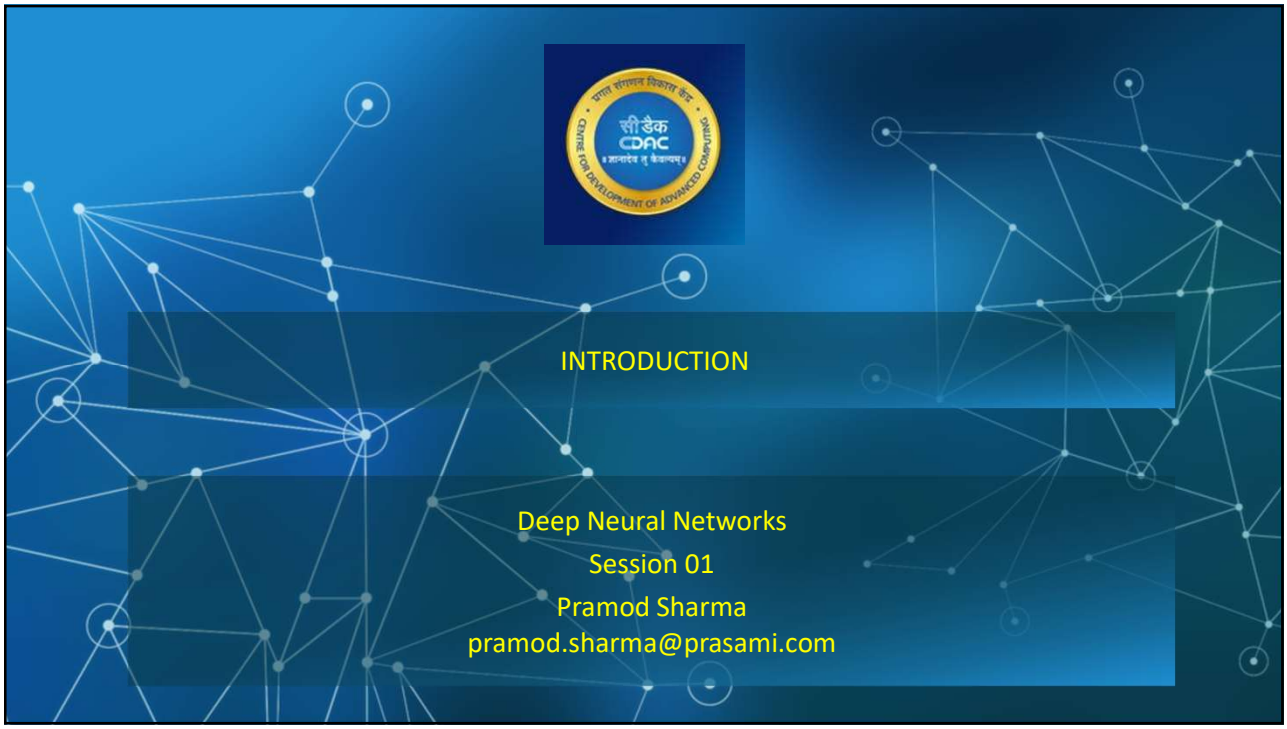
INTRODUCTION
Deep Neural Networks
Session 01
Pramod Sharma
pramod.sharma@prasami.com


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Agenda
Introduction
AI vs ML vs Deep Learning
MP Neuron
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## References


- Deep Learning using Python, S Lovelyn Rose,L Ashok Kumar, D Karthika R/ Wiley India, 1st Edition, 9788126579914
- Deep Learning, Ian Goodfellow, Yoshua Bengio, Aaron Courville
- Neural Networks and Learning Machines, Simon Haykin
- Pattern Recognition and Machine Learning, Christopher M. Bishop
- Deep Learning with Python - François Chollet
- Hands-On Machine Learning with Scikit-Learn and TensorFlow
- TensorFlow Deep Learning Cookbook




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*Theory exam– 40% weightage*

*Lab exam – 40% weightage*

*Internal exam – 20% weightage*

**Evaluation method**



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## Logistics

"The man who asks question is a fool for a minute, a man who doesn't ask is a fool for life."
~ Confucius



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## Logistics

- We encourage 'discussion groups':
  - Study groups
  - Whatsapp groups
- Expect you to complete your assignment individually!
- No group assignments unless stated otherwise
- Code is small part of it
- Pay special attention to inline comments
  - Comments should focus on what you were trying to implement



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## Journey So far


Search → Search and Inference → Uncertainty → Bayesian Network

Listen → Reflect → Implement → Share



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## Uncertainty Everywhere

Goal:
Delivering a passenger to the airport on time

- The agent forms a plan, lets say… A90,
  - Leave home 90 minutes before the flight departs
  - Driving at a reasonable speed
- Are you certain "*Plan A90 will get us to the airport in time.*"?
  - Not in absolute sense but with some riders



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## Uncertainty Everywhere

Goal:
Delivering a passenger to the airport on time

- How about other plans, such as A180,
  - Might increase the agent's belief that it will get to the airport on time,
  - But also increase the likelihood of a long wait
- Probability is an agent's measure of belief in some proposition — subjective probability.
- An agent's belief depends on its prior belief and what it observes.



