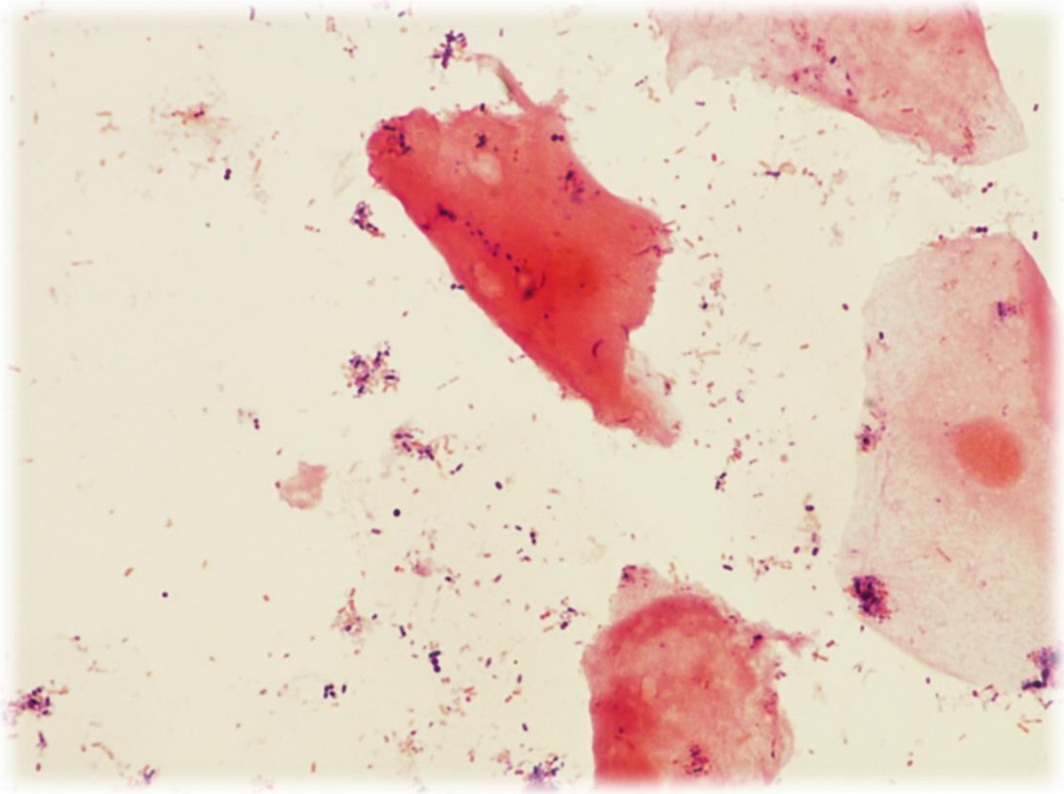
Michael Chi Ian Tang
3035209241

Classification for pathological images using machine learning

Outline

- **Digital Pathology**
- Convolutional neural networks (CNN)
- From CNN to Residual Network
- First prototype
- Second prototype
- Future direction



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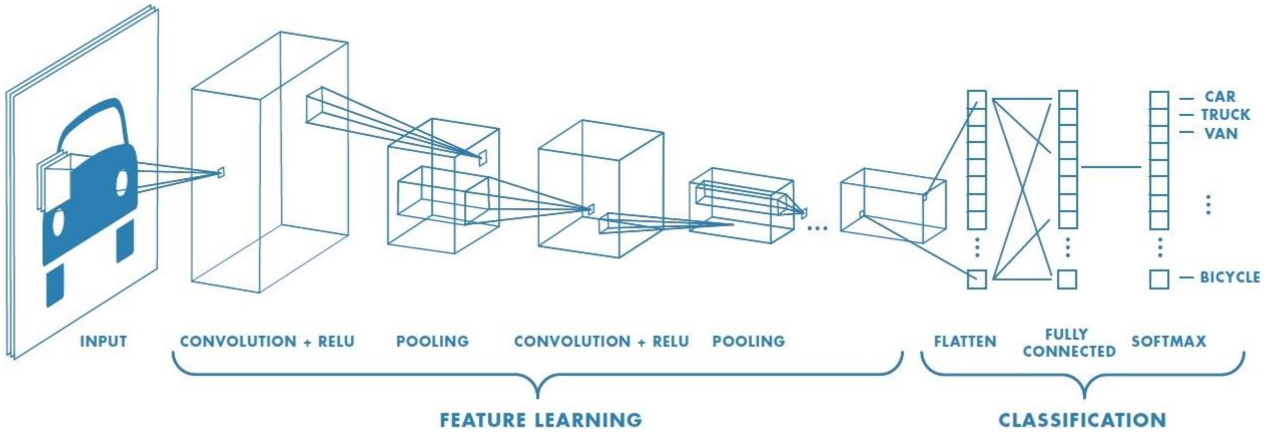

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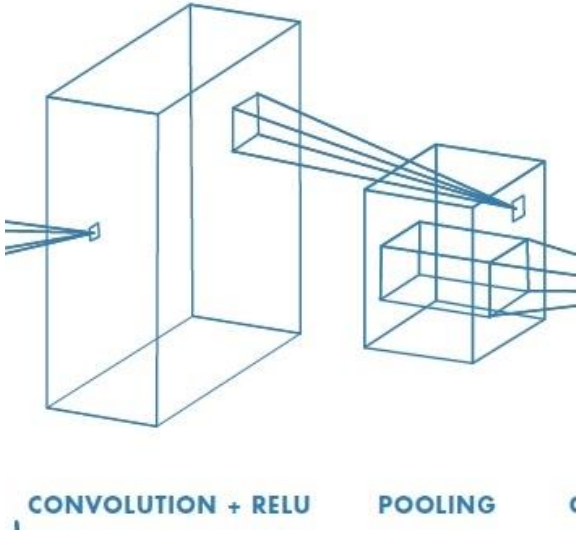

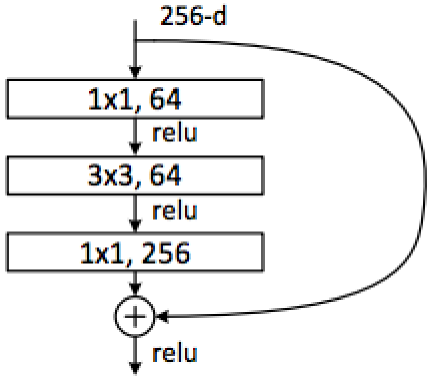

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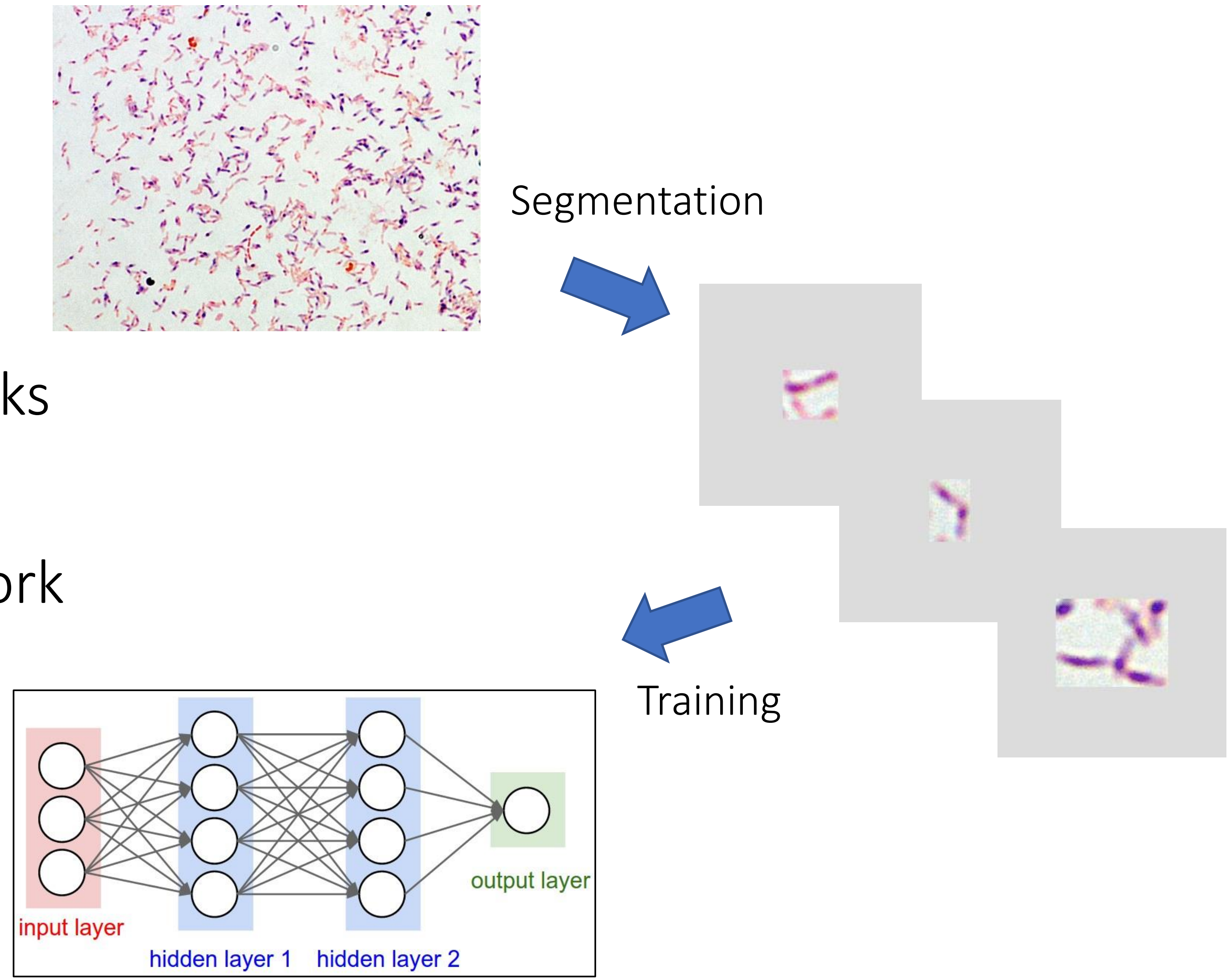

Machine Learning Model

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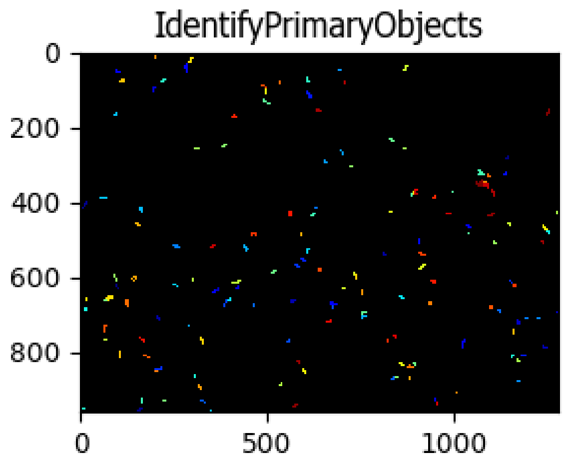

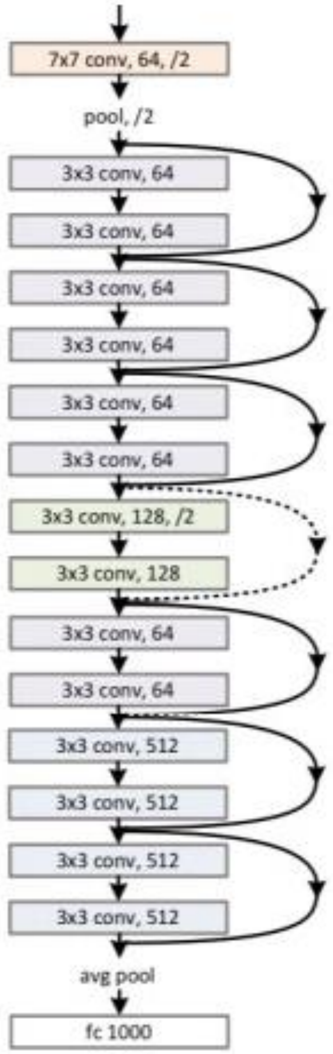

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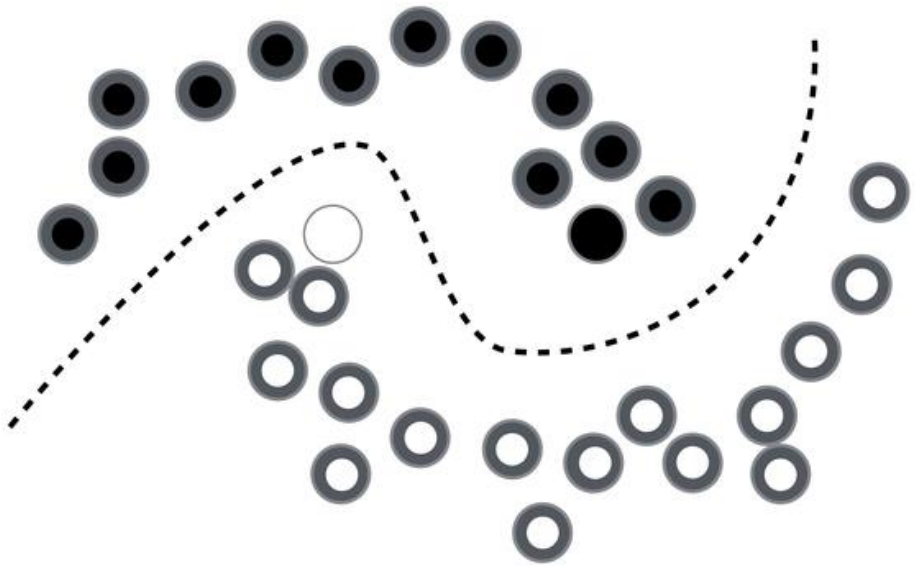
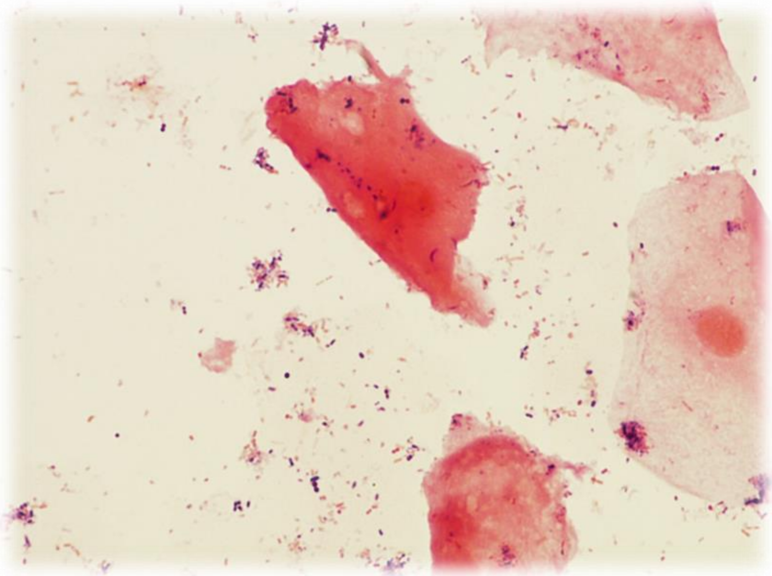


