National Defense Education Program
ARTIFICIAL INTELLIGENCE

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01

Intro To Artificial Intelligence

Tyler Hale & Kevin Comaduran

What is an AI?

AI stands for “Artificial Intelligence”. This is the way that scientists answer the question “How can a machine think?” AIs use pattern recognition (known as “machine learning”) to determine relationships between pieces of data. With these relationships, they can analyze inputs and determine an output accurately.

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Machine Learning

Machine Learning is how computer scientists train an AI. The process involves two major factors: training data and testing data.

Trainers

Training data is the information fed into pattern recognition

After the AI is done training, testing data is used to ensure that it has a high accuracy

Testers

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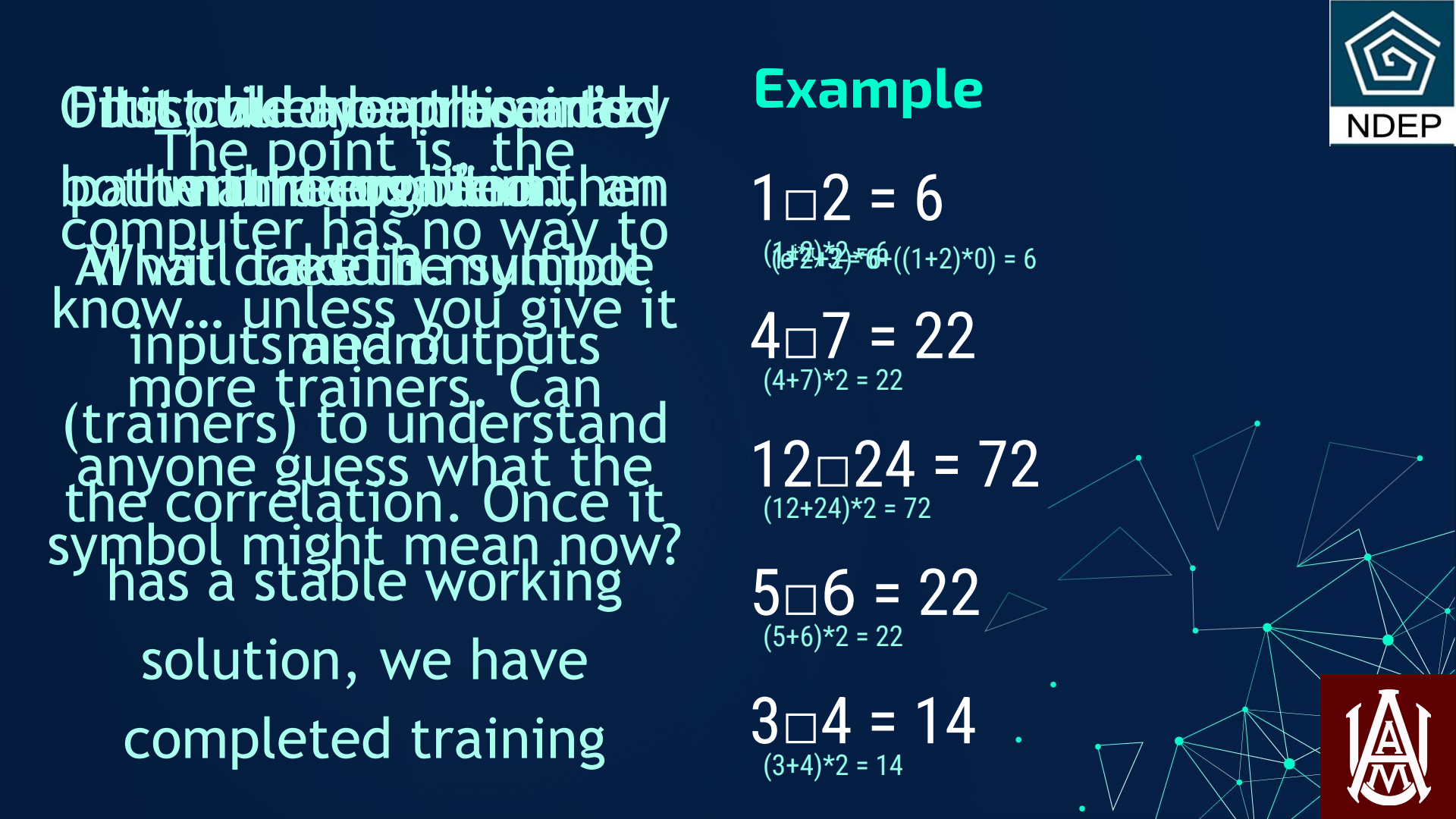
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Example
1□2 = 6
(1+2)*2 = 6
((1+2)*0) = 6
4□7 = 22
(4+7)*2 = 22
12□24 = 72
(12+24)*2 = 72
5□6 = 22
(5+6)*2 = 22
3□4 = 14
(3+4)*2 = 14

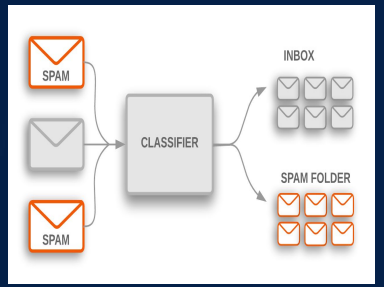
Applications

AI-based software to catch wrist fractures more quickly in the healthcare sector

Using AI to observe and identify potential investment market offenses in financial sector

Adopting AI to help find and detect new phenomena in astronomy

Employing AI to detect and filter spam mail or phishing emails



Source : https://www.ai.gov/strategic-pillars/applications/

02

OUR PROJECT

Prativa Regmi & Amari Brassfield

Image Recognition

Supervised Classification

In our project, our software will have the ability to “recognize” images. It will then classify these images into predefined groups.

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Modified National Institute of Standards and Technology (MNIST)

Definition

Large databases that are used to train different image processing systems

Uses

Provides baseline for testing image processing systems.

Source

Created by re-mixing different samples from NIST's database

Features

Databases can reach up to 70,000 pieces of data.

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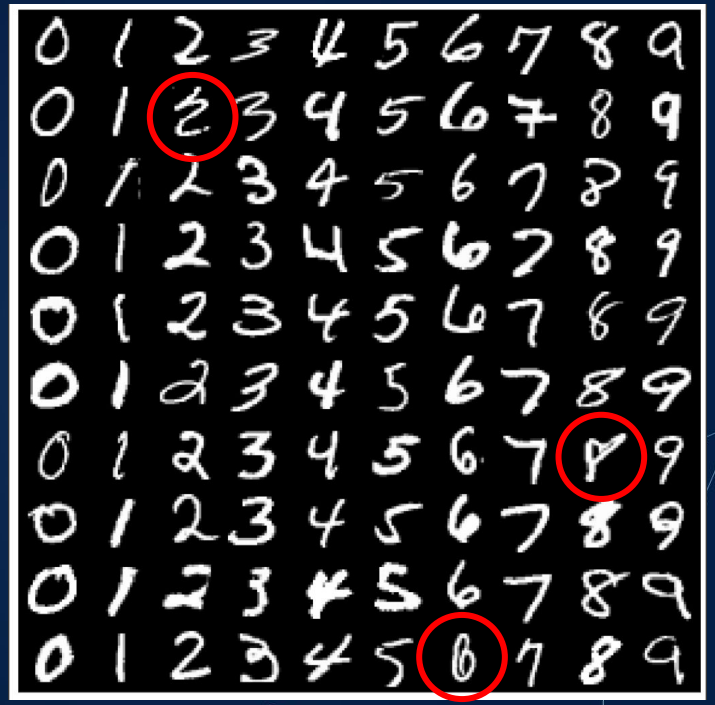
MNIST Numbers Dataset

The Handwritten Numbers dataset contains over 70,000 images that contain the digits 0-9 and our project is to classify these images.