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## Agent In Uncertain Environment

- Agents don't have complete knowledge about the world.
- Agents need to make (informed) decisions given their uncertainty.
- It isn't enough to assume what the world is like.
  - Example: wearing a seat belt.
- An agent needs to reason about its uncertainty.
- When an agent takes an action under uncertainty, it is gambling ⇒ probability



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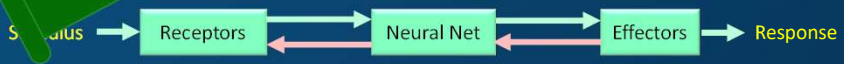
## Overview

- Nature is a continuum where as math is discreet values
  - Old film based images were continuous painting of colors ...are pixels
- Brain works differently than our mathem...
- Brain is highly complex, non... ...puter
- Neural networ... ...spired from brain
- Highly ... a Neural Network is modeled to simulate manner in which brain performs a task

All models are wrong... some models are useful!




Is this how our brain works? Really!!

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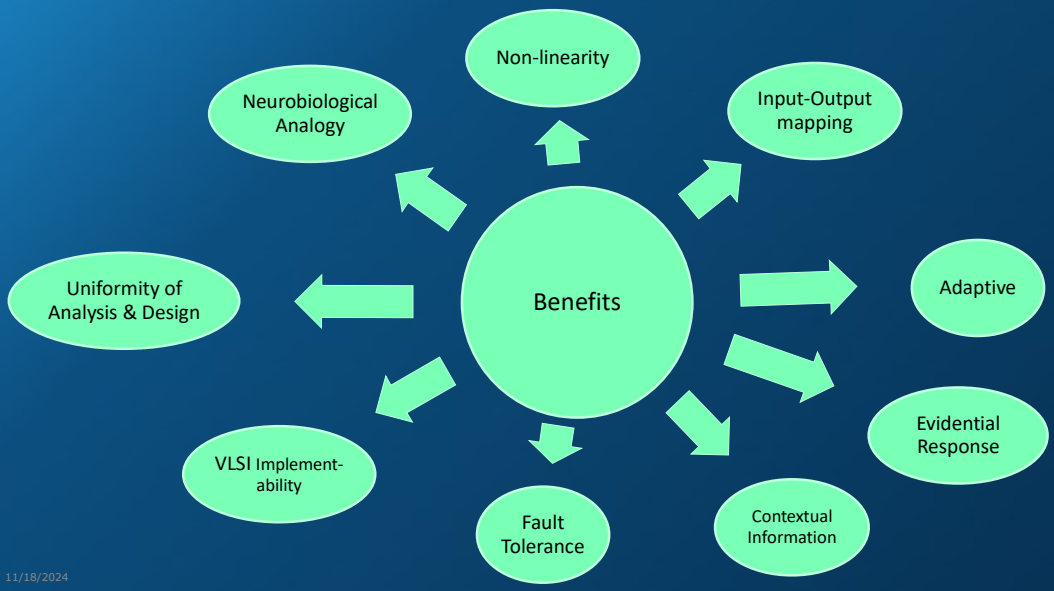
## Benefits of Neural Networks

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## What's Being Played...

Can a Rule based system answer based on the data provided?

We, as humans can easily guess!

| Time | Day | Type |
|---|---|---|
| 9:00 AM | Weekday | News |
| 11:00 AM | Weekday | K-Soaps |
| 3:00 PM | Weekday | Soaps |
| 5:00 PM | Weekday | Soaps |
| 6:00 PM | Weekday | Cartoons |
| 9:00 PM | Weekday | Sports, Movies |
| 4:00 PM | Weekday | ??? |
| 1:00 PM | Weekday | ??? |