Digital Pathology

Highly accurate

Time-consuming, Expensive, Dependent on experience



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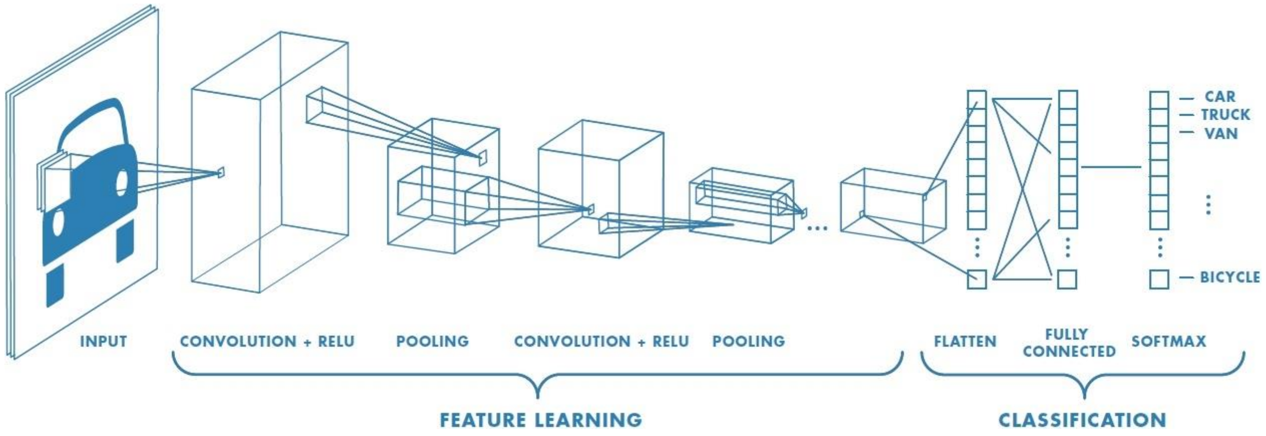
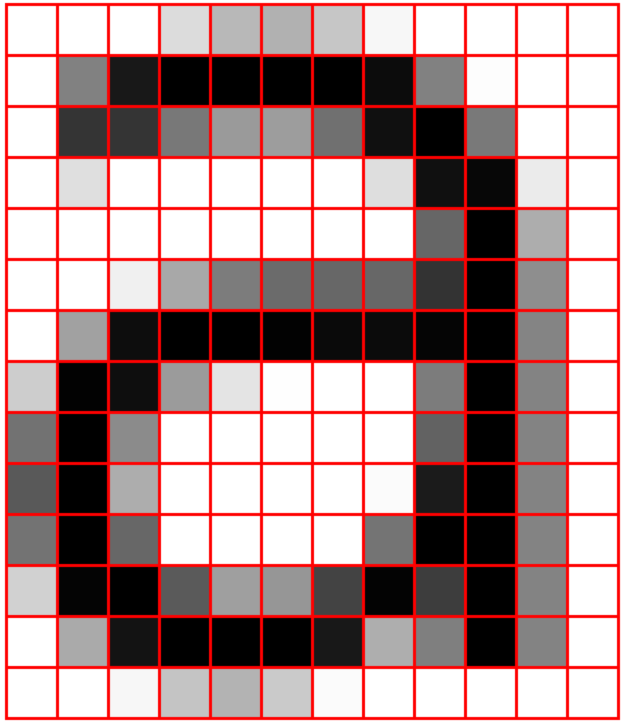


Convolutional Neural Networks

An image is just a collection of numbers stored in the memory

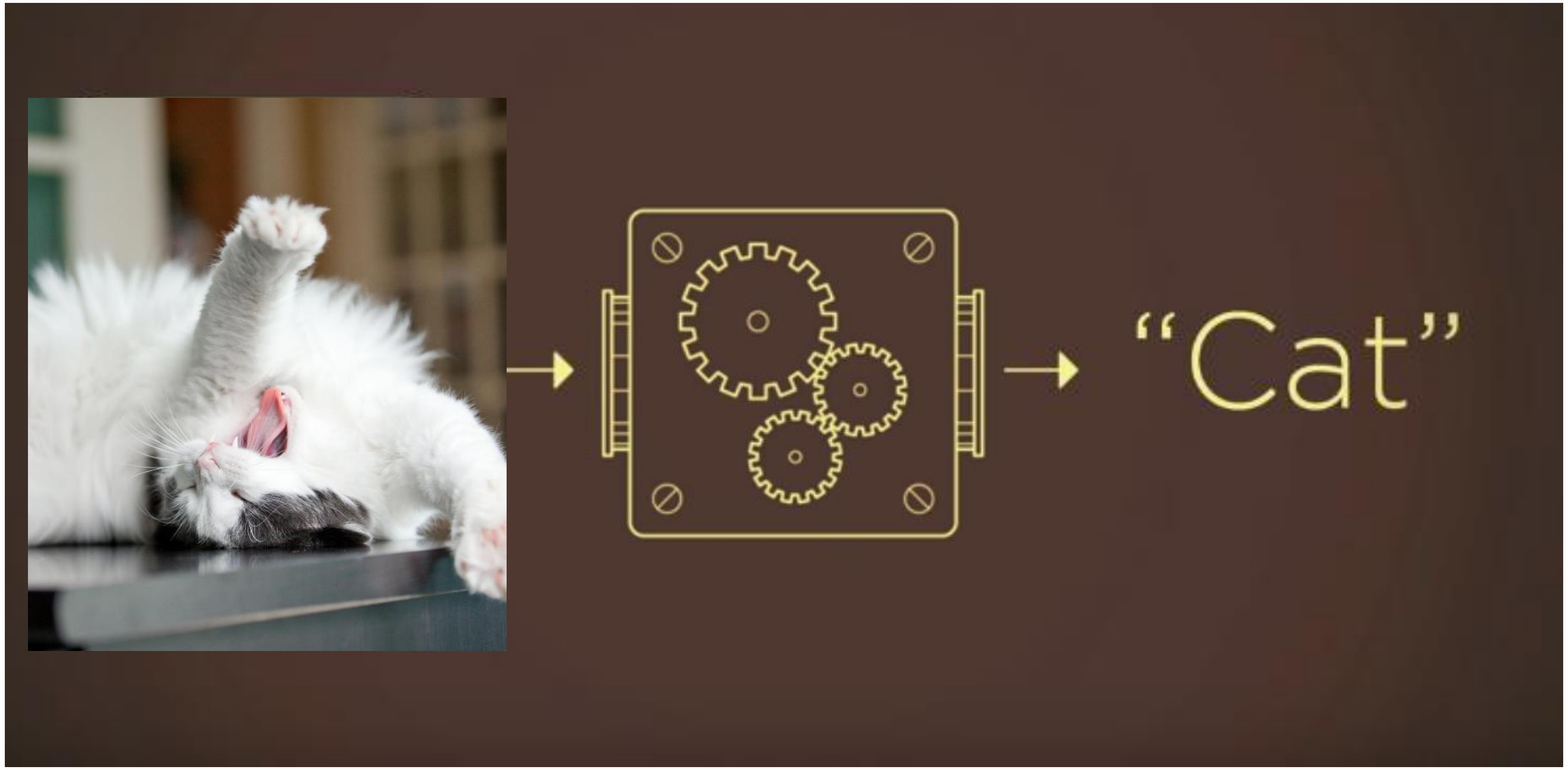
a



1.0	1.0	1.0	0.9	0.6	0.6	0.6	1.0	1.0	1.0	1.0	1.0
1.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0	1.0	1.0
1.0	0.2	0.2	0.5	0.6	0.6	0.5	0.0	0.0	0.5	1.0	1.0
1.0	0.9	1.0	1.0	1.0	1.0	1.0	0.9	0.0	0.0	0.9	1.0
1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.4	0.0	0.5	1.0
1.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	1.0
0.9	0.0	0.0	0.6	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
0.5	0.0	0.6	1.0	1.0	1.0	1.0	1.0	0.5	0.0	0.5	1.0
0.5	0.0	0.7	1.0	1.0	1.0	1.0	1.0	0.0	0.0	0.5	1.0
0.6	0.0	0.6	1.0	1.0	1.0	1.0	0.5	0.0	0.0	0.5	1.0
0.9	0.1	0.0	0.6	0.7	0.7	0.5	0.0	0.5	0.0	0.5	1.0
1.0	0.7	0.1	0.0	0.0	0.0	0.1	0.9	0.8	0.0	0.5	1.0
1.0	1.0	1.0	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.0	1.0

Convolutional Neural Networks

How to build a machine that recognizes objects?



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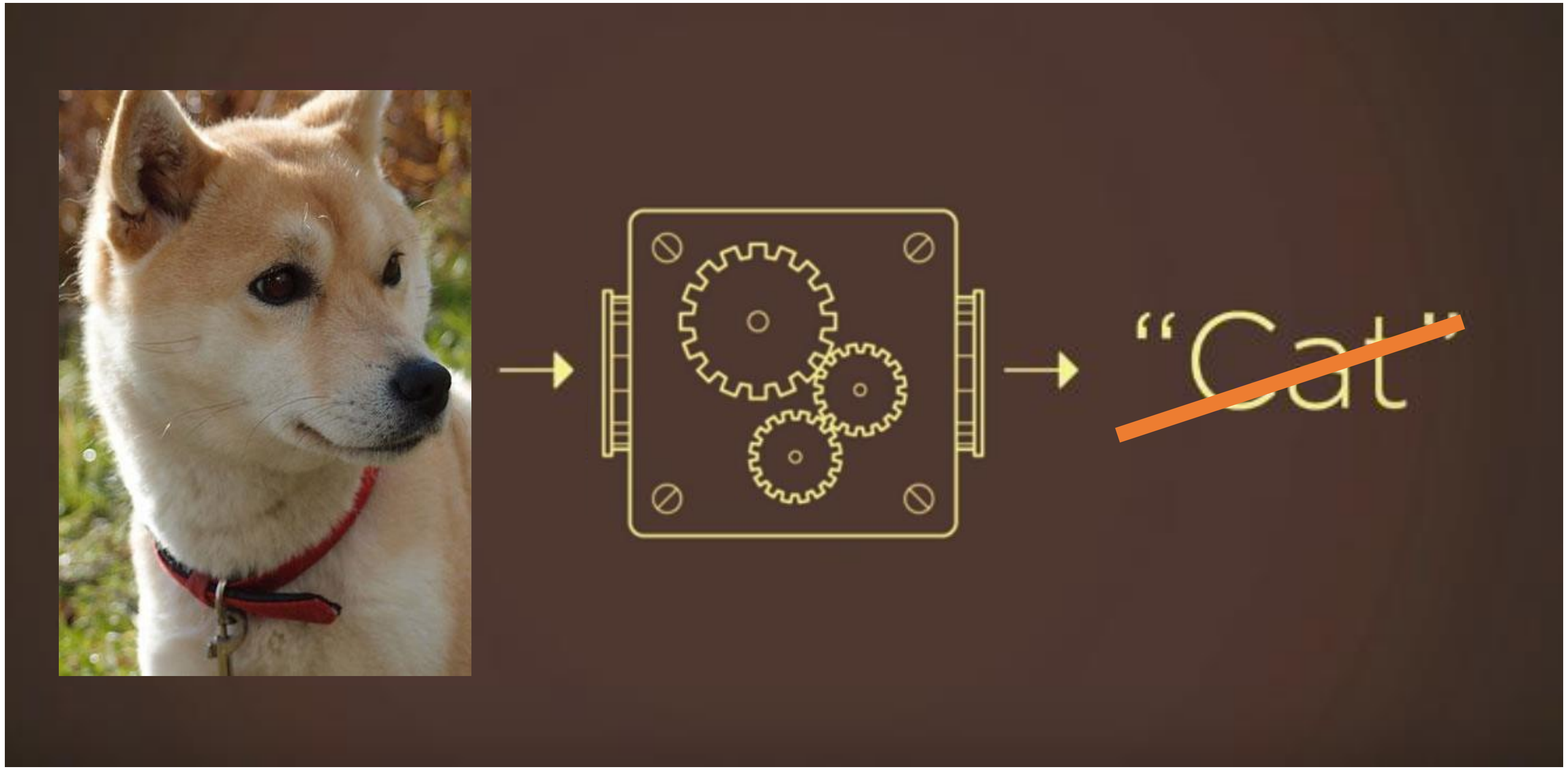
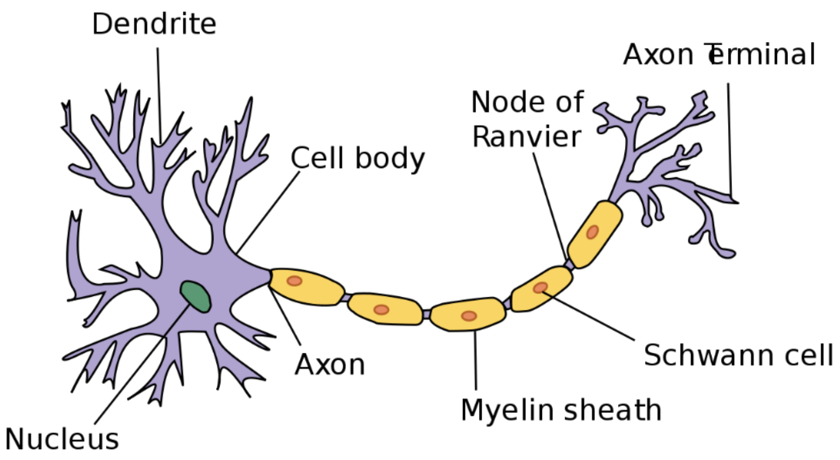
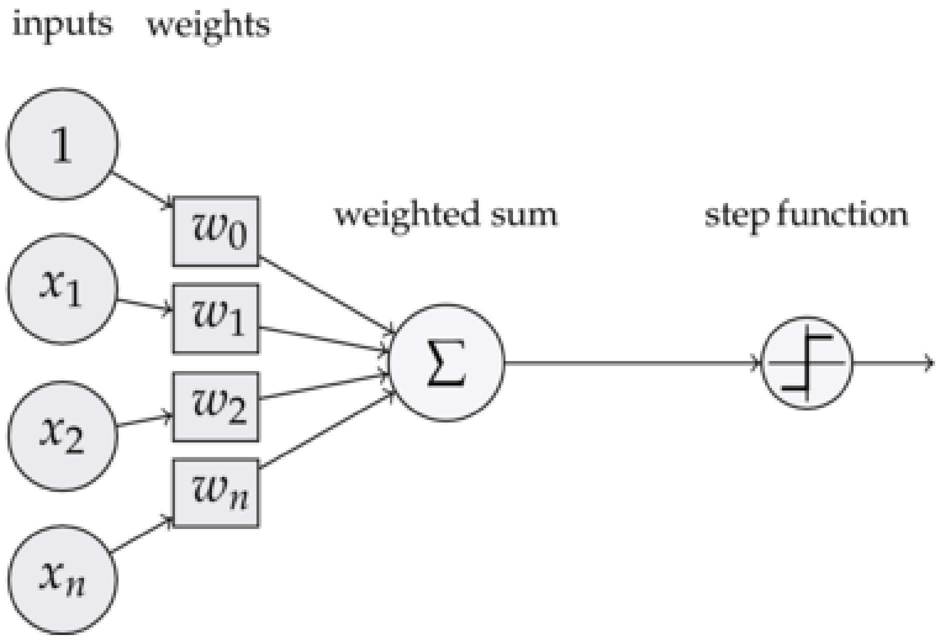