With this image, you can see how many variations there are to handwritten numbers and how that makes it difficult to identify specific digits



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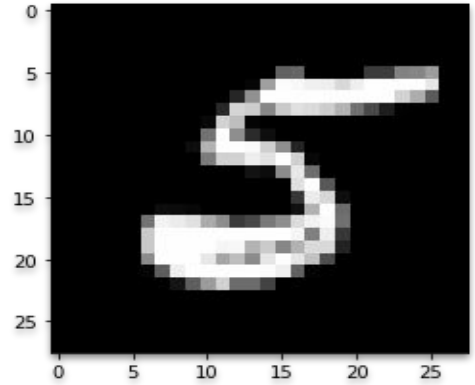
Examples

Each image is really an array of 784 pixels (28x28) that each contain a number from 0-255. This number signifies how light or dark the pixel will appear

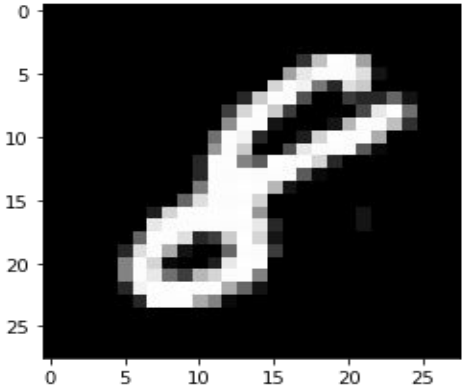
```
x = image_dictionary[5]
print(x.shape)
plt.imshow(x[100], cmap='gray')
```

(6313, 28, 28)




```
x = image_dictionary[8]
print(x.shape)
plt.imshow(x[6800], cmap='gray')
```

(6825, 28, 28)



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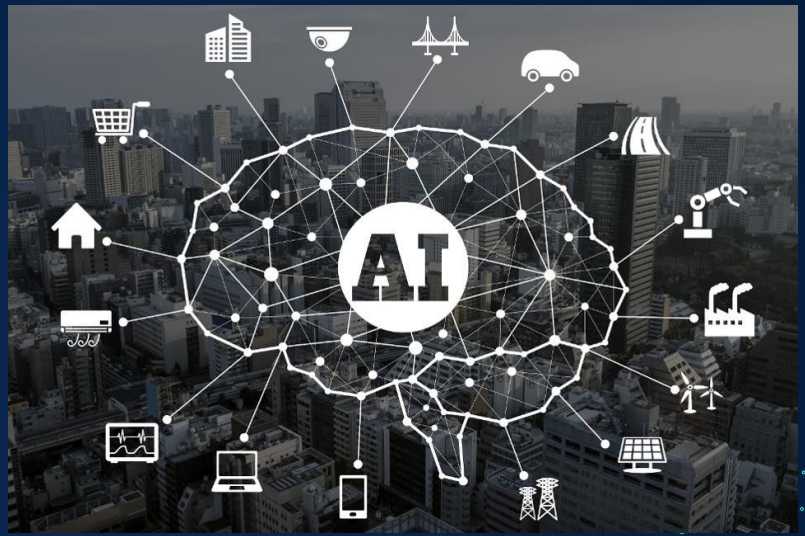
Real World Relevance

An AI that can read handwritten numbers is useful because we can use it to read postal addresses, bank checks, and any other paper documents where handwriting can cause issues.



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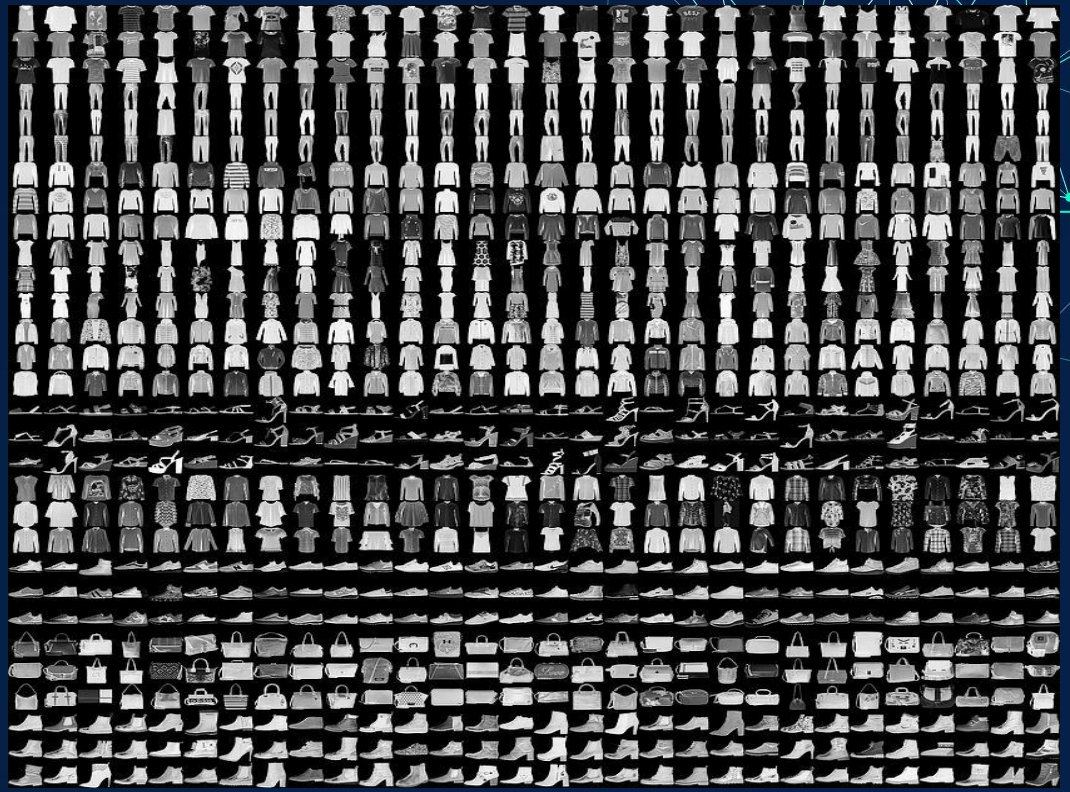
MNIST Clothing Dataset

Instead of digits, this dataset contains different items of clothing (Shirts, Trousers, Sneakers, Bags, etc.)

There is a total of 70,000 pieces of data. Each group contains ~7000 each



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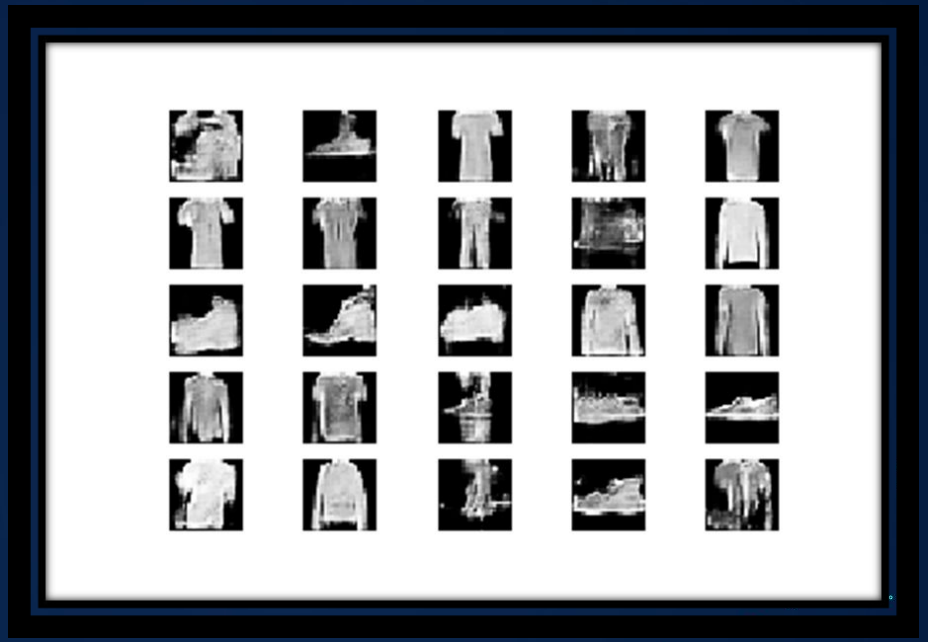
Source : https://emerj.com/ai-sector-overviews/artificial-intelligence-for-clothing-and-apparel/

Real World Relevance

Clothing recognition can be use to characterize people such as life style, age, and gender. Fashion brands around the globe use AI for their design process; regarding personal style to fit body shape.