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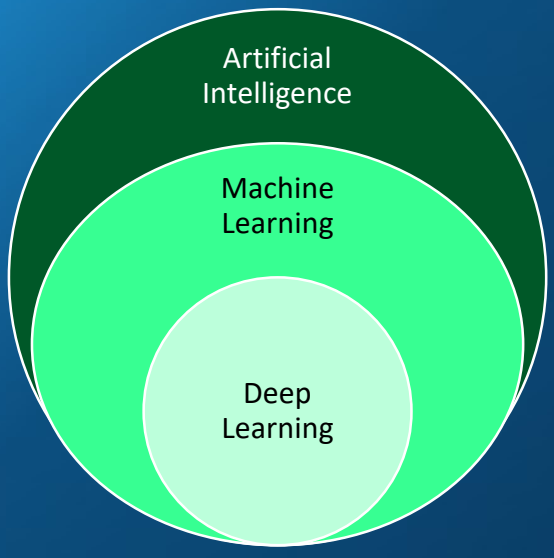
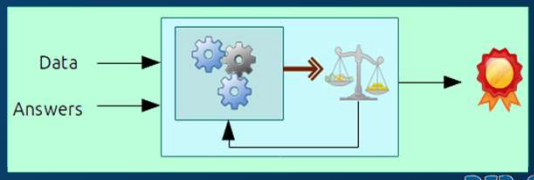
## AI vs ML vs Deep Learning




- Used interchangeably
- AI is a broader concept, it includes basic AI to Deep learning.
- Machine learning: enabling Machines to Learn from the past incidents (available data).
- Deep Learning: One can say that it tries to copy information processing patterns found in the human brain

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## Artificial Intelligence vs. Machine Learning

### Artificial Intelligence

- Create intelligent machines that can simulate Human thinking capability and behavior
- A man-made thinking power
- No pre-programing needed
- Algorithms which can work with their own "intelligence"
- Algorithms such as Reinforcement learning algorithm and deep learning neural networks being used in multiple places such as Siri, Google's AlphaGo, AI in Chess playing, etc.
- Based on capabilities, AI can be classified into three types:
  - Weak AI
  - General AI
  - Strong AI
- Currently, we are working with weak AI and general AI. The future of AI is Strong AI for which it is said that it will be more intelligent than humans (???)

### Machine Learning

- An application or subset of AI
- Allows machines to learn from data without being programmed explicitly
- Uses a massive amount of structured and semi-structured data
- It can work only on data it has seen
- For unknown cases it becomes unresponsive or unreliable
- Being used for online recommender system, for Google search algorithms, Email spam filter, Facebook Auto friend tagging suggestion, etc.
- It can be divided into three types:
  - Supervised learning
  - Unsupervised learning
  - Reinforcement learning



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## Deep Learning

- Large Neural Networks

"Using brain simulations, hope to:
Make learning algorithms much better and easier to use,
Make revolutionary advances in machine learning and AI,
I believe this is our best shot at progress towards real AI."

- Andrew Ng

- Learning successive layers of increasingly meaningful representations
- Modern network contain hundreds of successive layers
- Successive layers are learned via "neurons" connected via neural network

Some concepts were inspired by how our brain works
It is NOT a replica of human brain!!!



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## Deep Learning

- Why Deep Learning is more practical today?
  - Availability of large computing power
  - Availability of large datasets
- Most flavors of the old generations of learning algorithms, performance will plateau
- Deep learning that is scalable
  - Performance just keeps getting better as more and more data is fed
- Most value today is coming from supervised learning
- Eventually, we will see benefits of unsupervised learning



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## Deep Learning

- Usually a neural network contains
  - Input Layer
  - Hidden layers [ 1 … n]
  - Output layer
- We may call network with 1 to 2 hidden layer as shallow
- Network with 10 or more layers as deep
  - No set demarcation!
- I guess, scientists just got excited when someone labeled them as deep network
- Intelligent software to automate routine tasks, understand speech or images, make diagnosis in medicine and support basic scientific research



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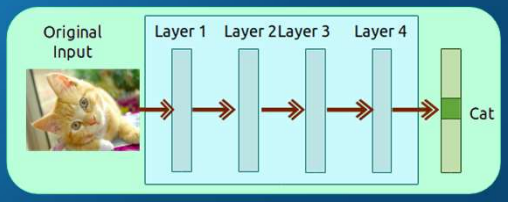
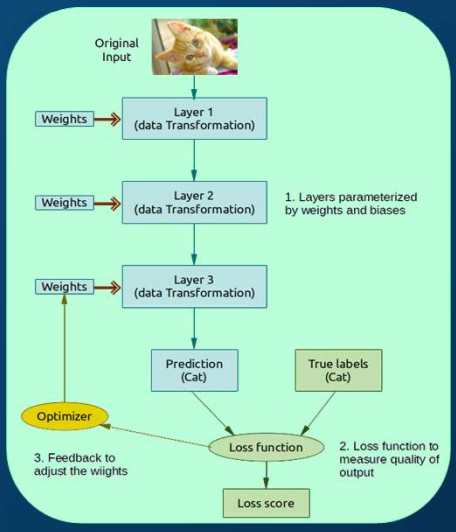
## How deep learning works…