Convolutional Neural Networks

We model the human brain - neurons





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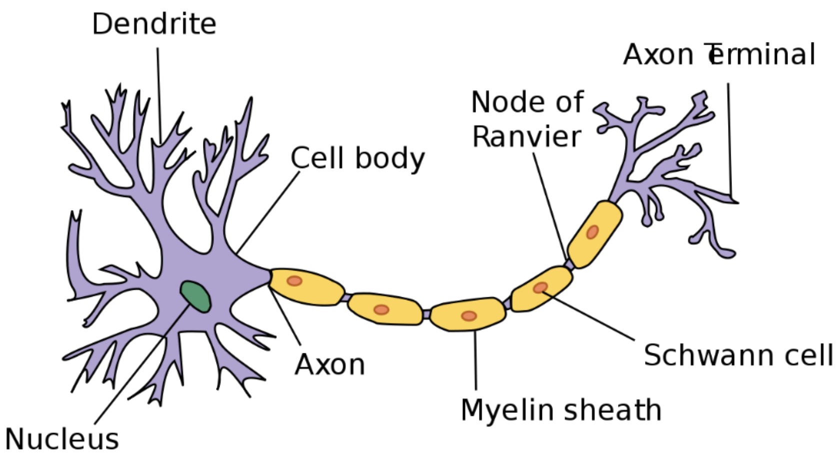
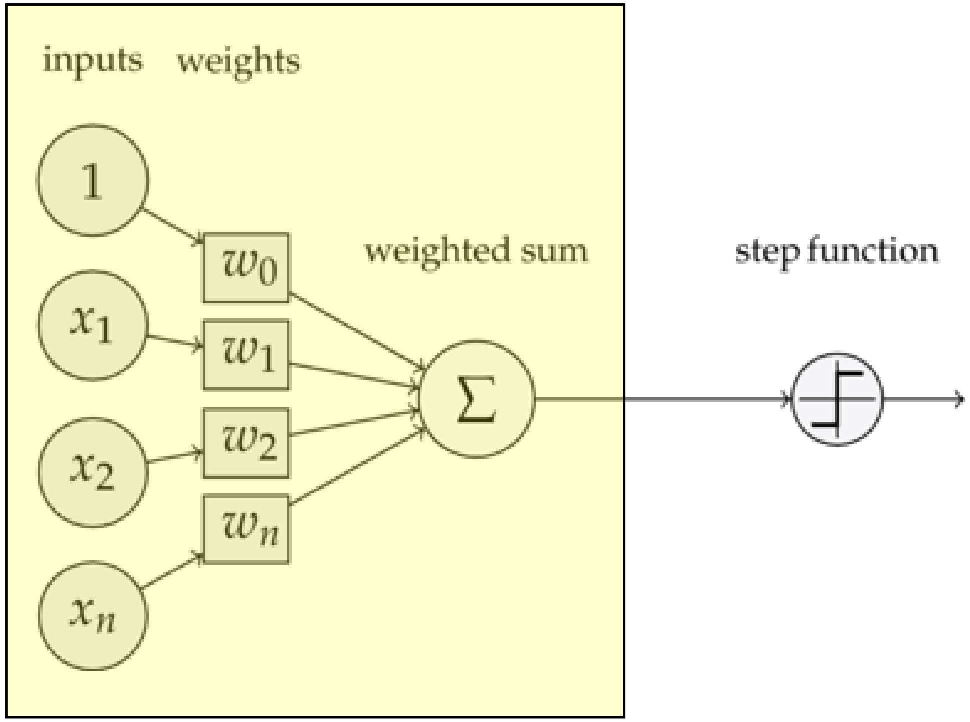
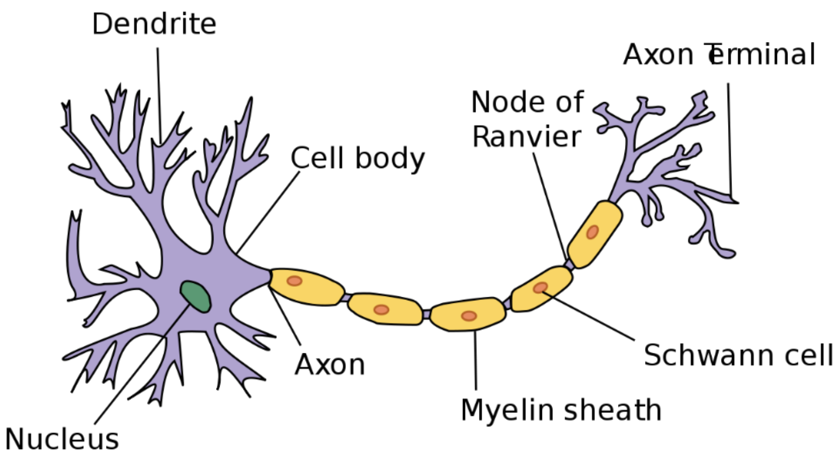
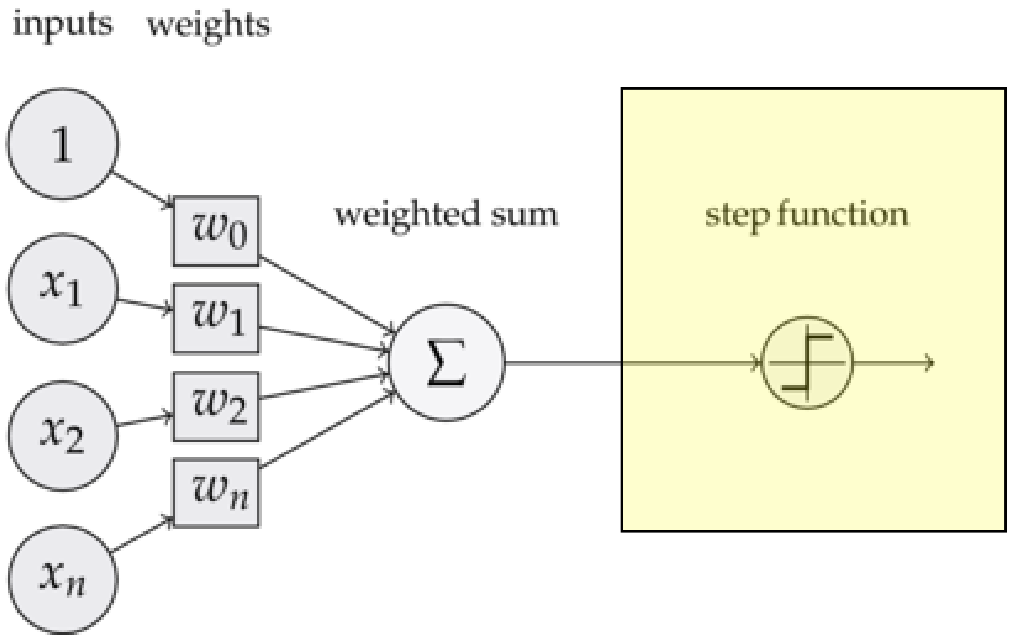




Convolutional Neural Networks

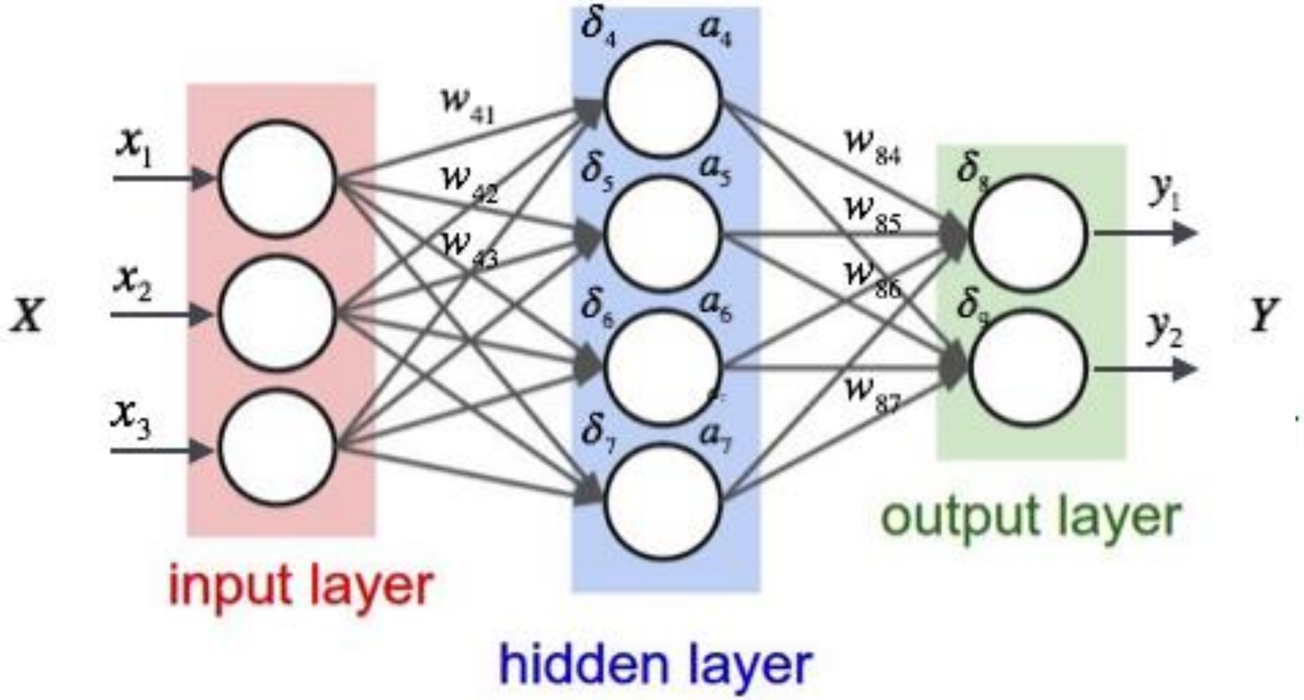
We model the human brain - neurons





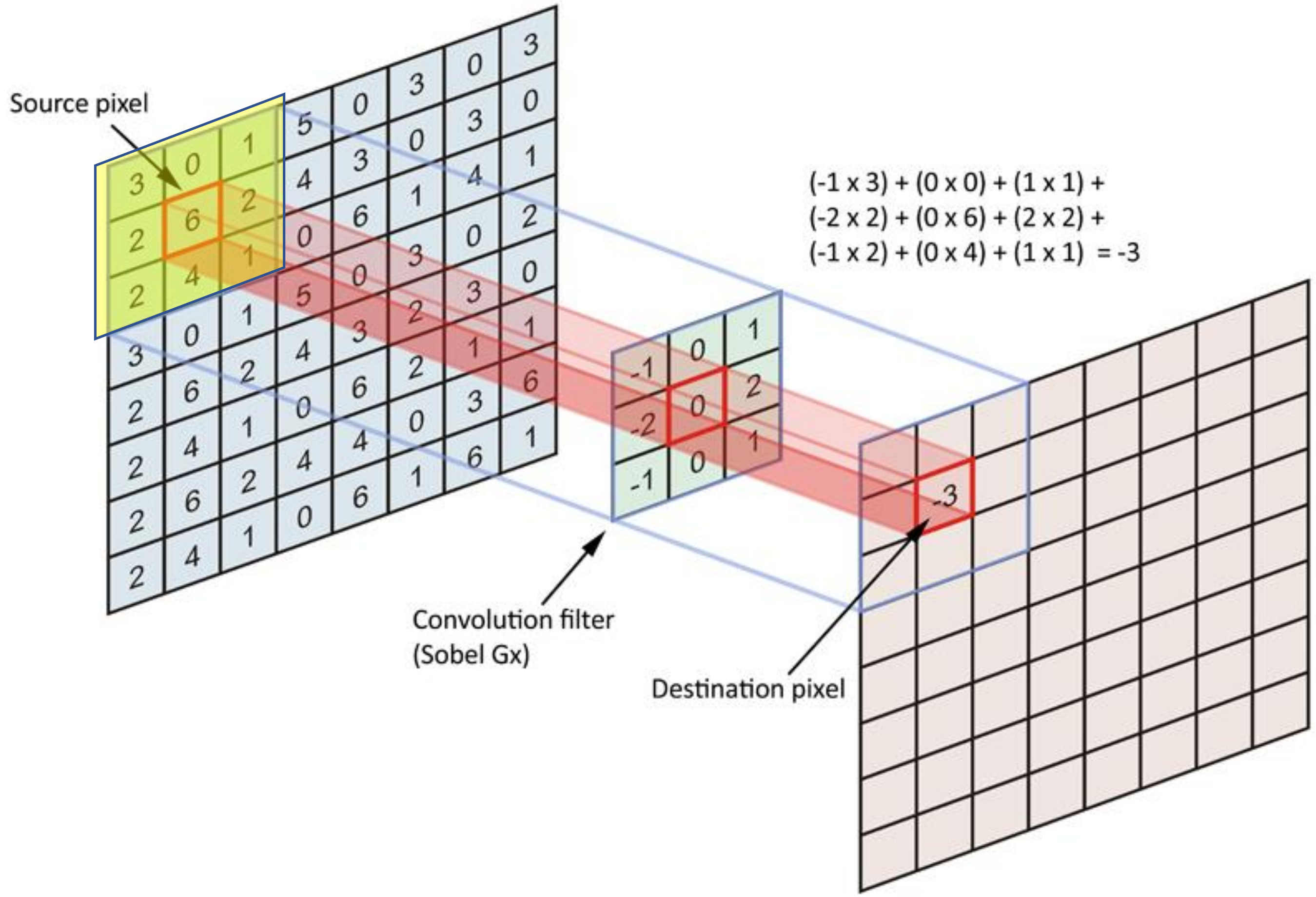
Convolutional Neural Networks

A neural network



Convolutional Neural Networks

Approximating human vision - Convolution



Convolutional Neural Networks

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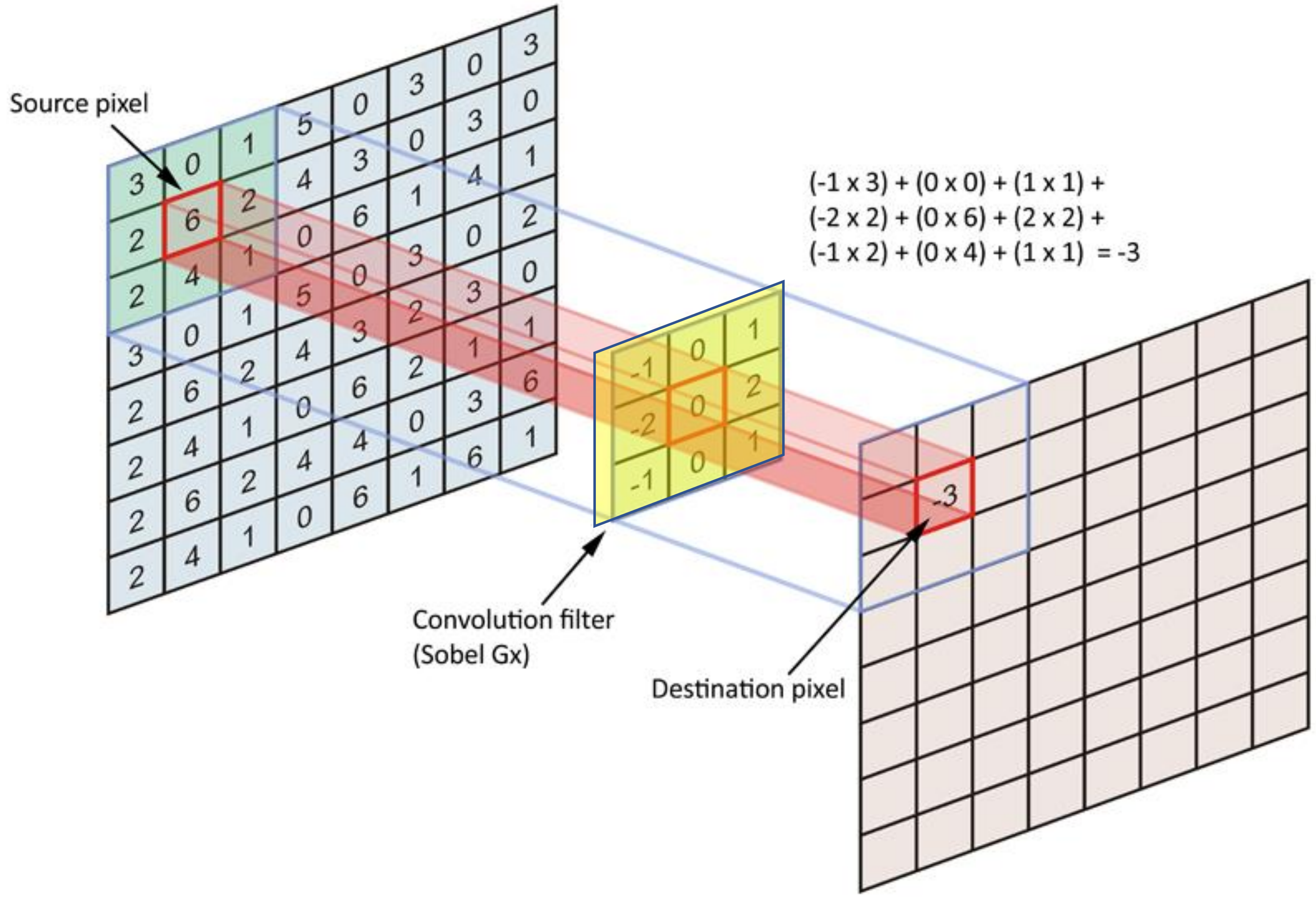
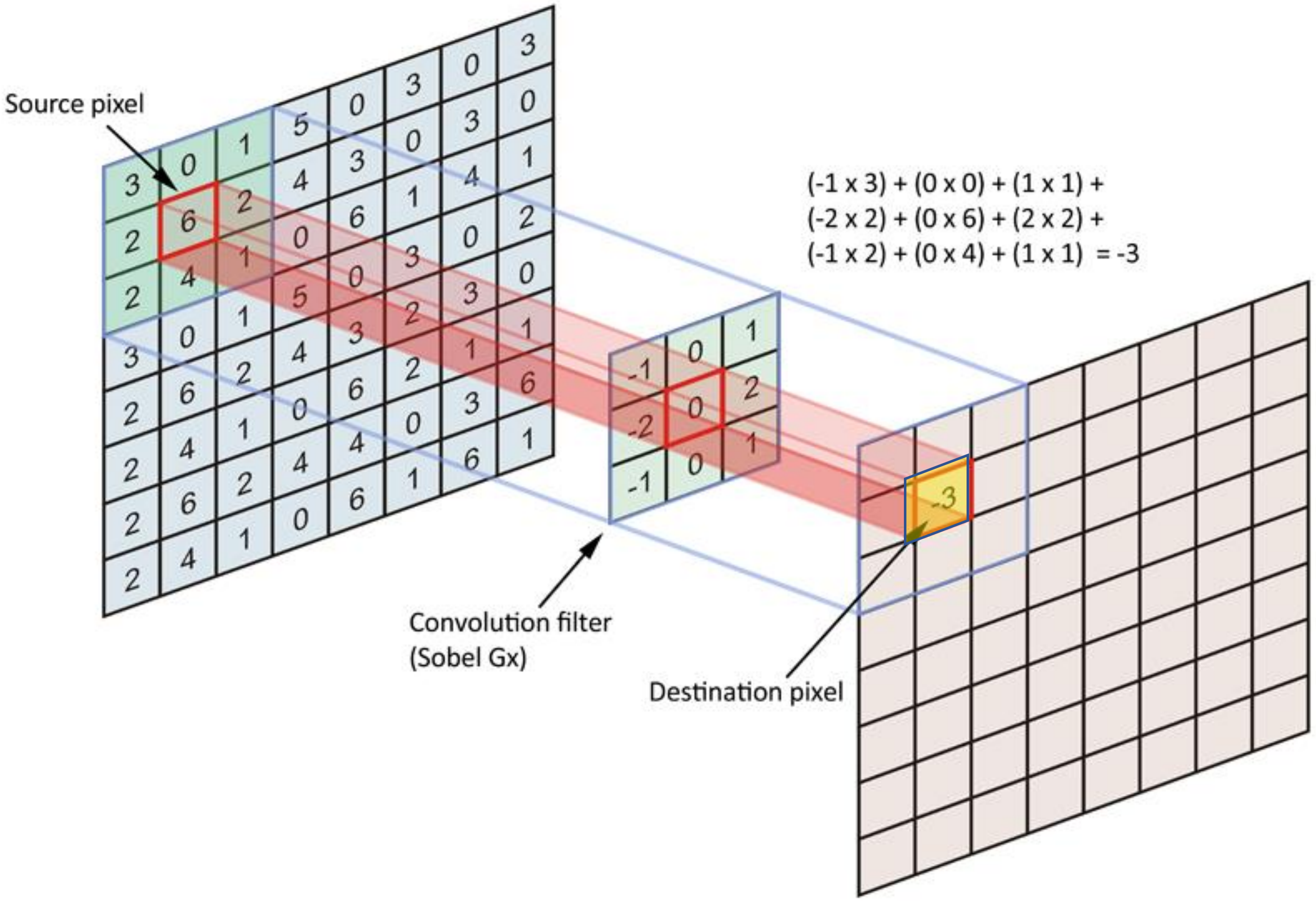