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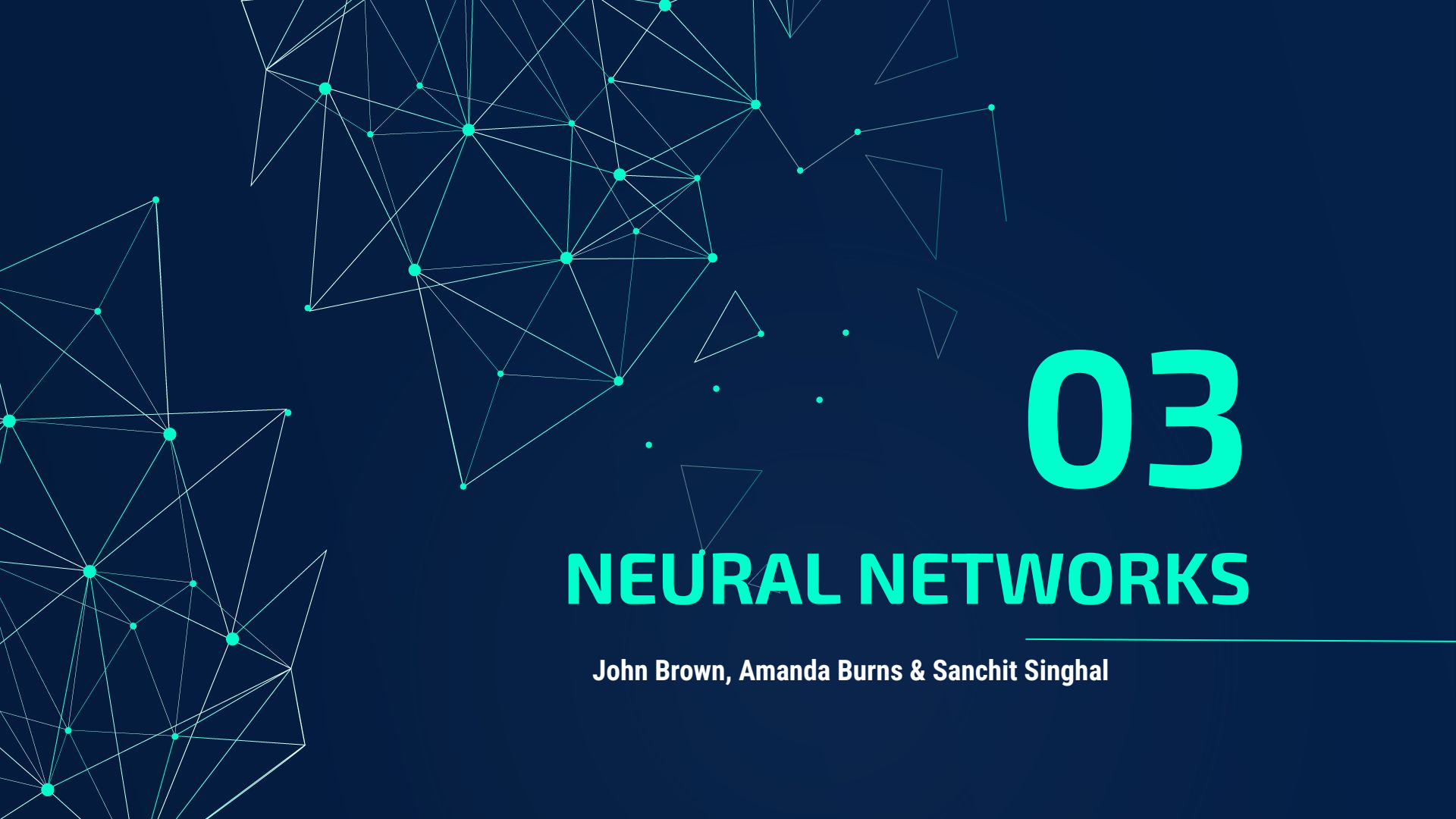

03

NEURAL NETWORKS

John Brown, Amanda Burns & Sanchit Singhal

What are Neural Networks?

Neural networks, also known as artificial neural networks, are a series of algorithms that recognize the underlying relationships in a set of data through a process that mimics the way the human brain operates. Neural nets are the means by which computer learns to perform some tasks by analyzing training examples.

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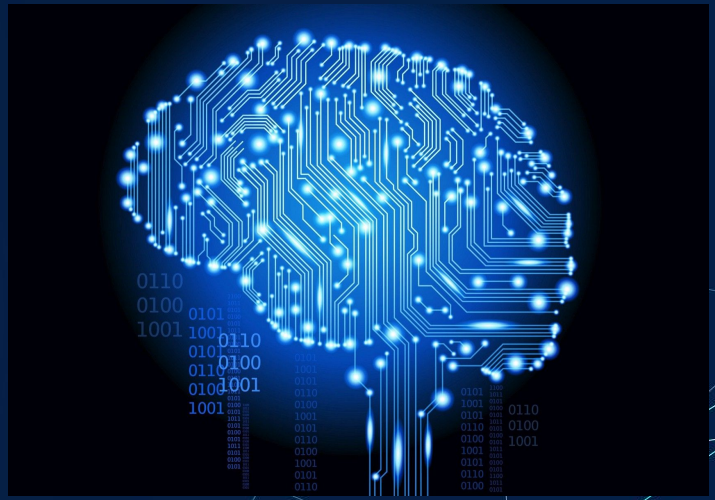
Relation to Human Brain

- Consists of numerous nodes interconnected like human brain
- Nodes = Neurons
- Sends and analyzes data send through layers
- Makes decisions based on the data



Source: https://www.bmc.com/blogs/neural-network-introduction/

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Breakdown of Parts

What is a Layer?

- Part of the structure
- Input, Hidden, & Output
- Order of computation; steps for the model
- Symbolic of a group of neurons activated at the same time
- Connections between layers are like axons

What is a Node?

- Computational unit
- Information travels from node to node
- Symbolic of a neuron

What is a Weight?

- Number from 0-1 representing connection strength
- Changes as the model learns
- Symbolic of the threshold potential

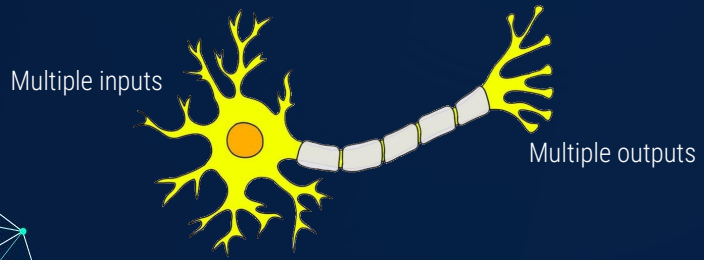

Image: https://neuroscientificallychallenged.com/glossary/neuron

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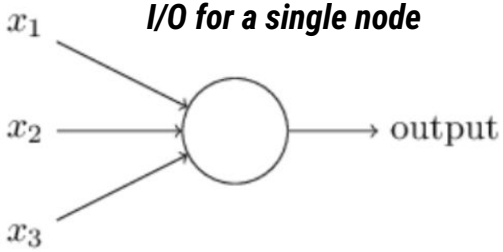
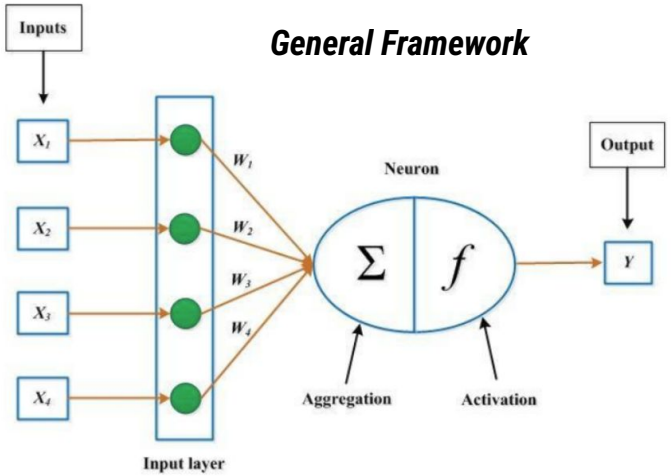
How does it work?

