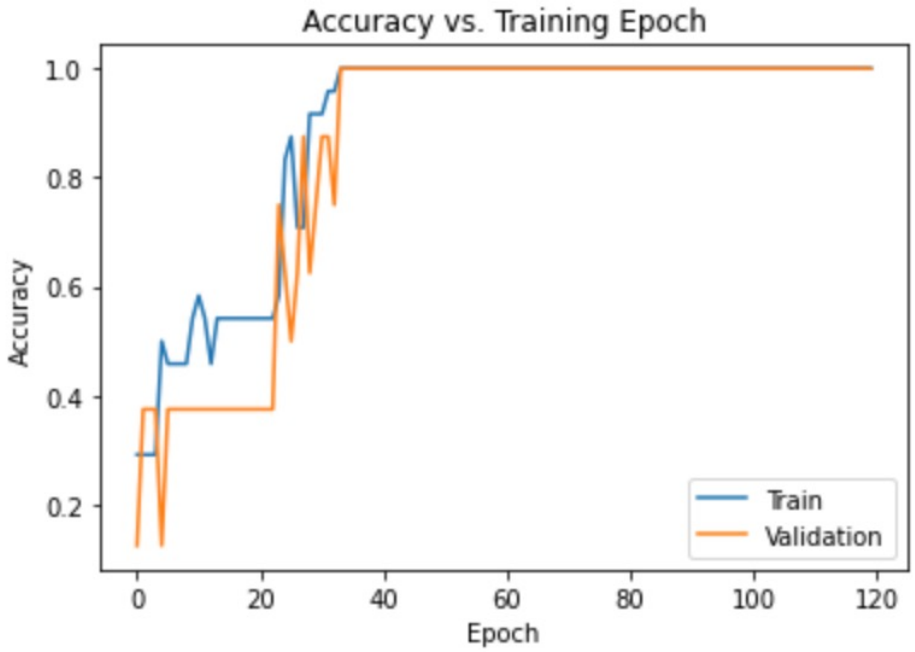
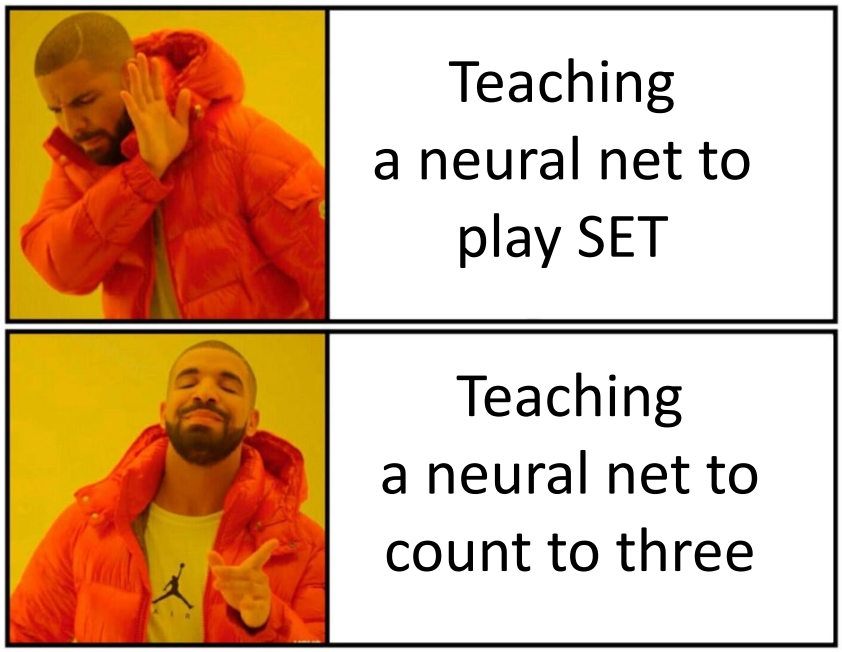
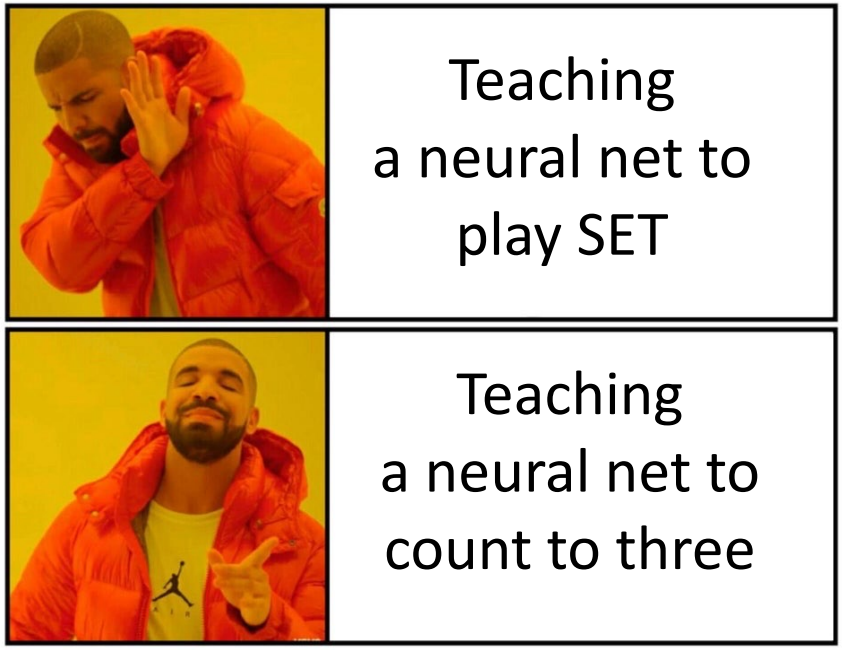


Color, Shape, Shading Classifiers:
~50%-80% Test Accuracy

Conclusions



Conclusions



Next Steps

- Further data augmentation (e.g. brightness, blurring)
- Hyperparameter tuning
- Regularization
- Hierarchical classifiers
- Different model architectures