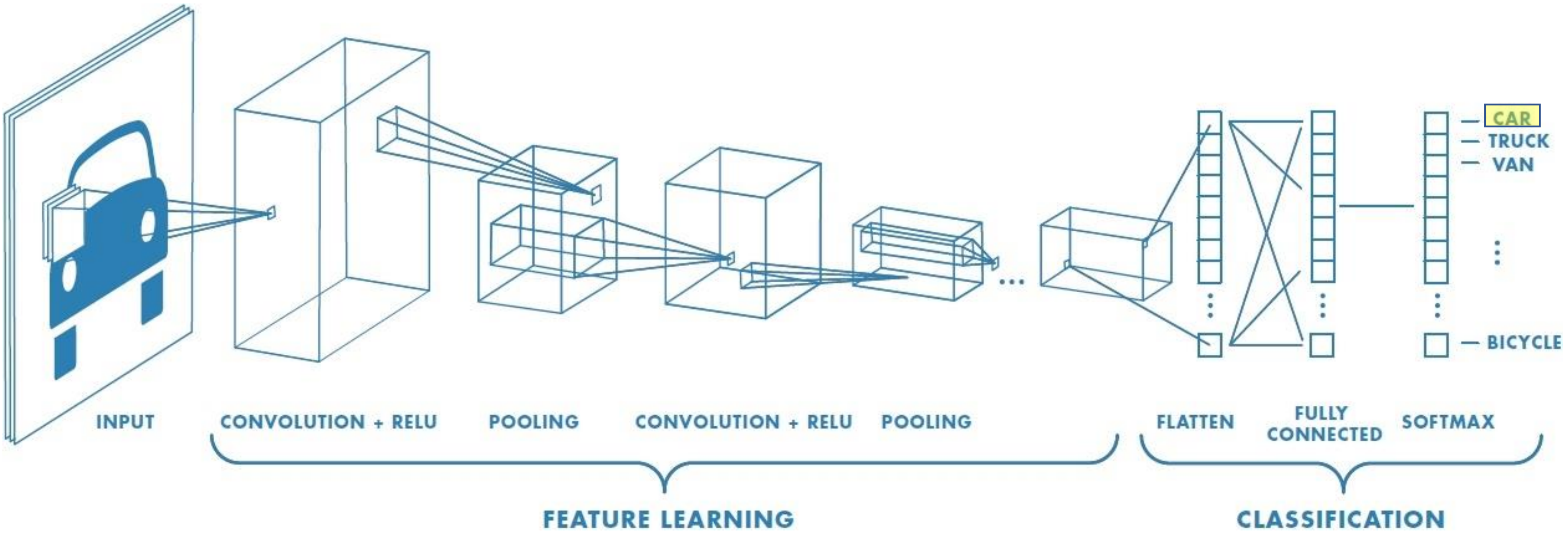
Convolutional Neural Networks

Approximating human vision - Convolution



Convolutional Neural Networks

Scale up the model



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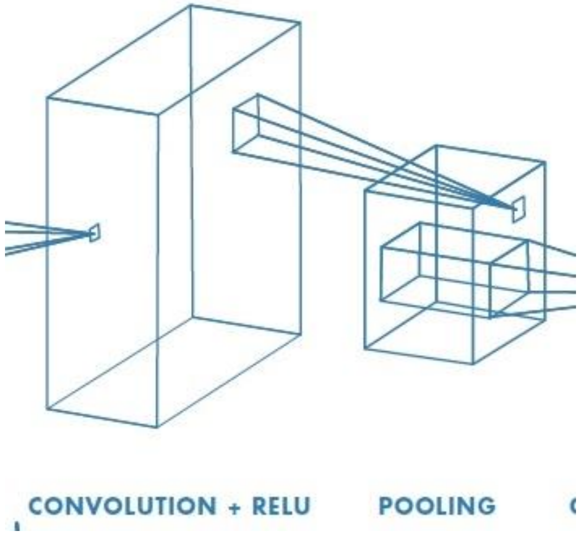
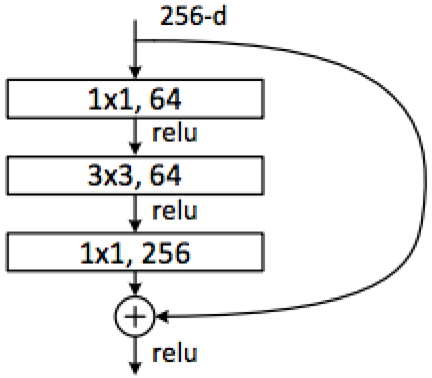
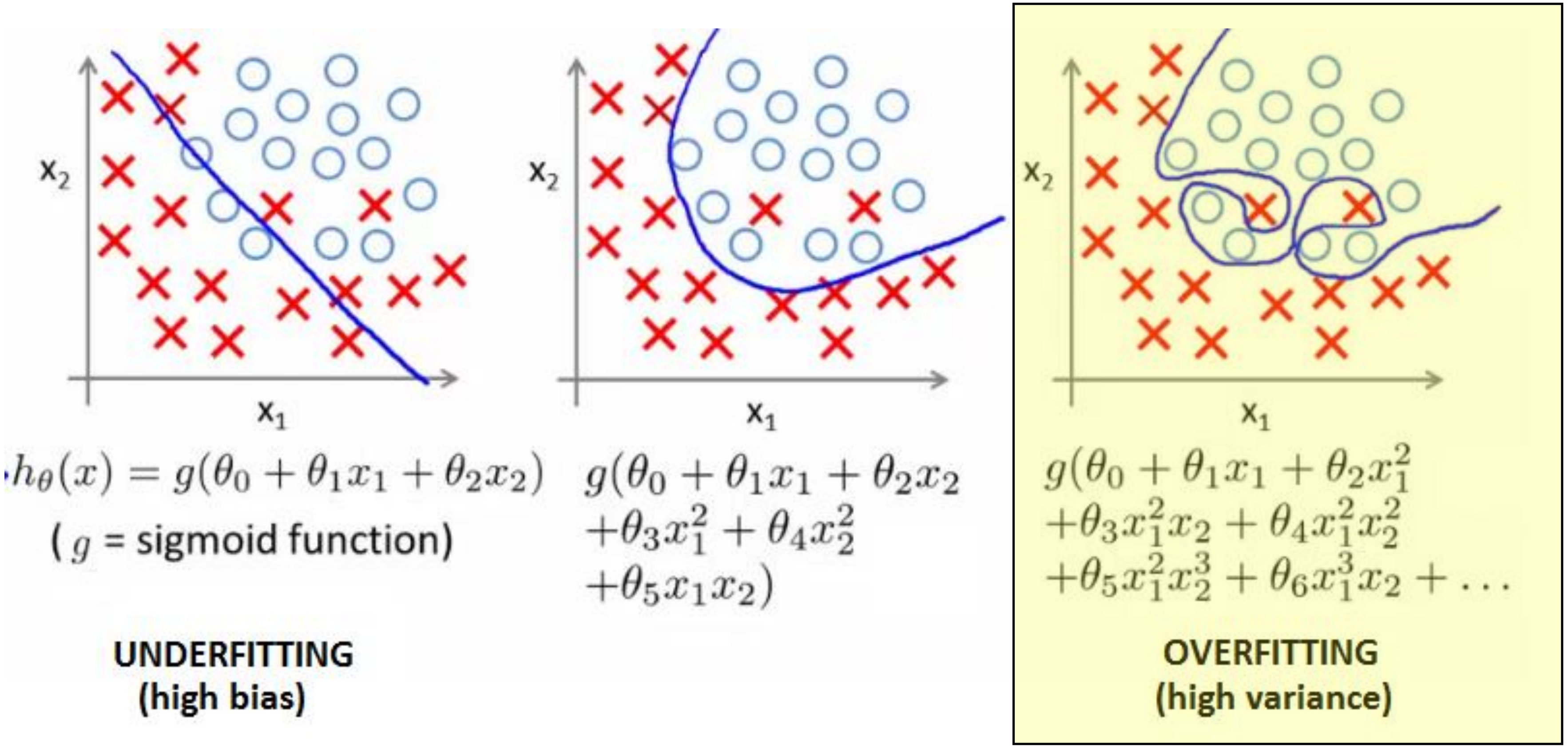




Overfitting and Underfitting

Difficult to find the right depth



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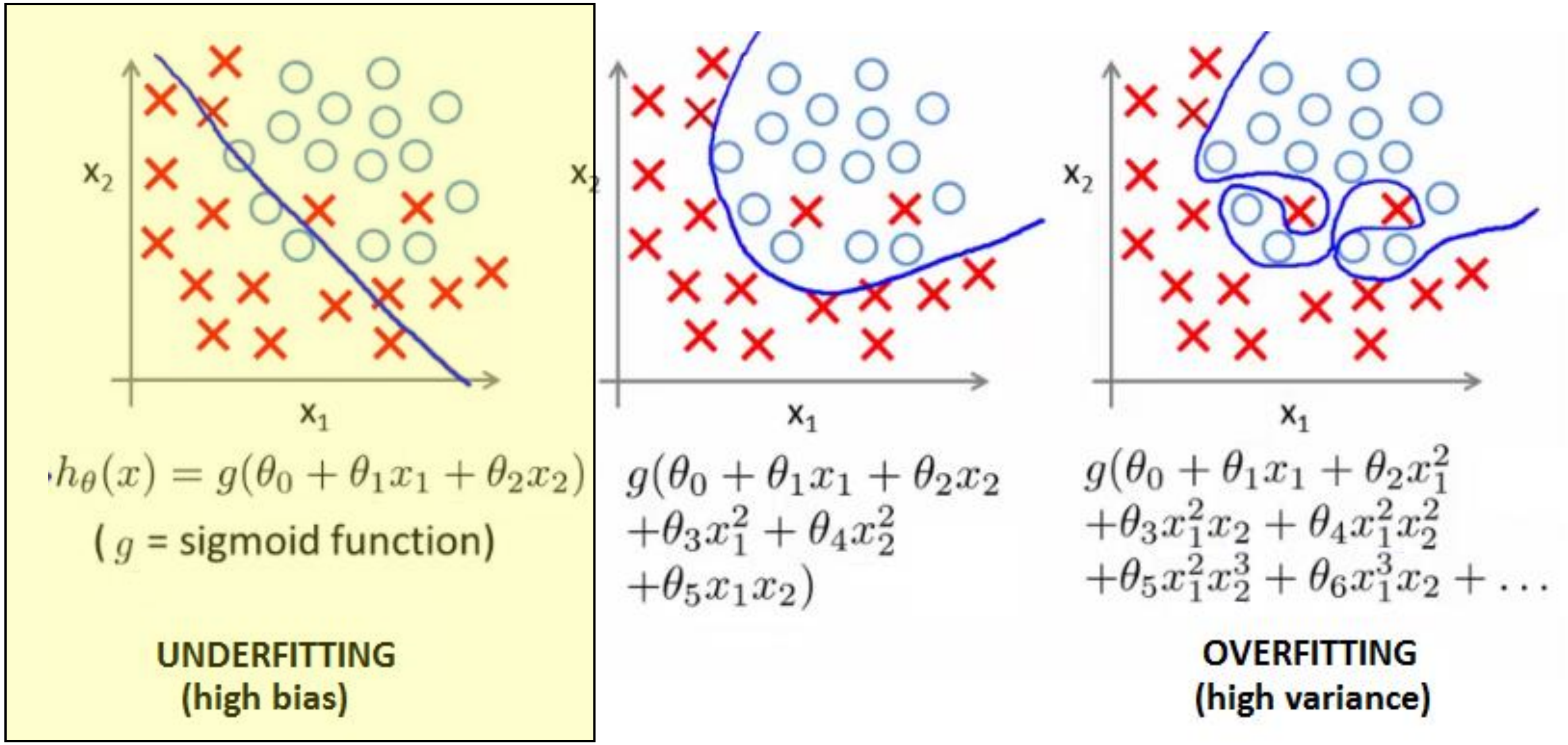