- Neural networks are comprised of interconnected layers and nodes
- Each node receives inputs and computes the data to make a decision
- Once a node is activated, it sends data to the next node through it's connections
- Eventually it reaches the output layer, where the most prominent node is chosen as the 'solution' and outputted
- They can adapt to changing input and use the training data to learn and improve accuracy over time

I/O for a single node



General Framework



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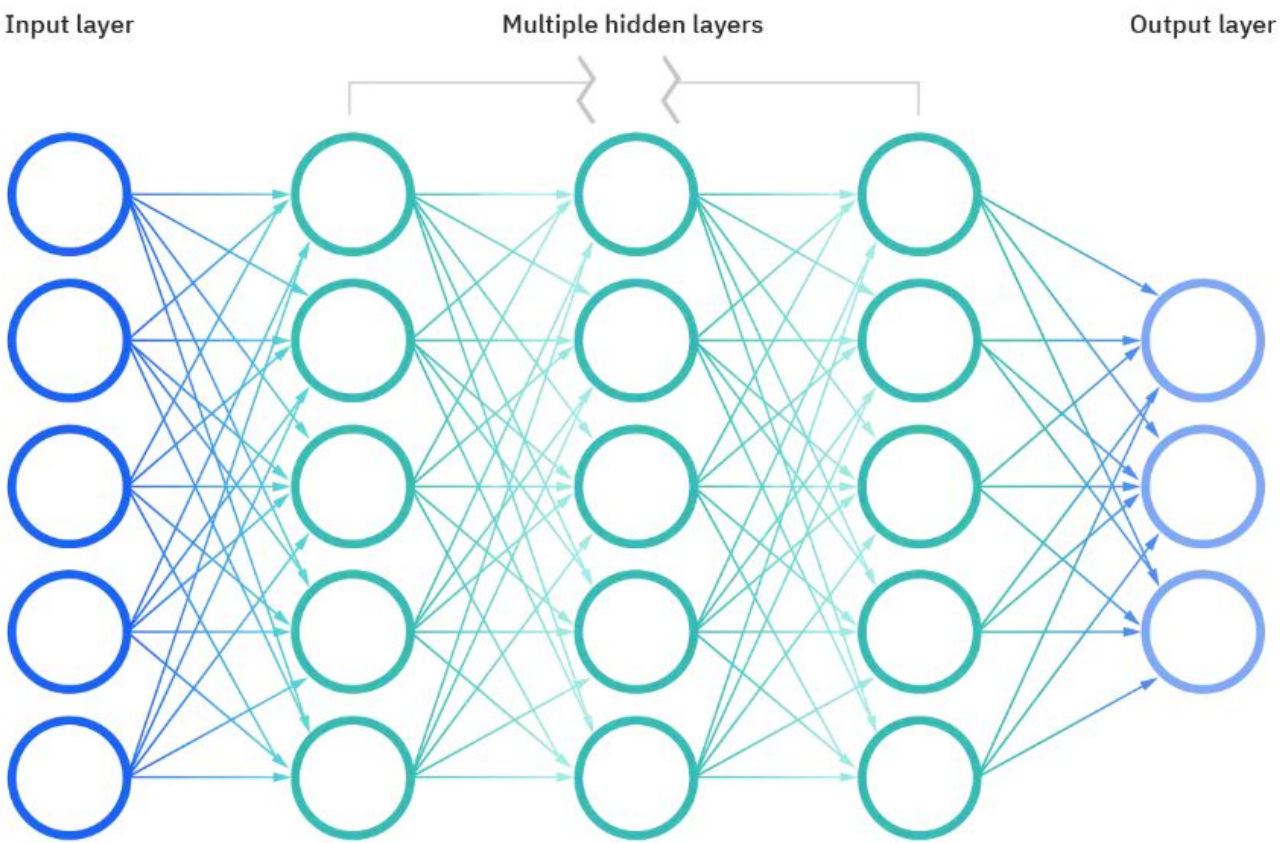
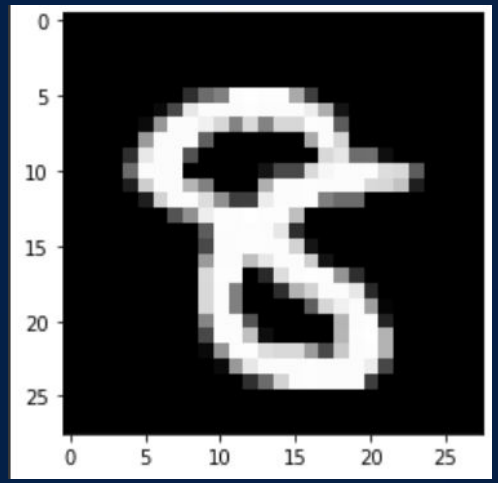
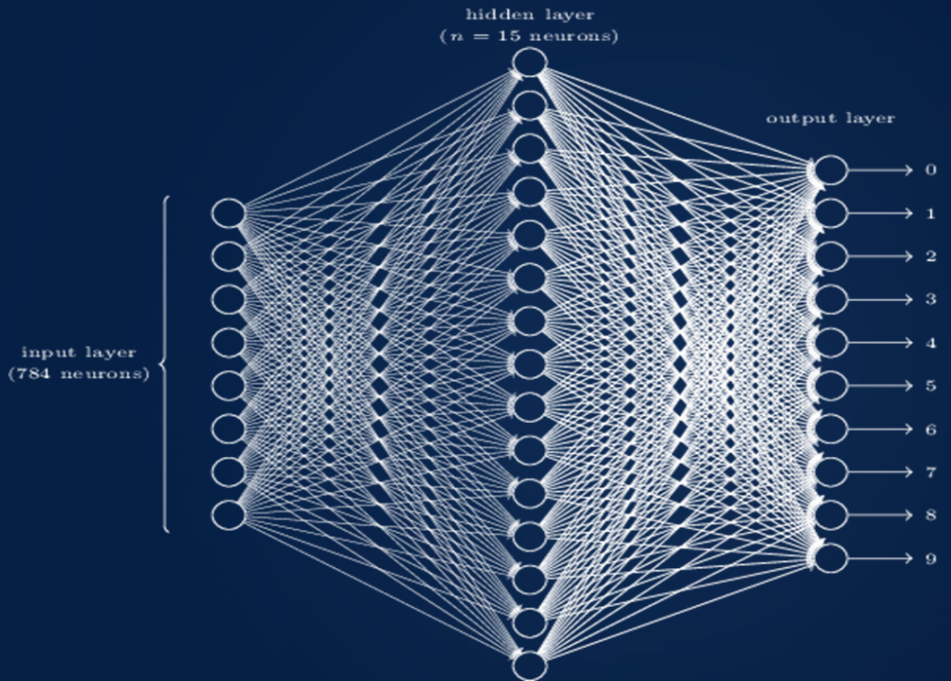


Image: https://www.ibm.com/cloud/learn/neural-networks

How Our Project Uses a Neural Network

- 28x28 pixelated image of a handwritten number
- Stored as a group of 784 individual pixels
- Pixels are a value 0-255 (Black to White)
- The nodes in the hidden layers analyze the pixels and produce an output based on what the weights were set to after training





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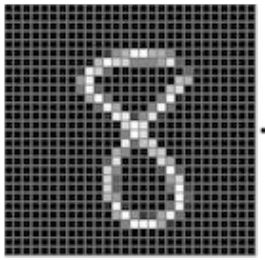
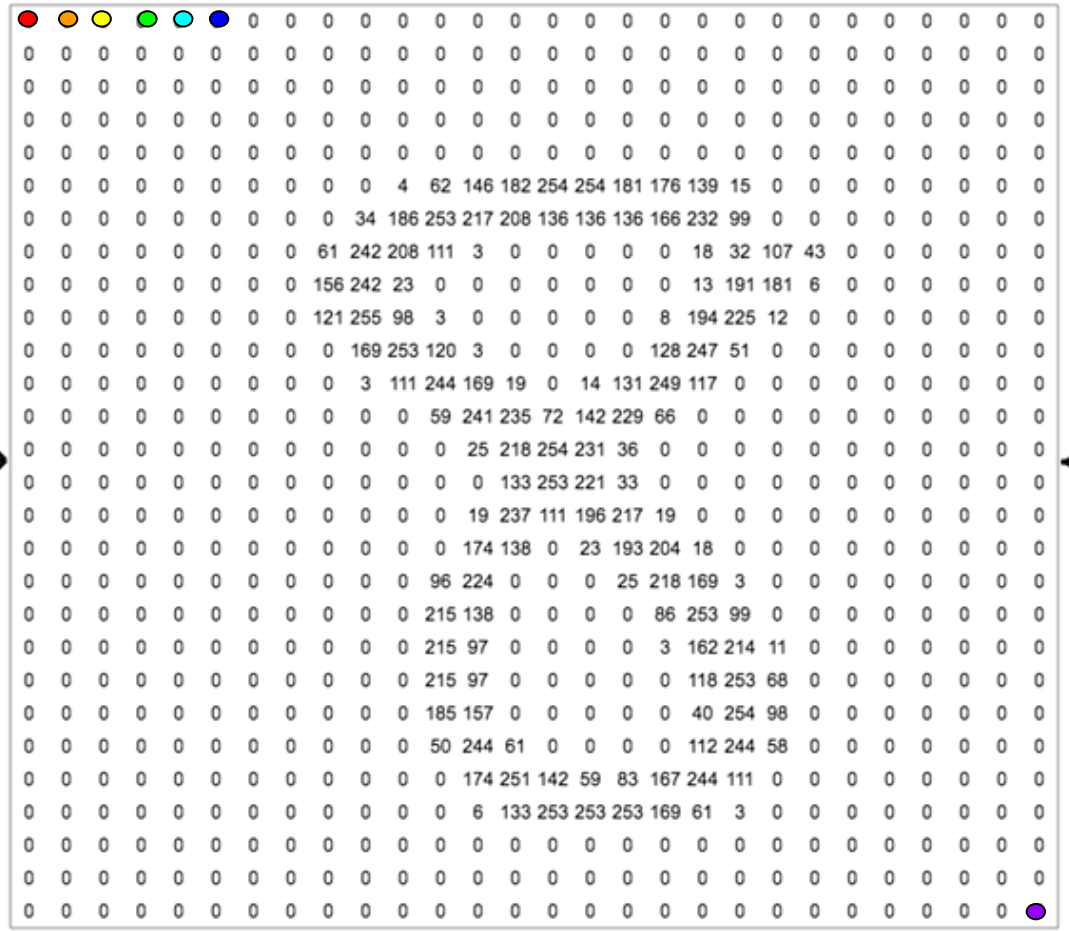


28 x 28
784 pixels



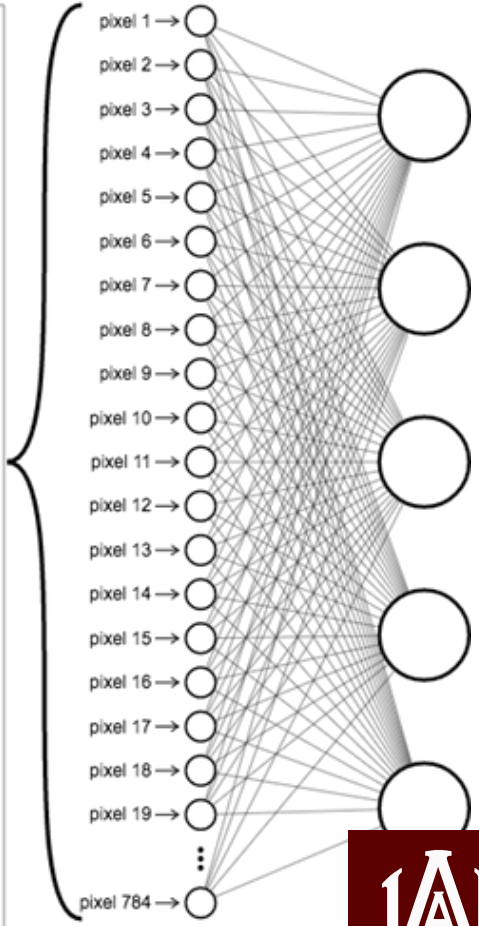


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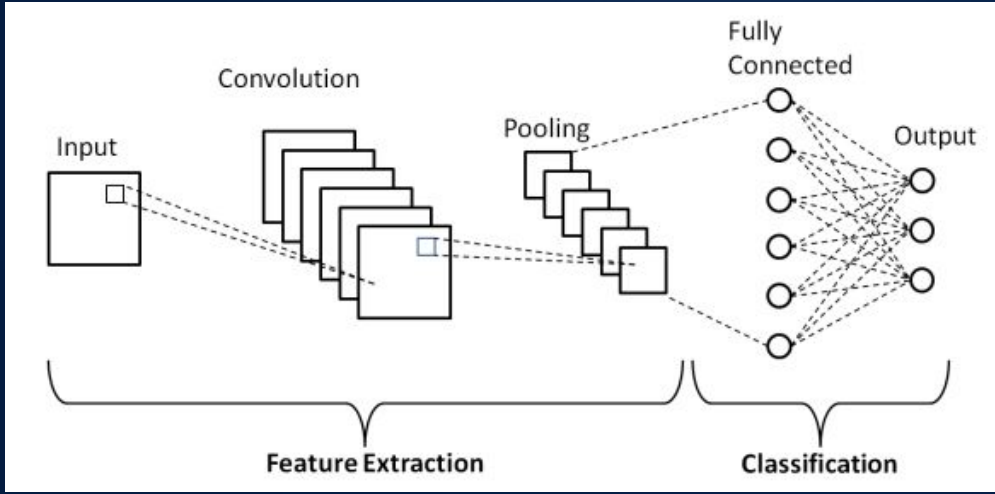
Image: https://medium.com/algorithms-for-life/numbre-a-number-recognizer-neural-network-fff9e9a35ee4

Convolutional Neural Networks

- So far we've looked at feed-forward neural networks (FFNN)
- Take raw pixels and begin analyzing based off of values
- A convolutional neural network (CNN) adds more to it

- The input goes through a series of convolutional and pooling layers which extract and analyze features for the model to be more accurate



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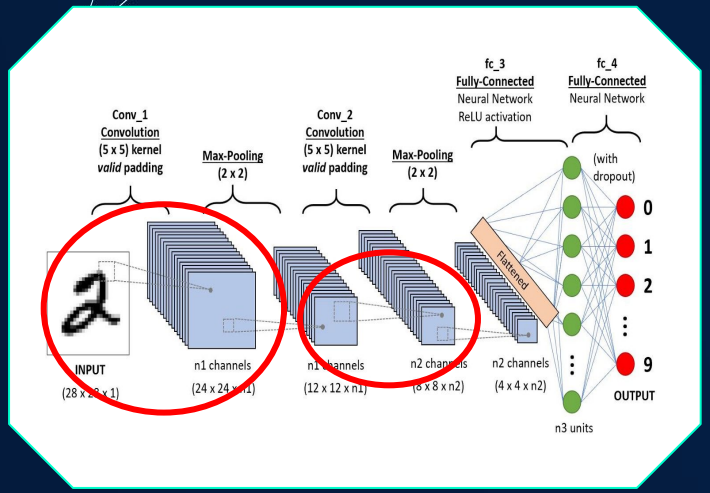
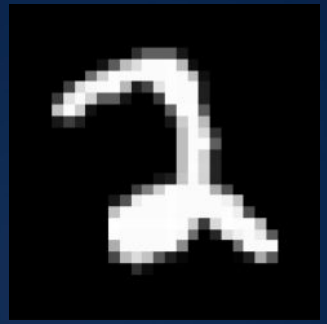
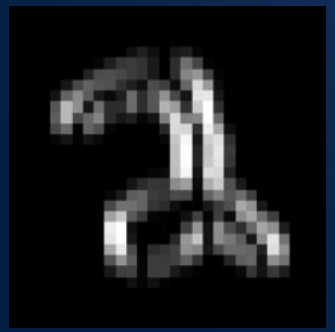
Convolution