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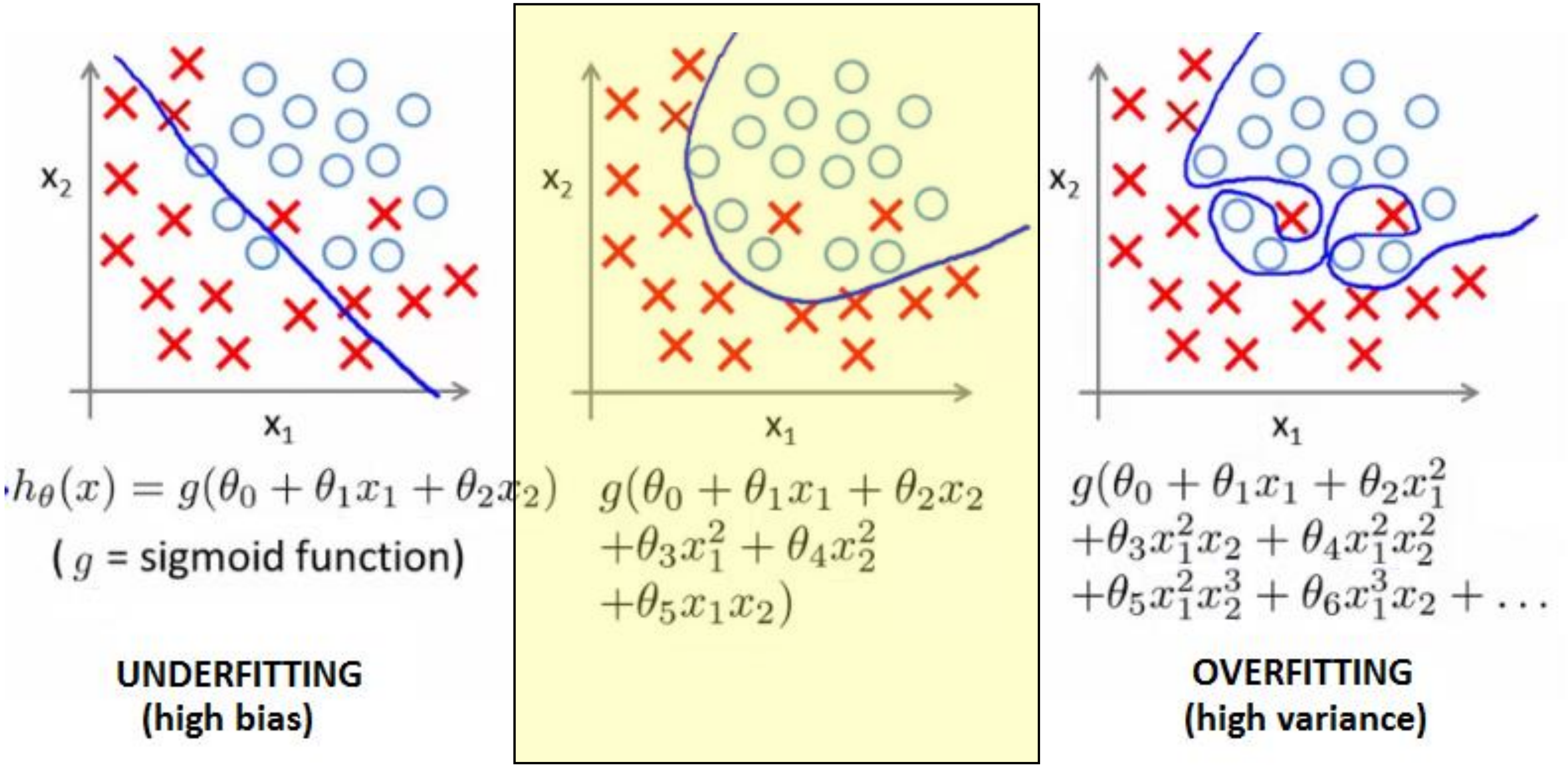
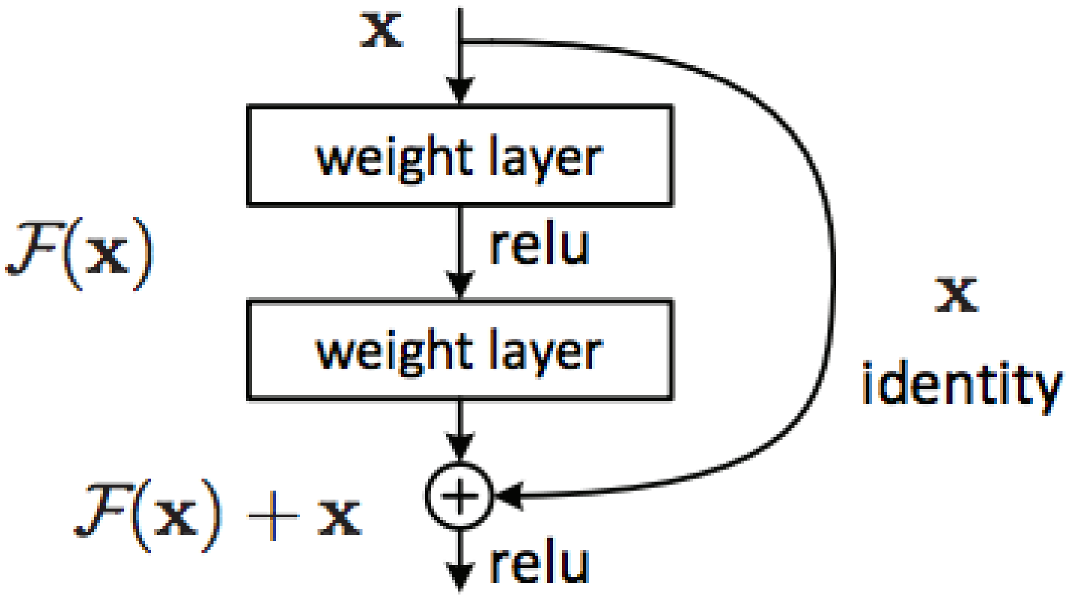


Skip Connection

Adaptive Depth



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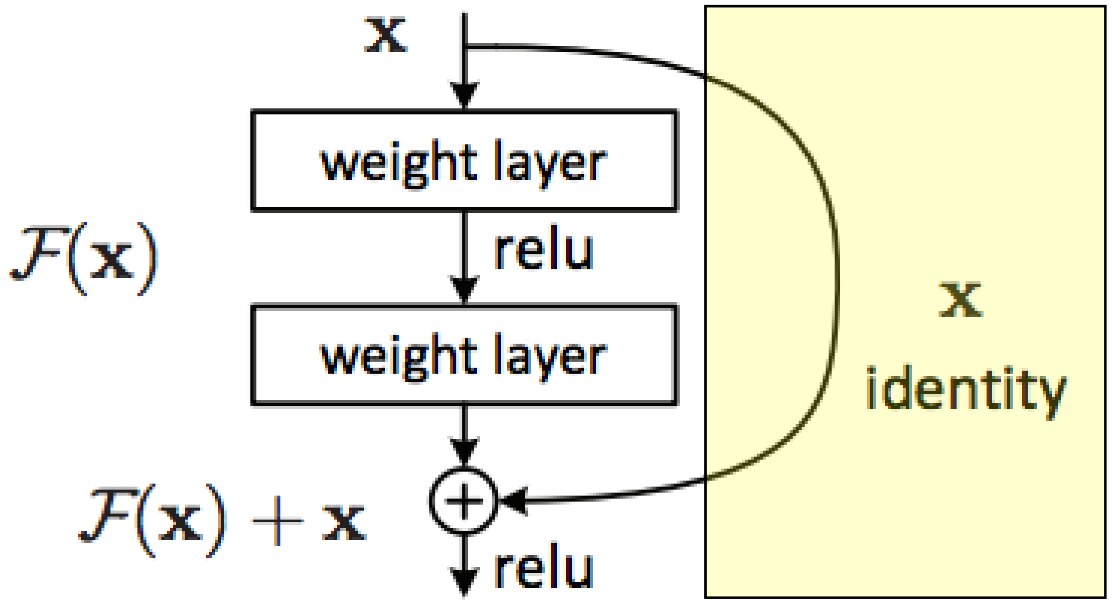

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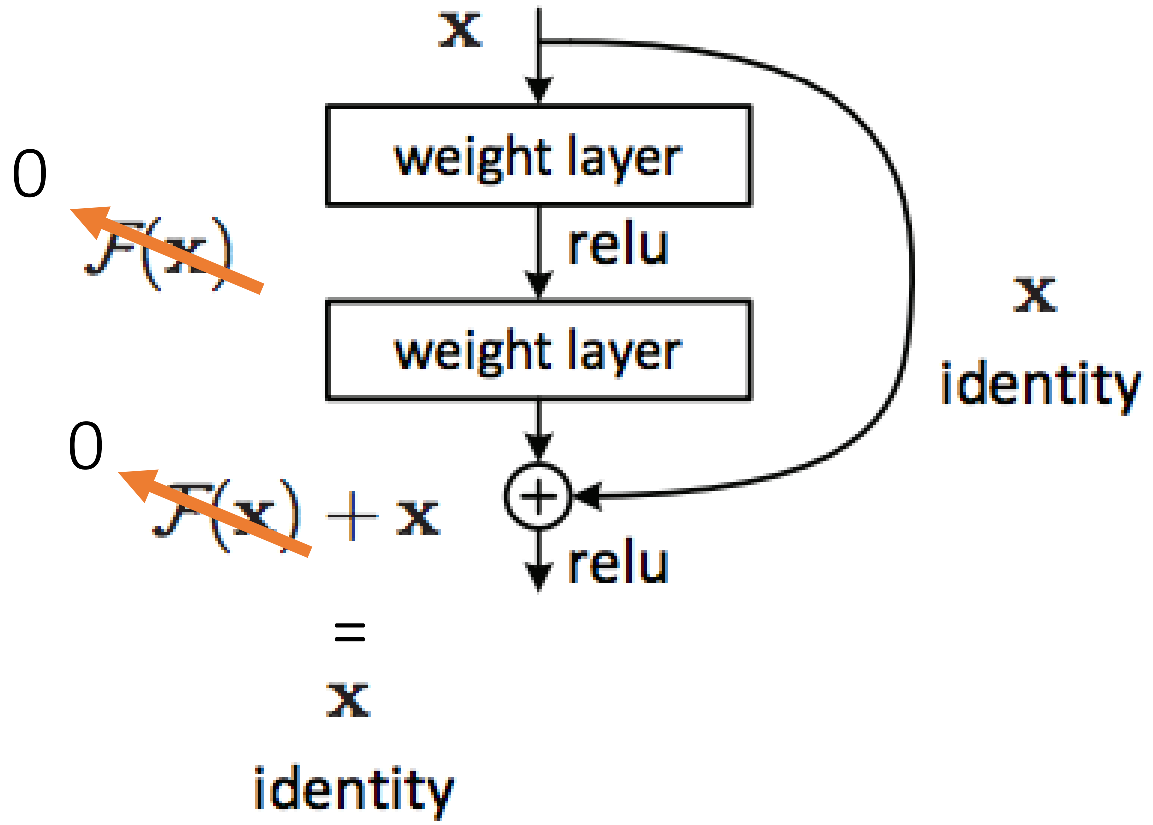
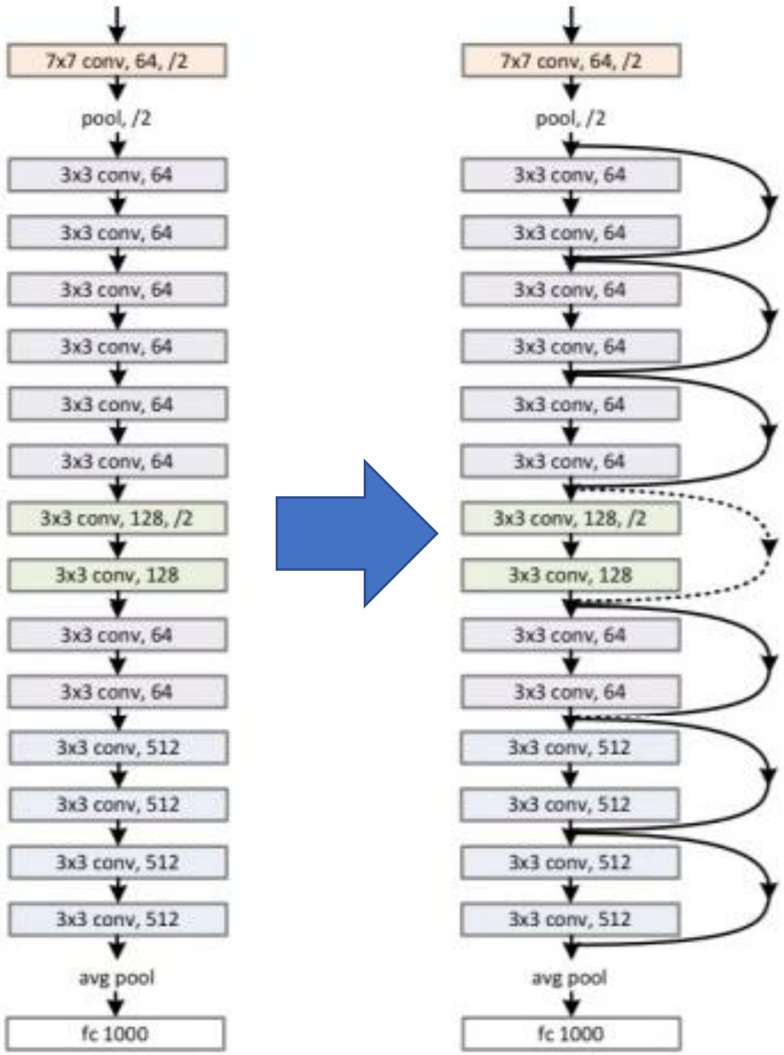