- Uses multiple filters to extract the image features
- E.g. emphasize verticals, horizontals, and outside edges
- We look for features such as the loop or the curved hook at the top







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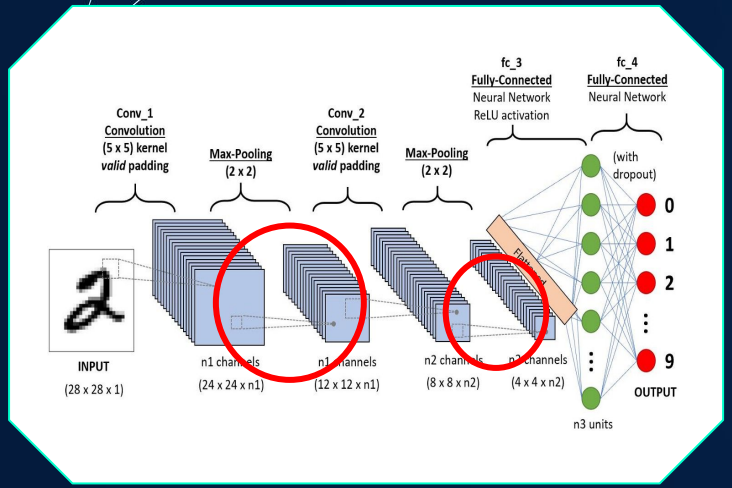
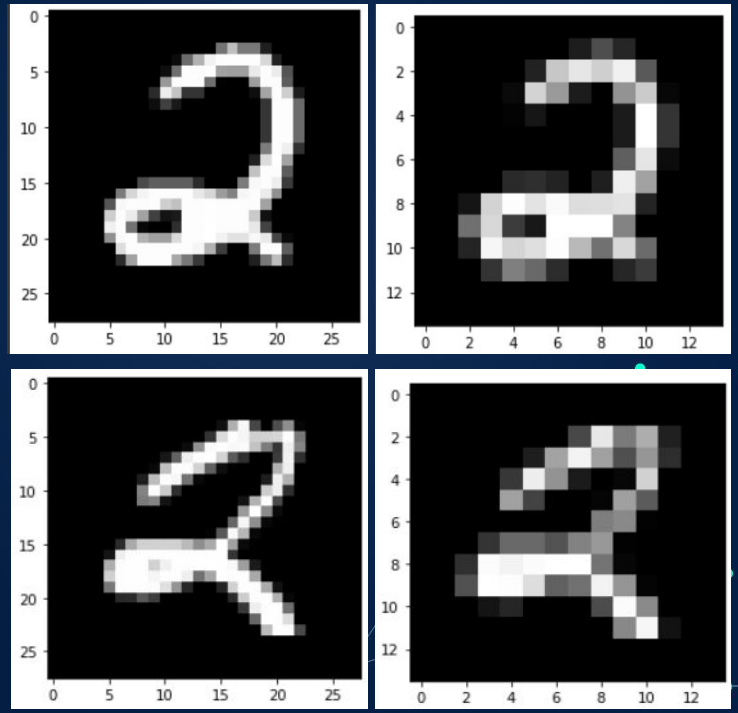
Pooling

- Features are associated with certain positions, but these positions may not always be the same
- Image is condensed but retains its basic features. This helps identify similarities more easily
- Lets you use a general position instead of exact





04

Results

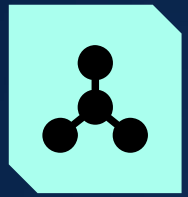
Manas Agrawal & Sanchit Singhal

Independent Variables

Trainers per Digit

The more training data, the more information to learn from

Nodes/Filters per Layer



More nodes or filters mean more processing. This increases the fine tuning

Layers in the Network

More layers increases how much repetition occurs

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Dependent Variables

Accuracy

Comparison of the model's output to the actual value. **For human-like levels, we need a 99.5% accuracy**

This factors into the overall effectiveness because even with near perfect accuracy, it isn't as functional if it takes hours to train

Time

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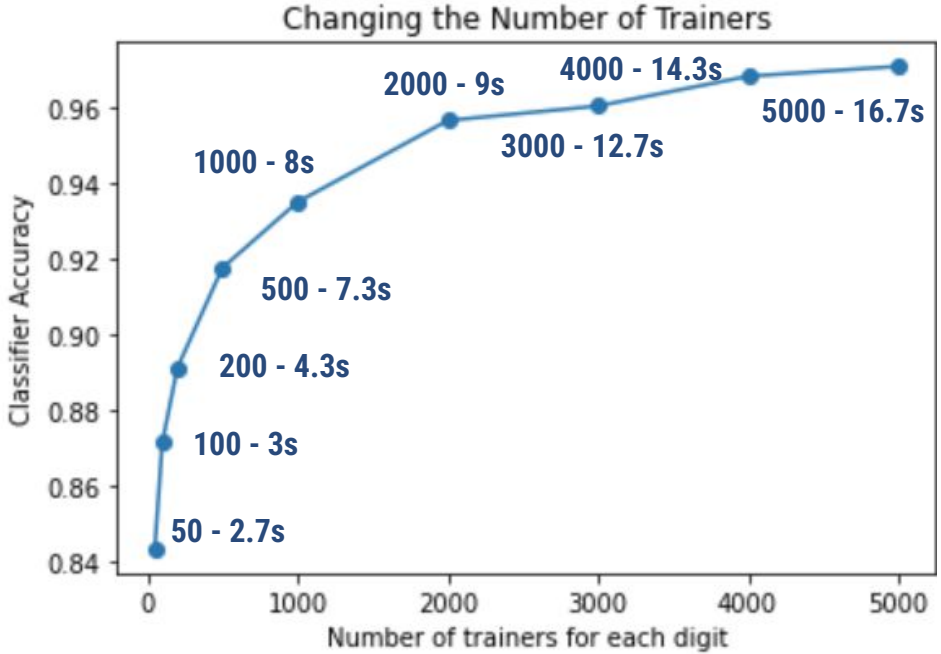
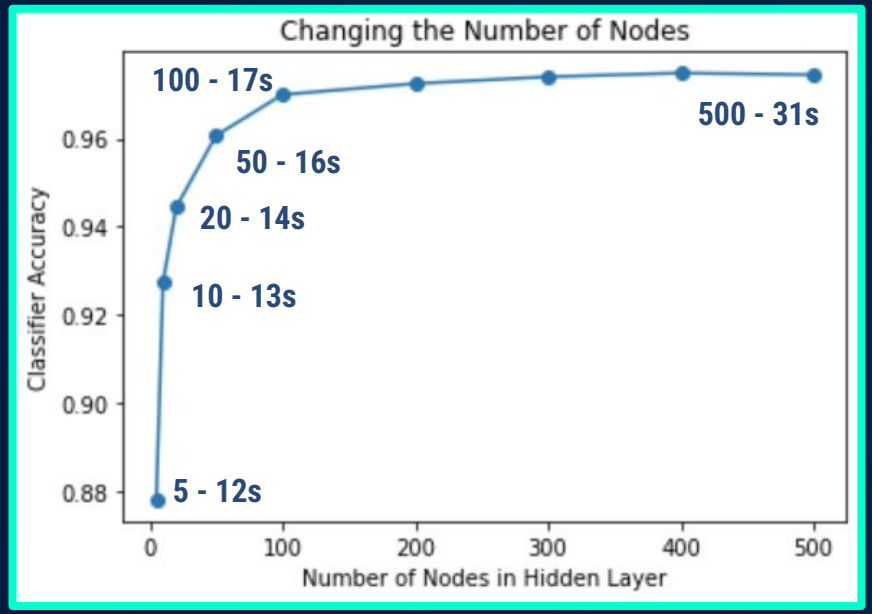
FFNN: Increasing Accuracy with Trainers