CNN to Residual Network



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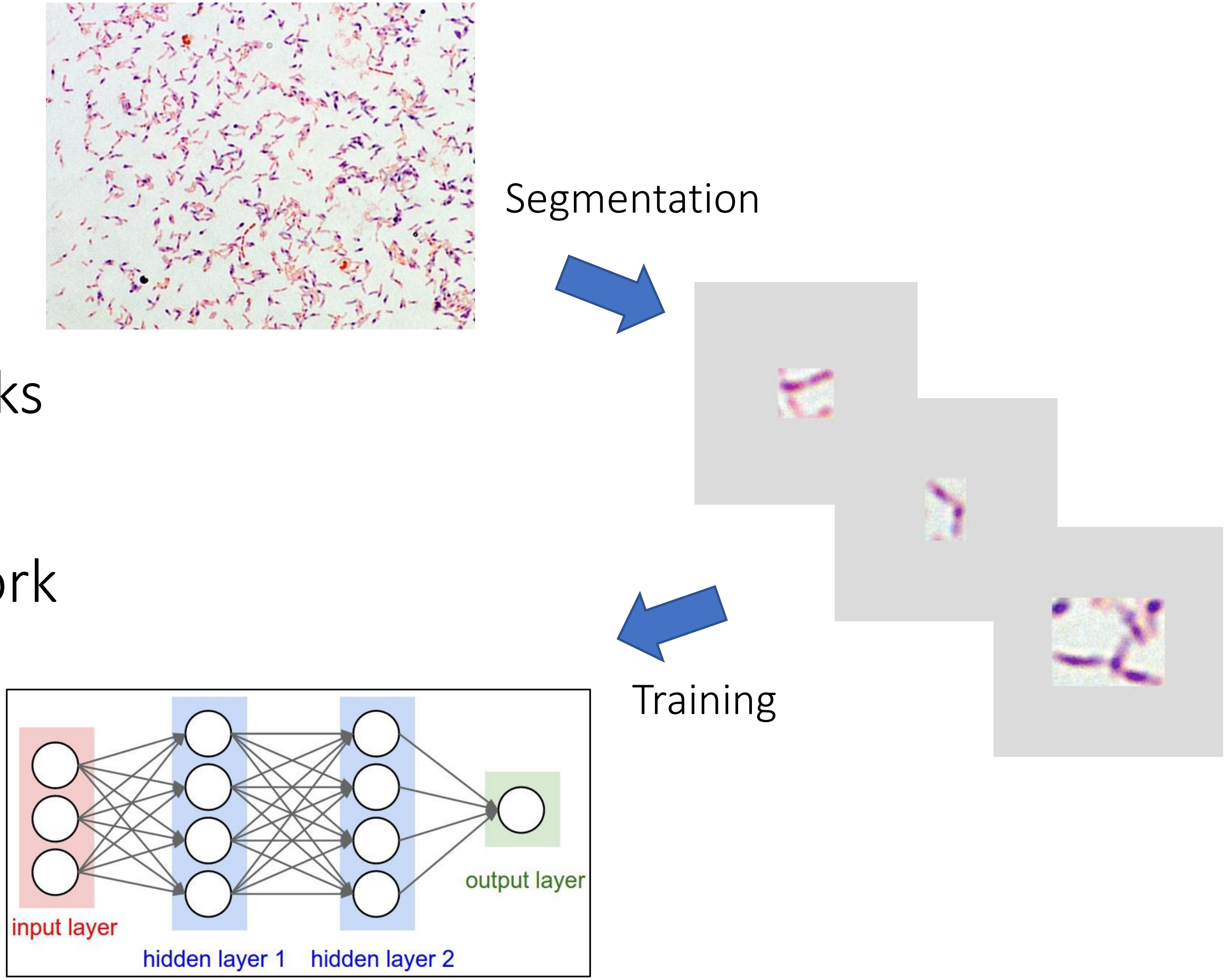
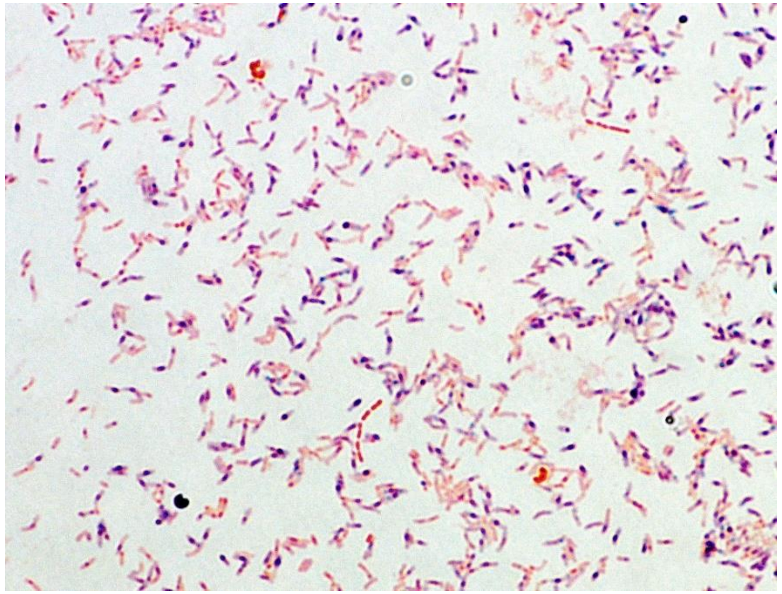
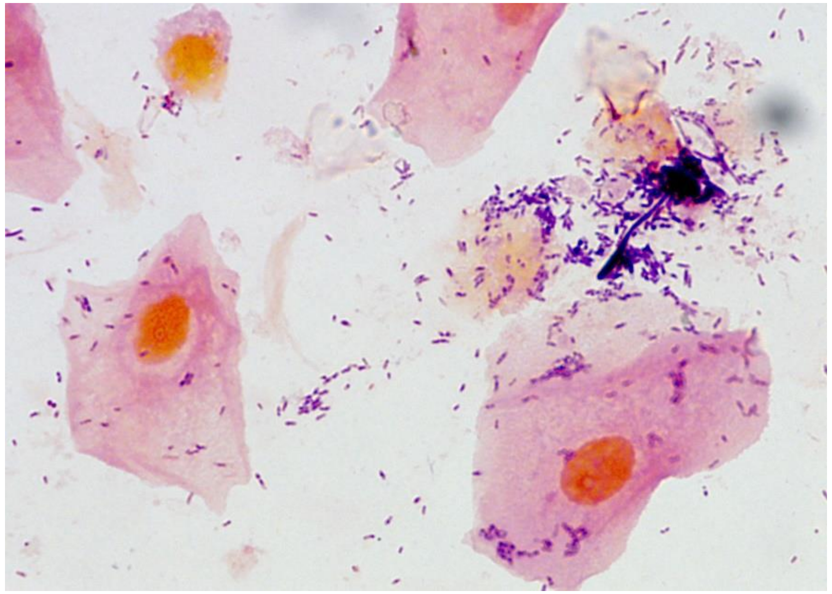


Machine Learning Model

The First Prototype - Data Pipeline

Step 1: Separation of training and testing Data

Training	Testing
 Smear Images of bacterial colonies	 Smear Images from patients

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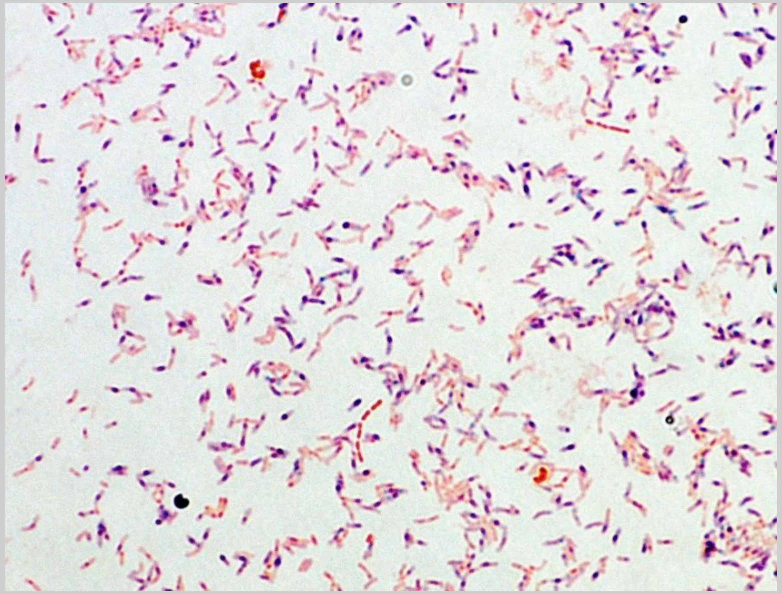	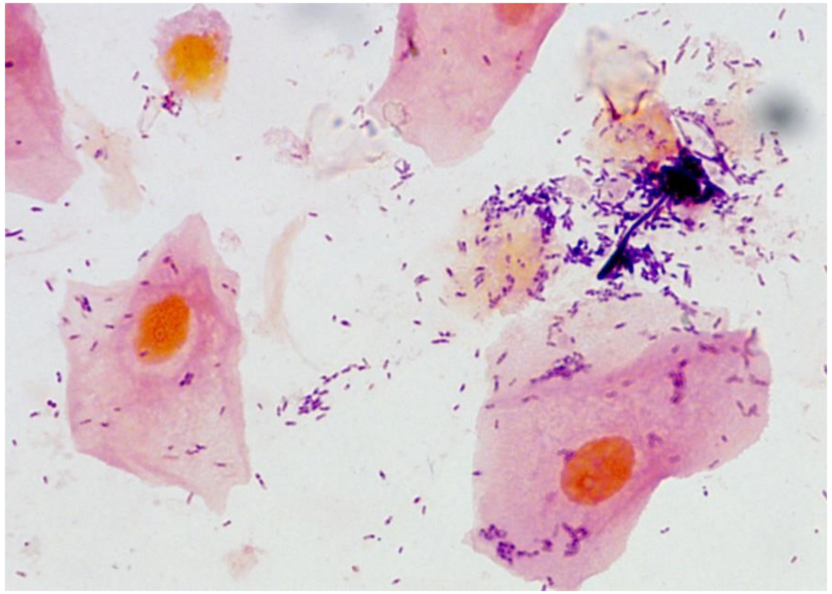
Smear Images of bacterial colonies	Smear Images from patients

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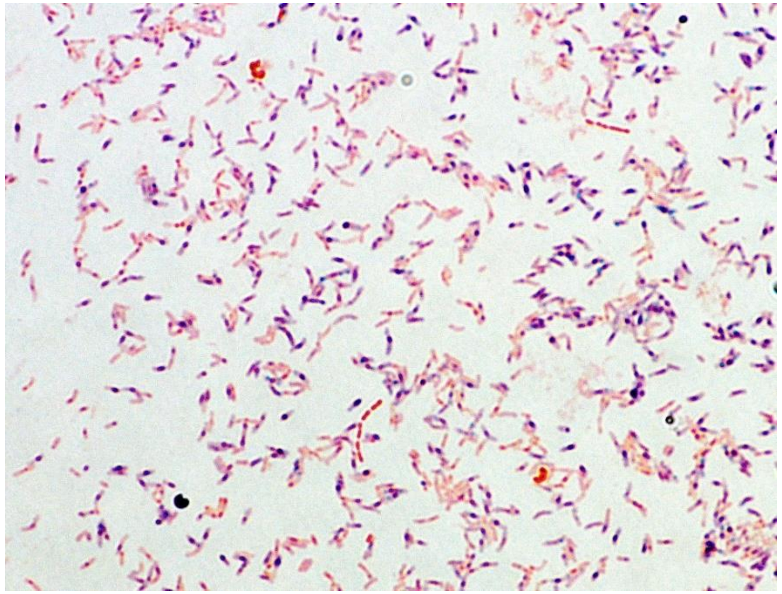
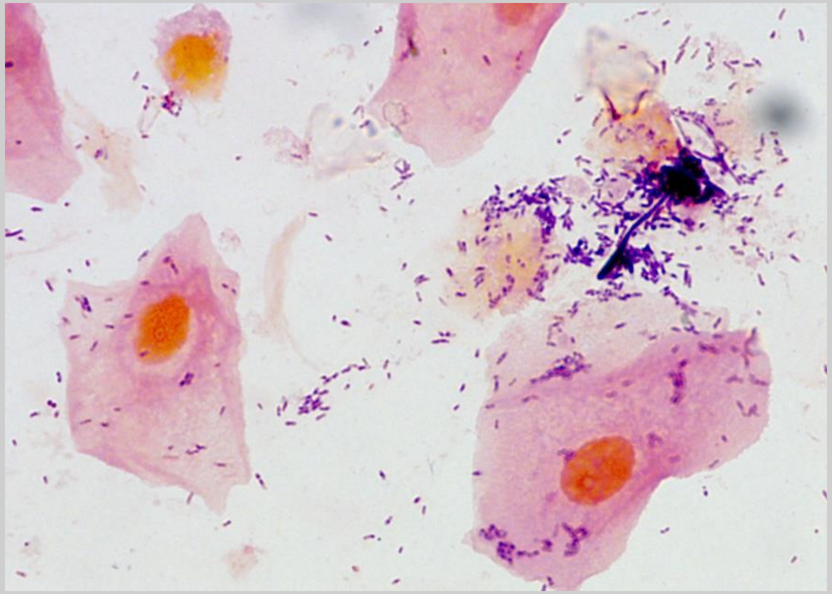
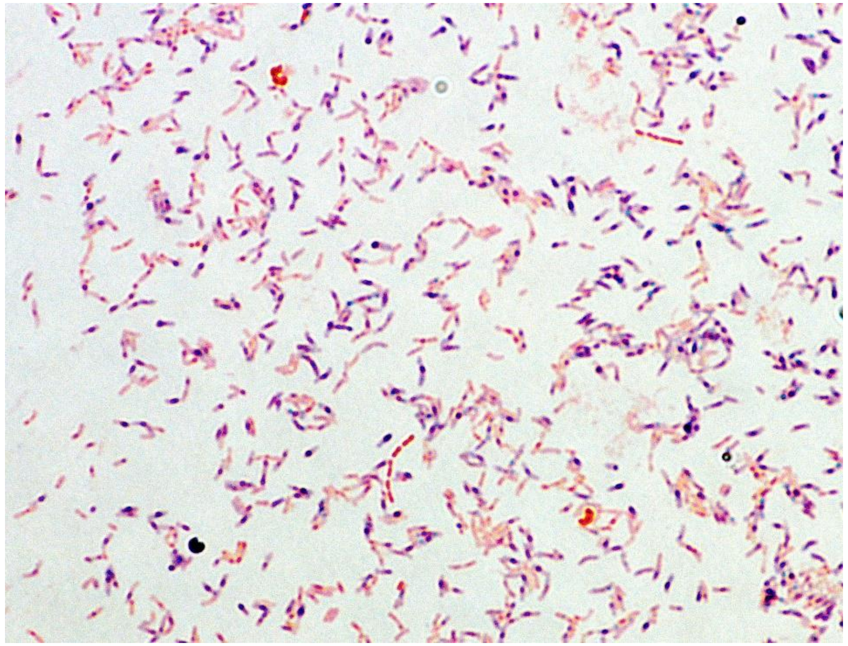
 Smear Images of bacterial colonies	 Smear Images from patients

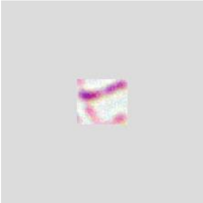
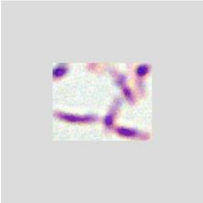
The First Prototype - Data Pipeline

Step 2: Segmentation of images

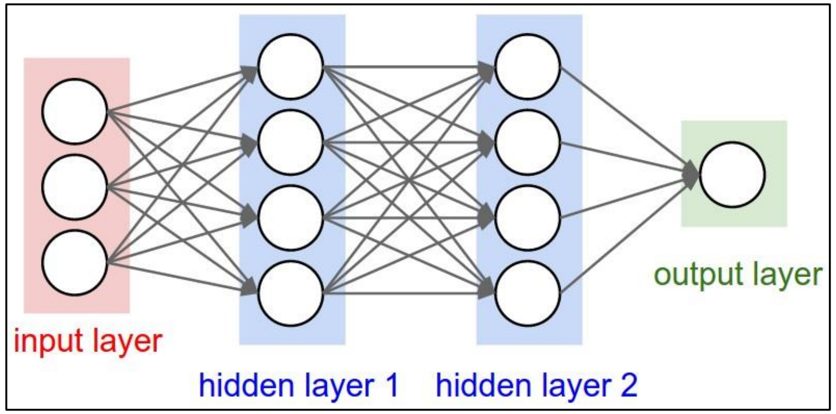

Gardnerella Vaginosis colony

The First Prototype - Data Pipeline

Step 3: Training using the images

Input	Output
	Lactobacillus
	Gardnerella
	Gardnerella

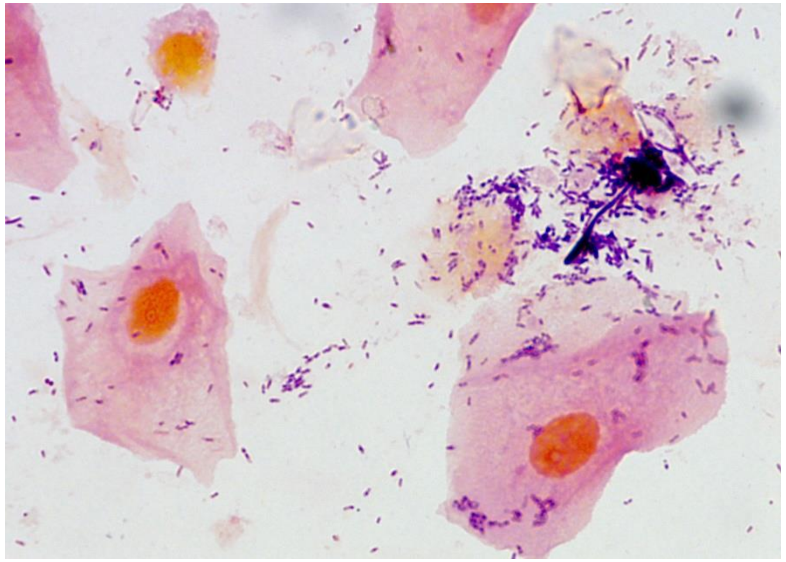
Training



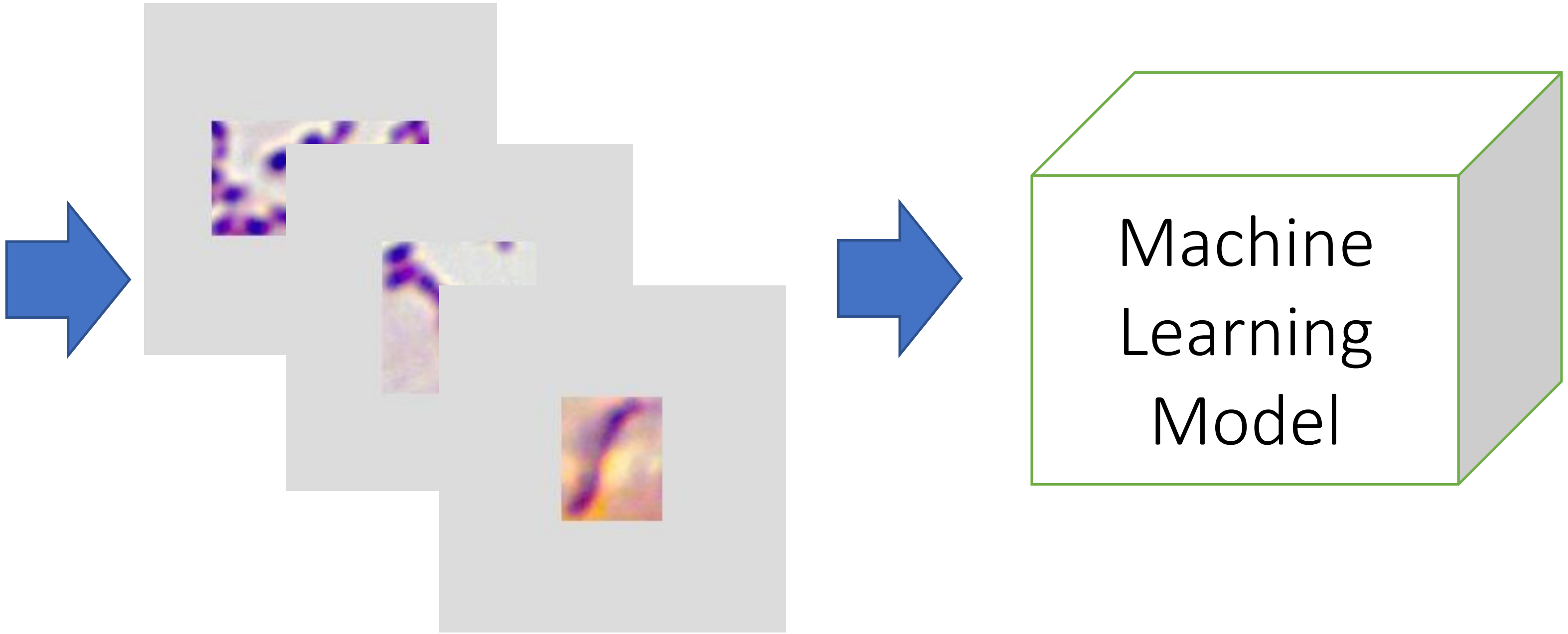
Machine Learning Model

The First Prototype - Data Pipeline

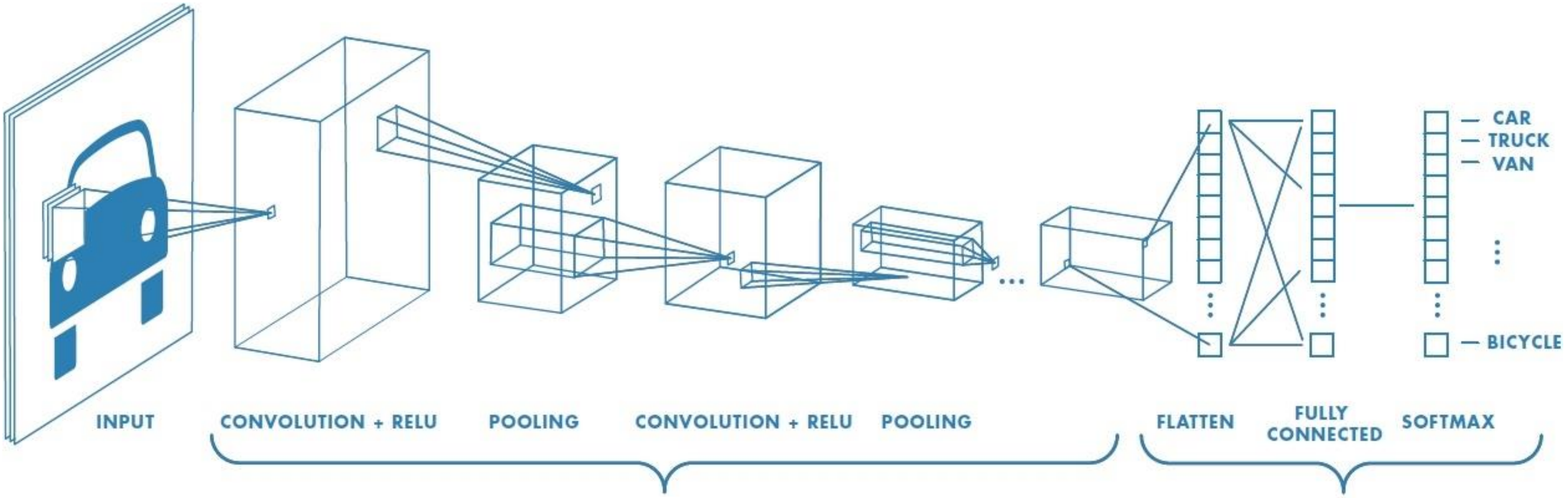
Step 4: Testing using the patients images



Patient Smear Image



The First Prototype – Model Architecture



7 Convolutional Layers

3 Fully Connected Layers

The First Prototype - Performance

Hold-out validation of 30% of unseen training data:

98.7% accuracy

		Prediction by the model			
		Lactobacilli	Gardnerella	Curved rods	Other
Actual type of bacteria	Lactobacilli	**499**	6	1	2
	Gardnerella	0	**559**	3	4
	Curved rods	0	2	**589**	0
	Other	2	5	0	**63**

The First Prototype - Performance

Testing on 31 patient images:

45.1% accuracy

		Prediction by the model		
		Normal	Intermediate	BV Infection
Actual degree of infection	Normal	**8**	0	0
	Intermediate	5	**3**	0
	BV Infection	6	6	**3**

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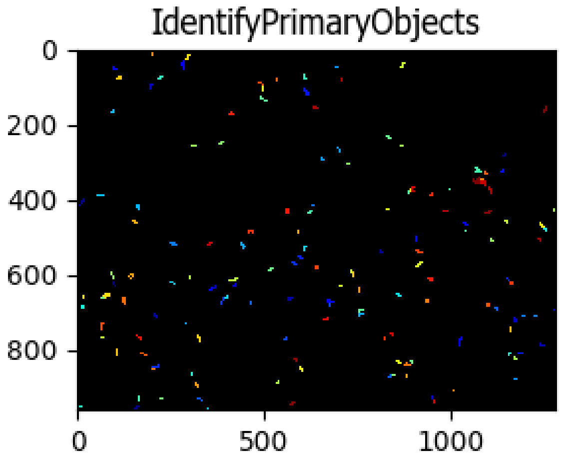
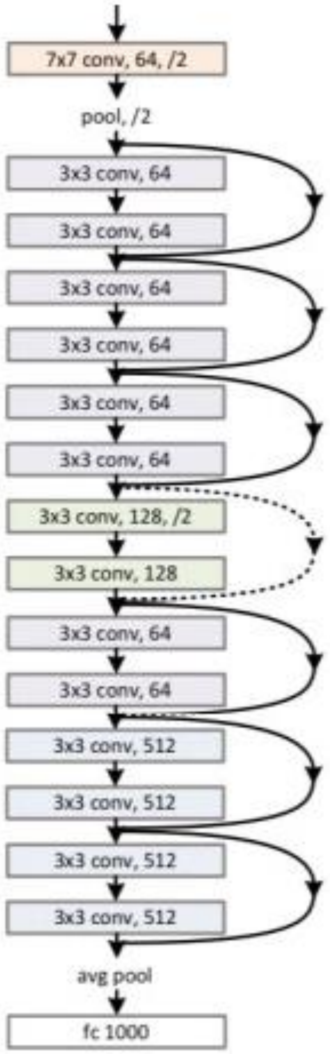
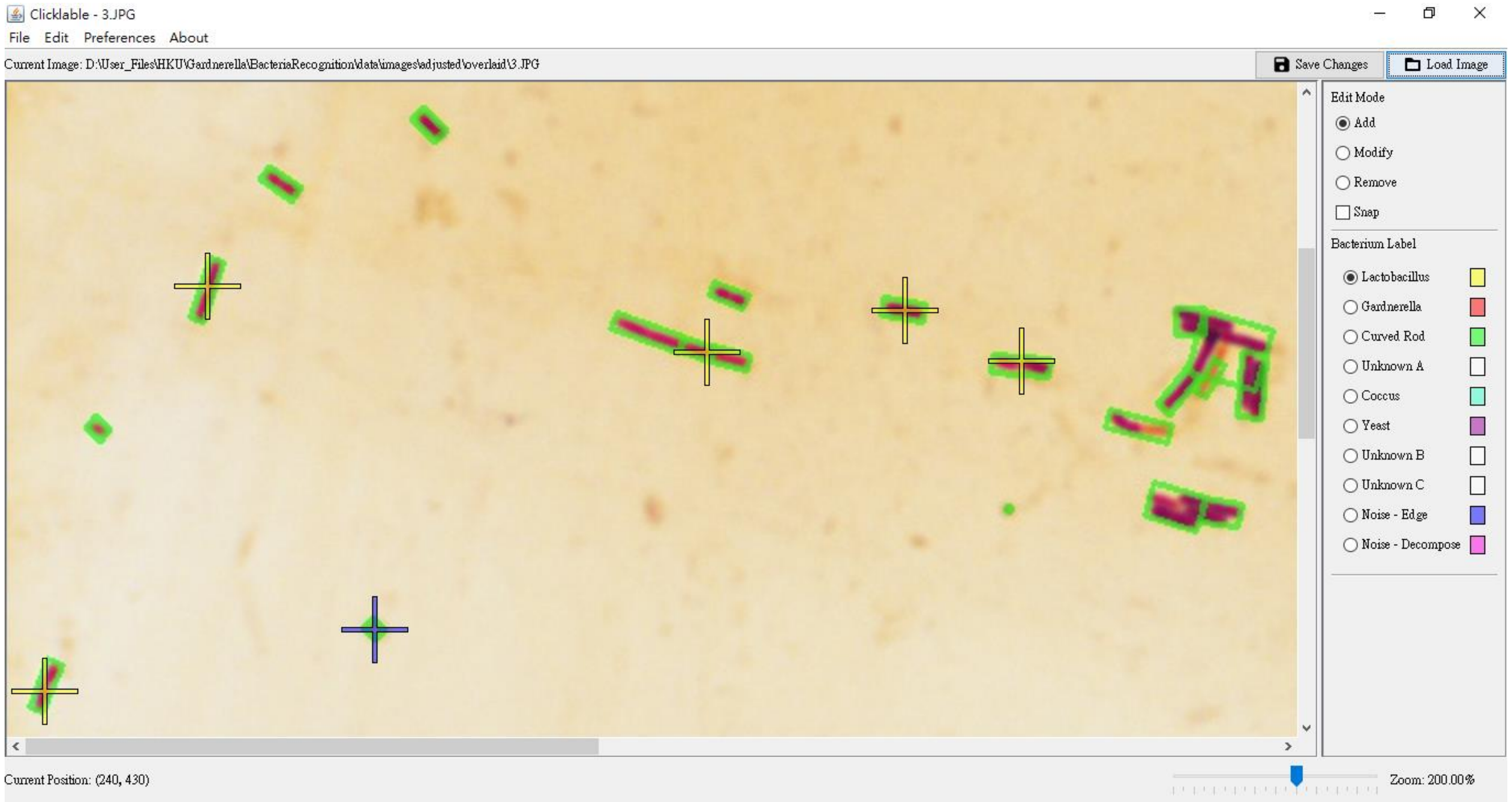




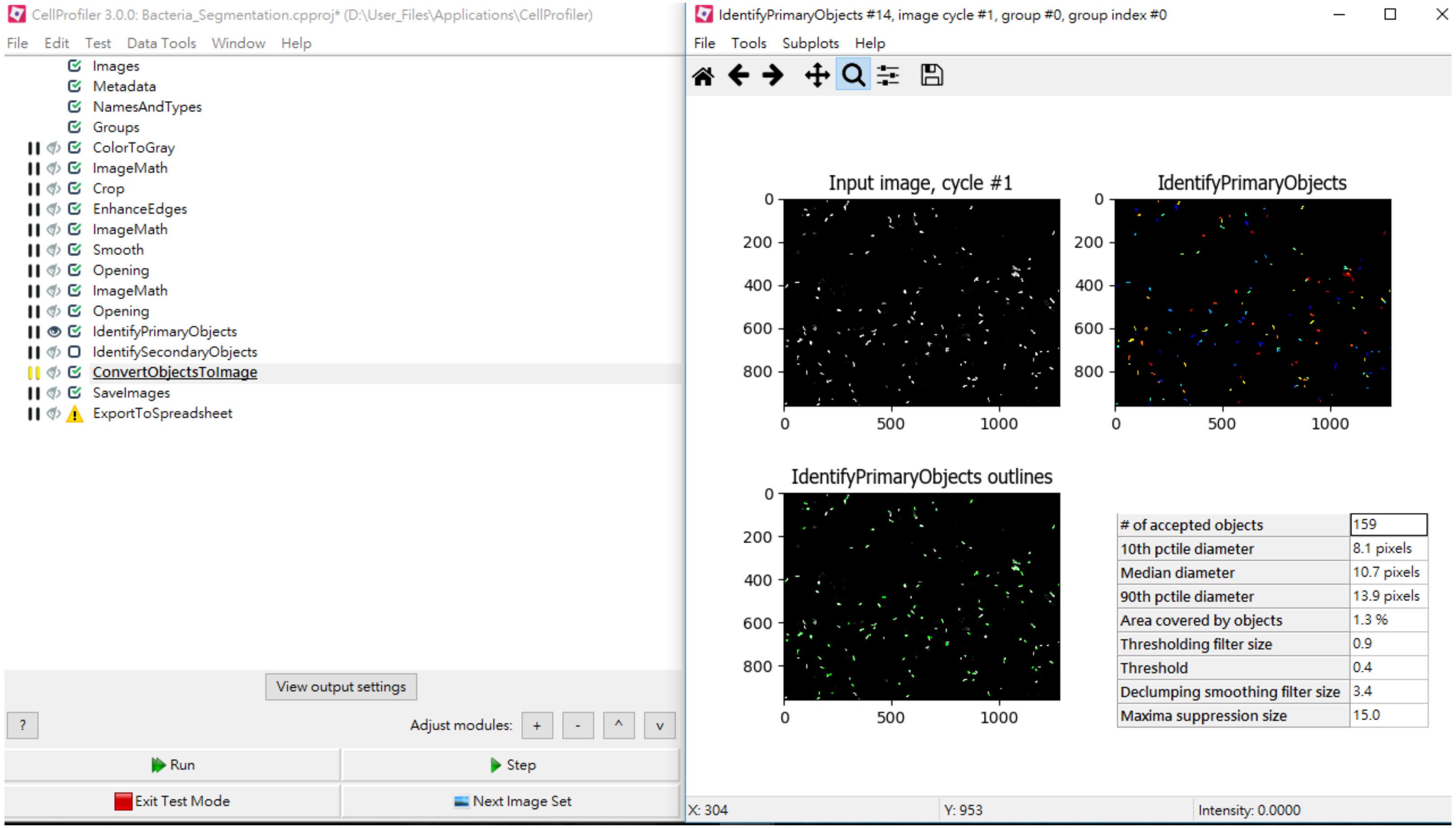
Second Prototype – Data Pipeline

Step 1: Collection of Data by Customized Tool "Clicklable"