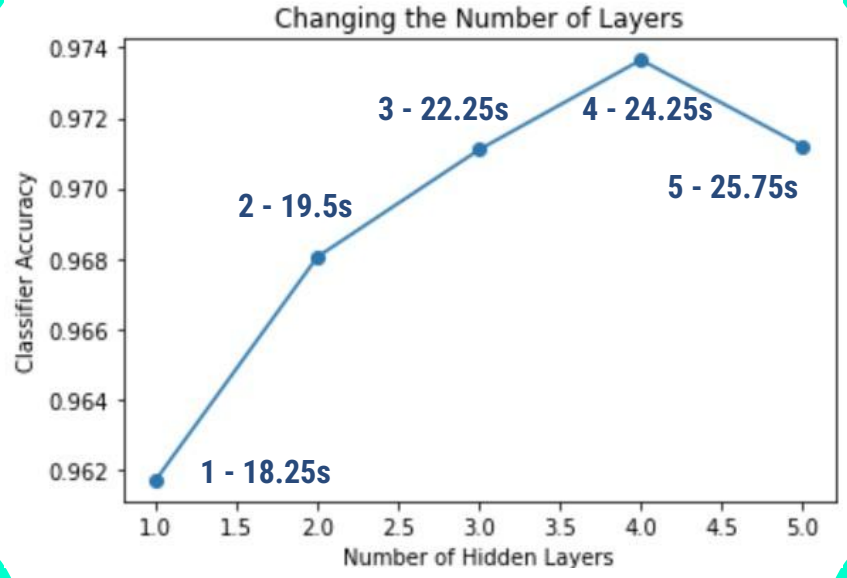
- Constants: 1 Hidden Layer, 150 Nodes
- Adding trainers helps the model learn what to look for better
- Randomly guessing a digit is a 10% accuracy and just adding 5 trainers is 8x that

FFNN: Increasing Accuracy with Nodes



- Constants: 1 Hidden Layer, 5000 Training Images
- Adding nodes means it's computing more, but you can only solve one problem in so much detail

FFNN: Increasing Accuracy with Layers



- Constants: 100 Nodes per Layer, 5000 Trainers
- Adding too many layers increases the initial randomness of the model before it learns and there will not be enough training data for it to learn properly

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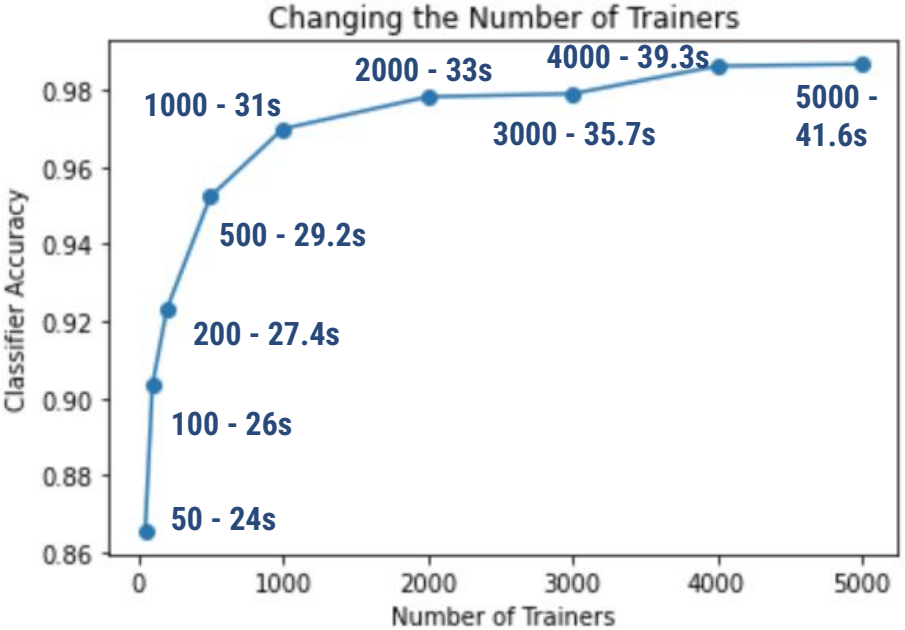
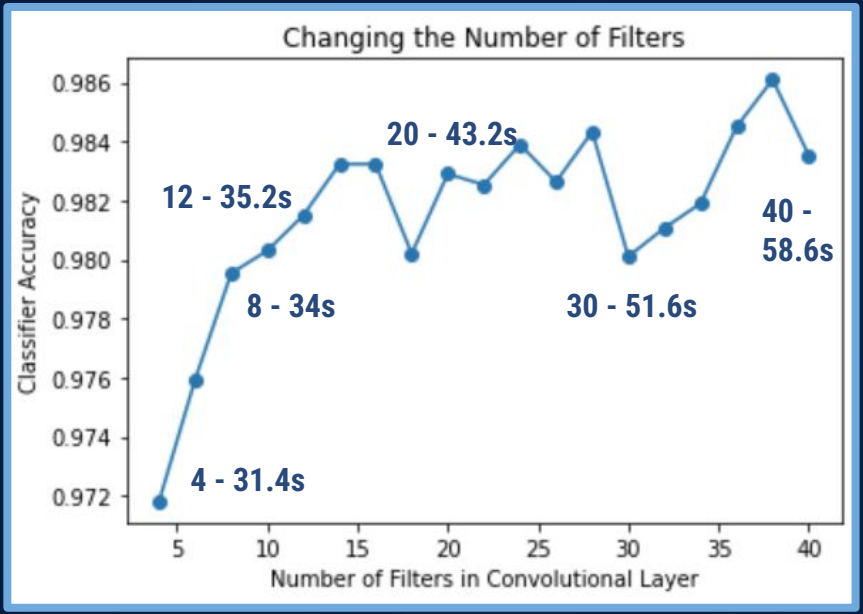
CNN: Increasing Accuracy with Trainers



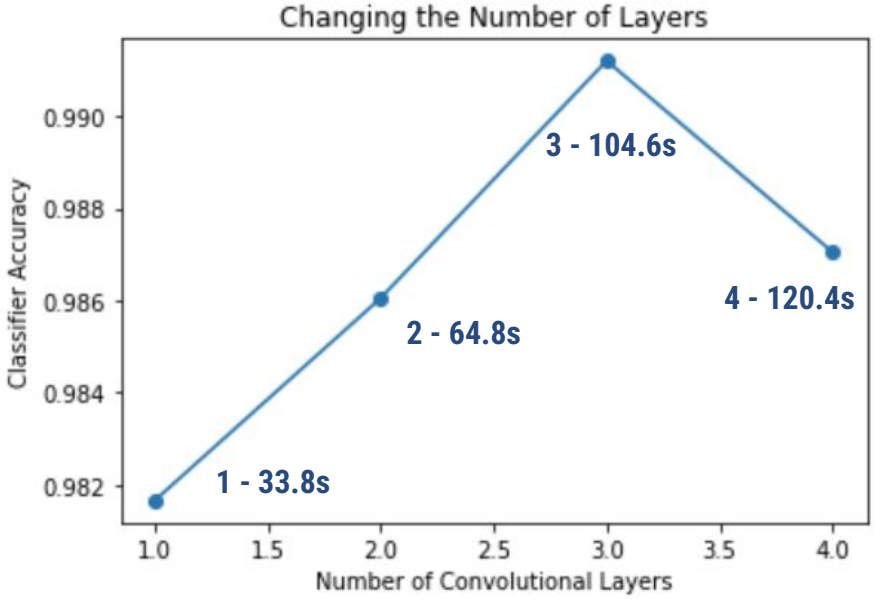
- Constants: 1 Convolutional/Pooling Layer, 40 filters
- Almost exact same trend as increasing trainers in FFNN, just higher accuracies

CNN: Increasing Accuracy with Filters



- Constants: 1 Convolutional/Pooling Layer, 5000 trainers per digit
- Generally, adding more filters increases the accuracy because more sections are analyzed
- Certain numbers show drops because they may focus on specific areas and cause confusion

CNN: Increasing Accuracy with Layers



- Constants: 40 filters, 5000 trainers per digit
- More layers → more processing, but adding too many can result in the model looking for very specific characteristics

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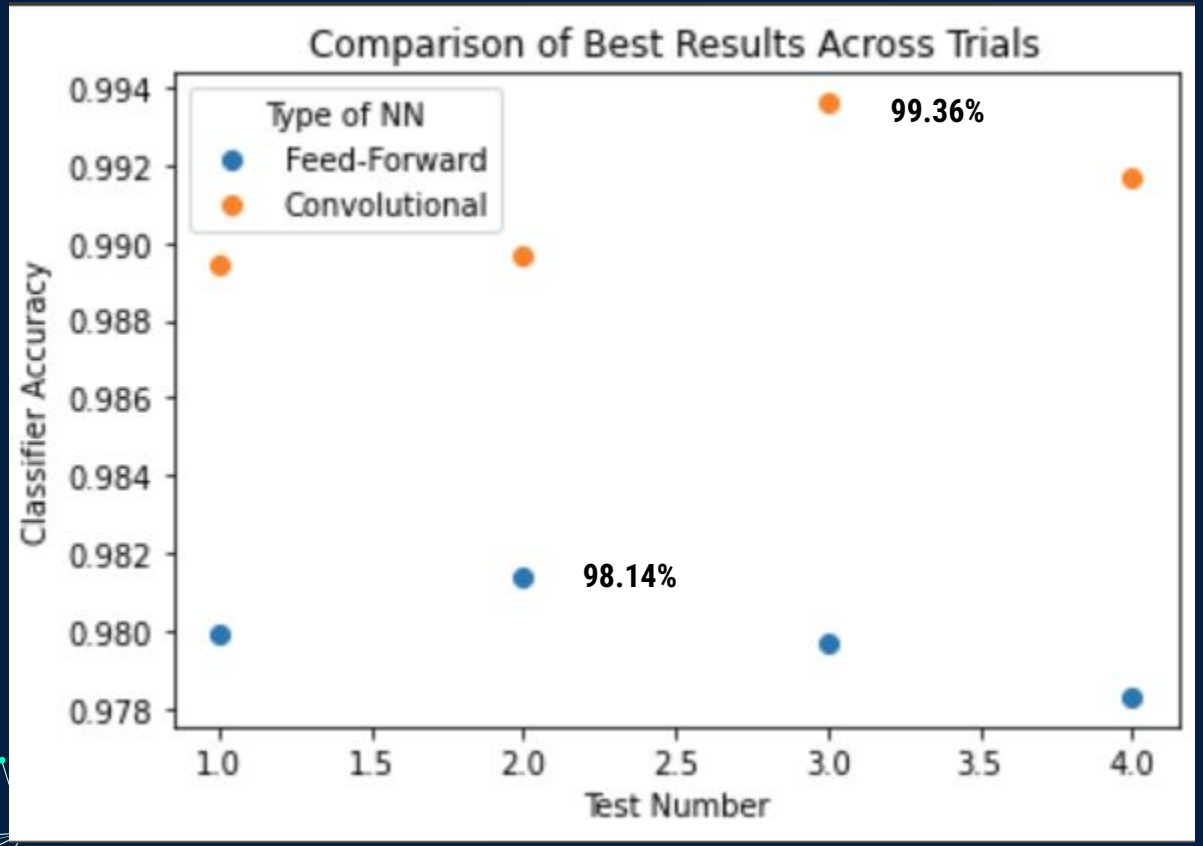
05

SUMMARY

Melvin Witten & Destiny Dixon

Overall Accuracies in Both Networks



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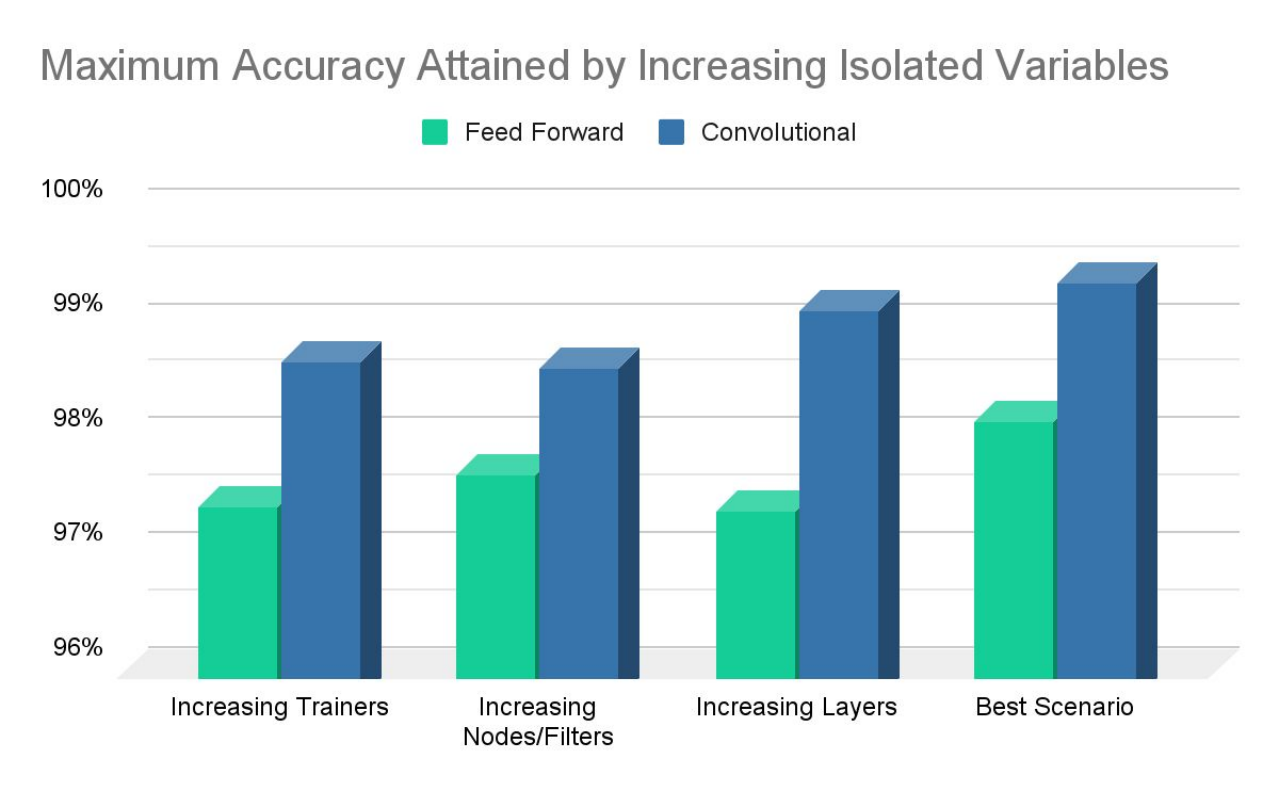
Feed Forward v. Convolutional



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Accuracy Matrix

Being Tested \ Classified As	0	1	2	3	4	5	6	7	8	9
0	**99.7**	0	0.2	0	0	0	0	0.1	0	0
1	0.1	**98.7**	0.2	0.1	0.1	0.1	0.1	0.3	0.3	0.2
2	0	0.1	**99.1**	0.2	0.1	0	0	0.3	0.2	0
3	0	0	0.2	**98.8**	0	0.2	0	0.4	0.4	0.2
4	0	0	0.7	0	**97.3**	0	0.5	0.2	0.4	0.8
5	0	0	0	0.3	0	**98.7**	0.3	0	0.6	0
6	0.3	0	0	0.1	0	0.2	**99.2**	0	0.1	0
7	0	0.2	0.5	0.6	0.2	0.1	0	**97.4**	0.2	0.9
8	0.1	0.4	1.2	0.2	0	0.1	0.8	0.1	**96.4**	0.6
9	0.4	0	0	0.4	0	0.5	0	0.3	0.3	**98**

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Conclusion

Our project determines the impact of the different independent variables associated with constructing a neural network. We also went over the differences in feed-forward and convolutional neural networks and analyzed how a CNN is more accurate. In doing so, we learned how to balance time and accuracy in order to create an artificial intelligence that can classify images in a human-like manner

THANK YOU

Special thanks to our mentor Dr. Kaveh Heidary for instructing us. Thank you to Dr. Paul Ruffin, Ms. Vetrea Ruffin, Dr. Jonathan Lassiter, Ms. Yvette Clayton, Mr. Willie Love, Dr. Venkata Atluri, Dr. Satilmis Budak, Dr. Zhengtao Deng, Dr. Tyesha Farmer, and Dr. Andrew Scott. Thank you to Dr. LaShauna Evans and the Department of Defense.