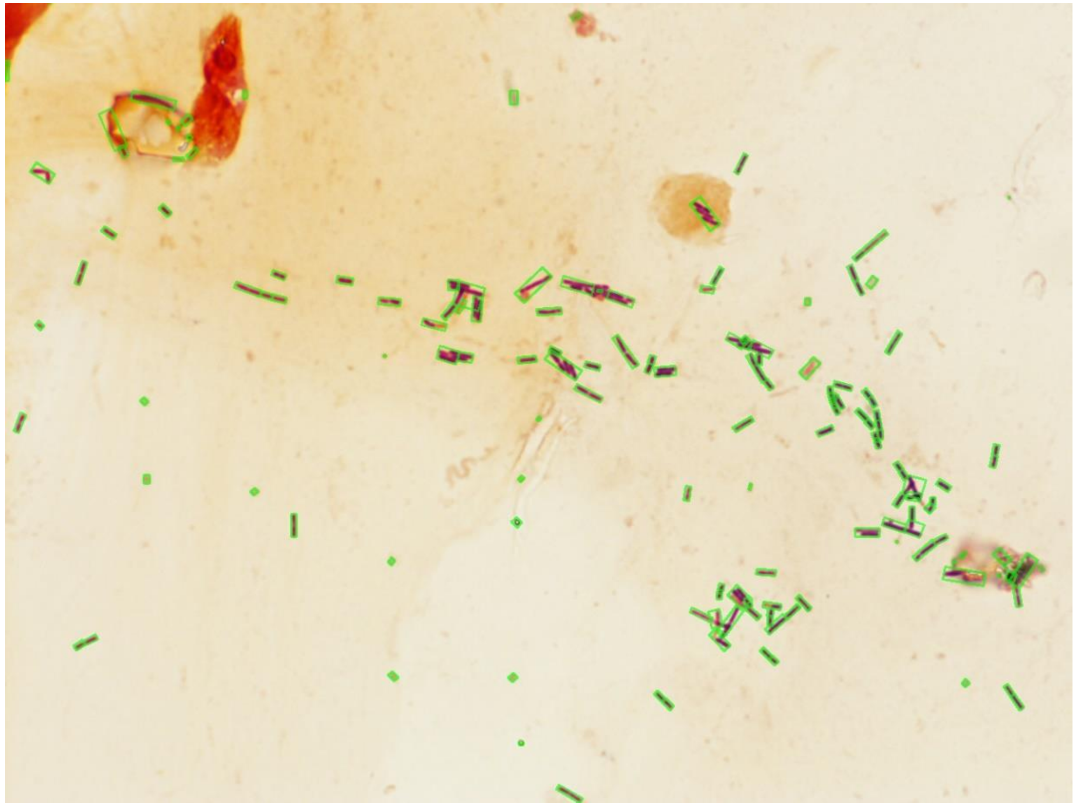
Second Prototype – Data Pipeline

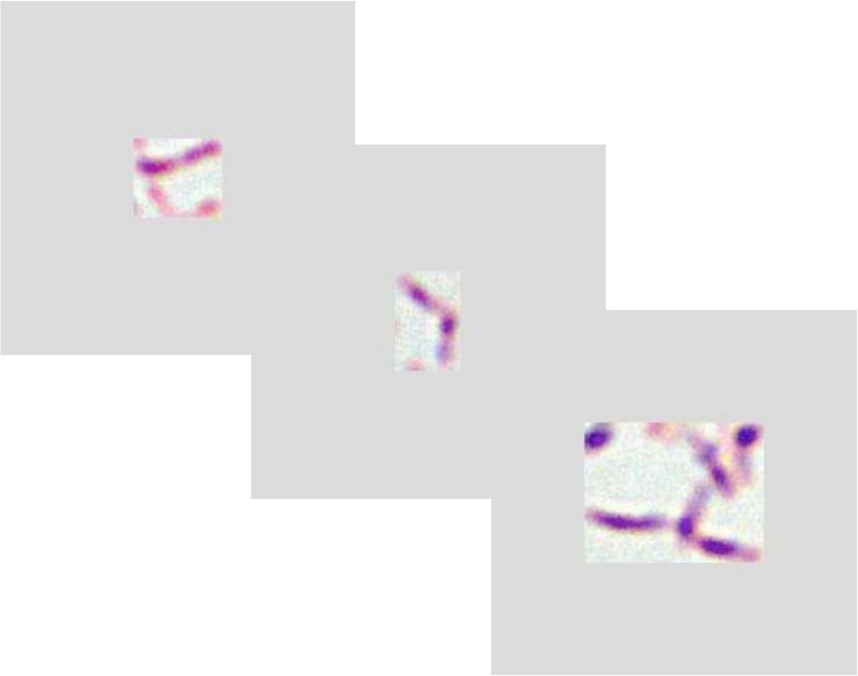
Step 2: Regions of Interest (ROIs) Identification by Image Processing



Second Prototype – Data Pipeline

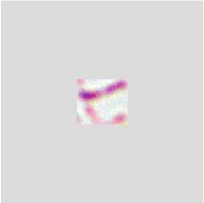
Step 3: Image Segmentation





Second Prototype – Data Pipeline

Step 4: Training and Validating using the images

Input	Output
	Lactobacillus
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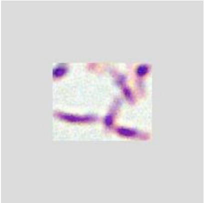
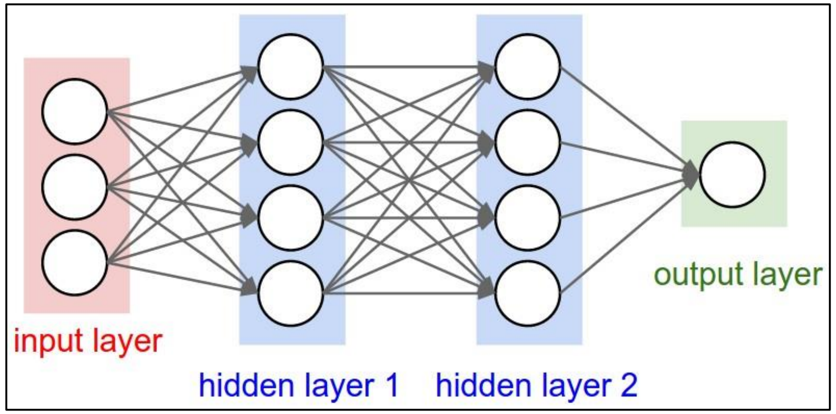
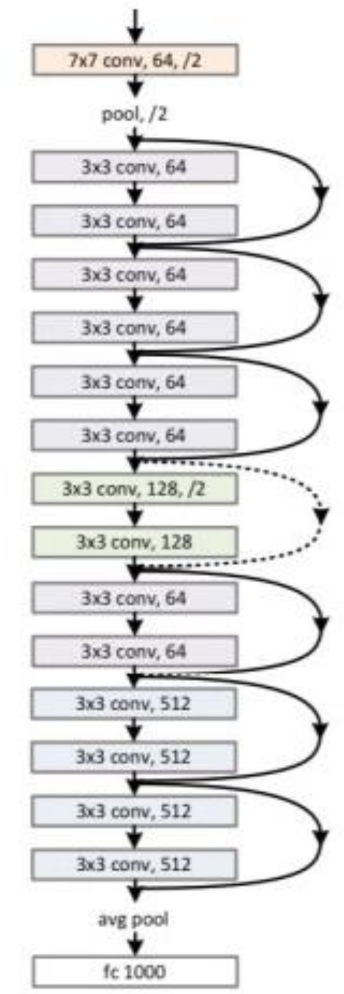
	Gardnerella



Machine Learning Model

The Second Prototype – Model Architecture



1 Standard Convolutional Layer

7 Residual Blocks

1 Fully Connected Layer

The Second Prototype – Performance (Provisionary)

Hold-out validation of 10% of unseen training data:

81.4% accuracy

Testing on unseen image data (not used in tuning):

72.9% accuracy

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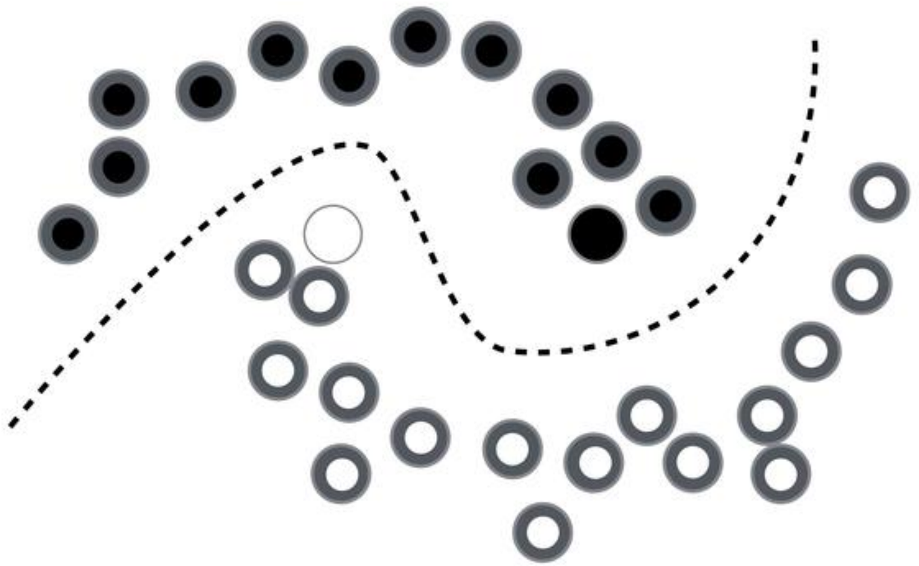
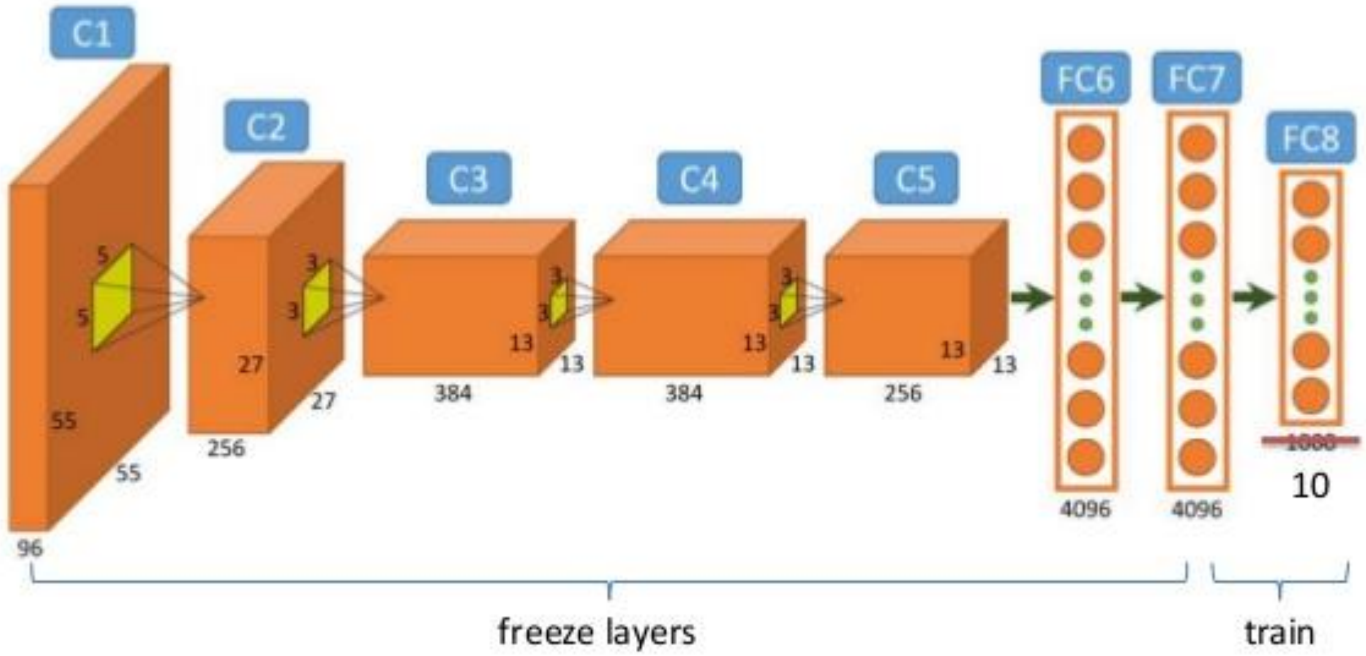
- Second prototype
- **Future direction**



Future Direction

Validation accuracy < 90% →

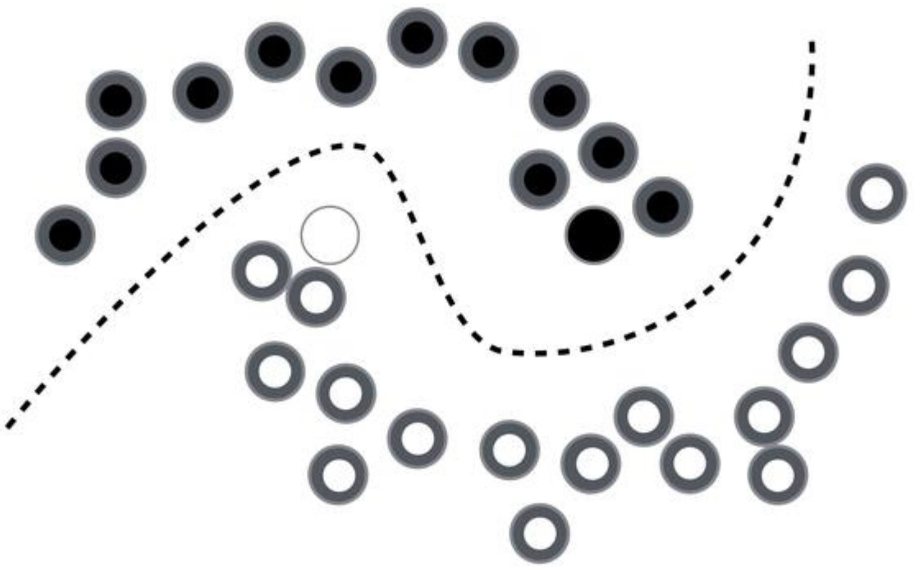
Increase complexity, fine-tuning and further training



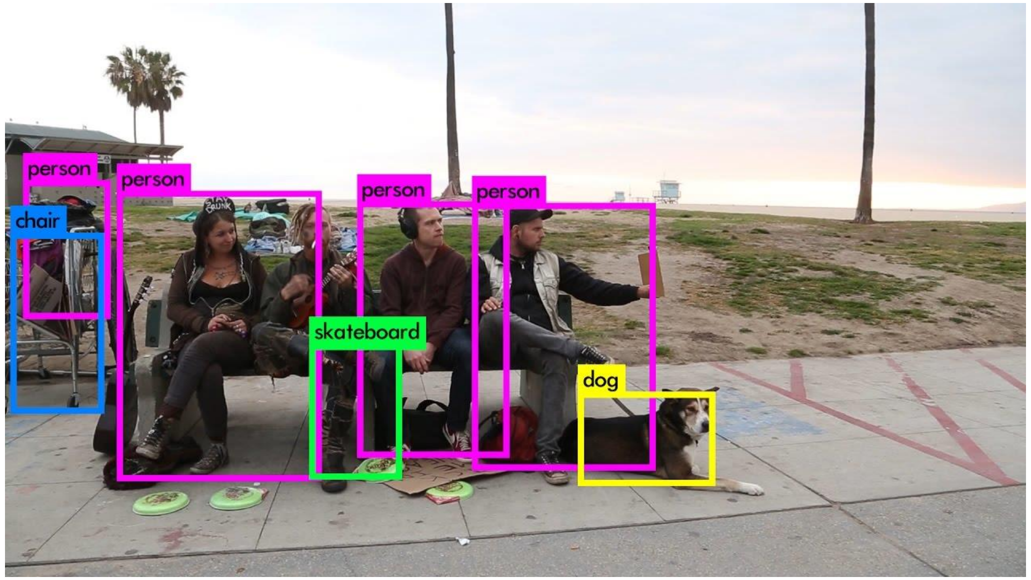
Future Direction

Large number of unlabelled data →

Exploration of other learning algorithms / architecture



Semi-supervised learning



YOLO algorithm for object recognition

Q & A