- As the images are processed through the layers




- The representations are increasingly filtered, purified and distilled to make them more meaningful



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## What has been achieved so far

- Learn to see and hear… so natural to humans but elusive to machines earlier
- Image classification
- Speech recognition
- Handwriting reco
- Writing style recognition (who was the author)
- Improved machine translation
- Text-to-speech conversion
- Digital assistants such as Google Now and Amazon Alexa
- Little autonomous driving
- Improved ad targeting, as used by Google, Baidu, and Bing
- esults on the web
- Ability to answer natural-language questions
- Superhuman games playing: chess, go…

Still long way to go…
Human-level general intelligence too far away…



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Neurons



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## To play or not to play!

| id | Dry Weather | Low Temp | Homework Done | Team Members | Equipment | Ground | Played |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 5 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |



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## 23 Neurons

- Features:
  - Is it raining?
  - Is it too hot?
  - Have I completed my homework?
  - Are sufficient players ready?
  - Is cricket equipment ready?
  - Is ground available?
- Depending on the feature values, you may get to play or not
- Features like homework and availability of ground can be considered as 'inhibitory'.

| id | Dry Weather | Low Temp | Homework Done | Team Members | Equipment | Ground | Played |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 4 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 5 | 0 | 0 | 1 | 1 | 1 | 0 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

- Notes :
  - Aggregator function is sum and threshold can be 3.
  - Assign 0 or 1 if a parameter is in favor or not

Given sufficient data point, we can train an algorithm to make such simple decisions for us.



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## 24 MP Neuron

- In 1943 Warren S. McCulloch, a neuroscientist, and Walter Pitts, a logician, published "A logical calculus of the ideas immanent in nervous activity" in the Bulletin of Mathematical Biophysics
- In this paper McCulloch and Pitts tried to understand how the brain could produce highly complex patterns by using many basic cells that are connected together
- These basic brain cells are called neurons, and McCulloch and Pitts gave a highly simplified model of a neuron in their paper
- The McCulloch and Pitts model of a neuron, which we will call an MCP neuron for short, has made an important contribution to the development of artificial neural networks -- which model key features of biological neurons



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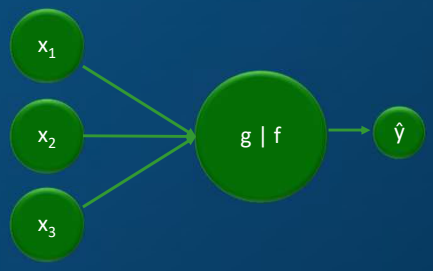
## MP Neuron

- Neurons receive signals and produce a response
- In this model:
  - All inputs are binary i.e. [0,1]
  - Inputs are “inhibitory” or “excitatory”.
  - Inhibitory have maximum influence on the model
  - It has an aggregator ‘g’ and a function ‘f’
  - There is a threshold
  - If g is more than threshold, $\hat{y}$ = 1 else 0




- $\hat{y}$ = 0 if any $x_i$ is inhibitory, else g(x) = $\sum x_i$
- $\hat{y}$ = 1 if g(x) ≥ threshold else $\hat{y}$ = 0



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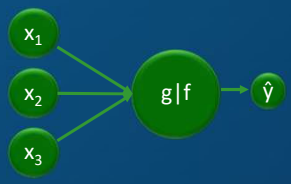
## MP Neuron




| id | Dry Weather | Low Temp | Homework Done | Team Members | Equipment | Ground | Sum | Played |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 5 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 |
| 4 | 0 | 1 | 0 | 1 | 1 | 1 | 4 | 0 |
| 5 | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |



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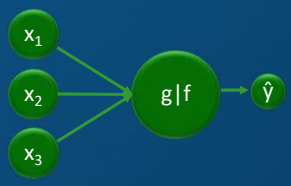
## MP Neuron




| id | Dry Weather | Low Temp | Homework Done | Team Members | Equipment | Ground | Sum | Played |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 0 | 1 | 5 | 1 |
| 2 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 |
| 3 | 1 | 1 | 1 | 1 | 1 | 1 | 6 | 1 |
| 4 | 0 | 1 | 0 | 1 | 1 | 1 | 4 | 0 |
| 5 | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 0 |
| 6 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |

The logic is straight forward. Let's implement this model on a dataset.



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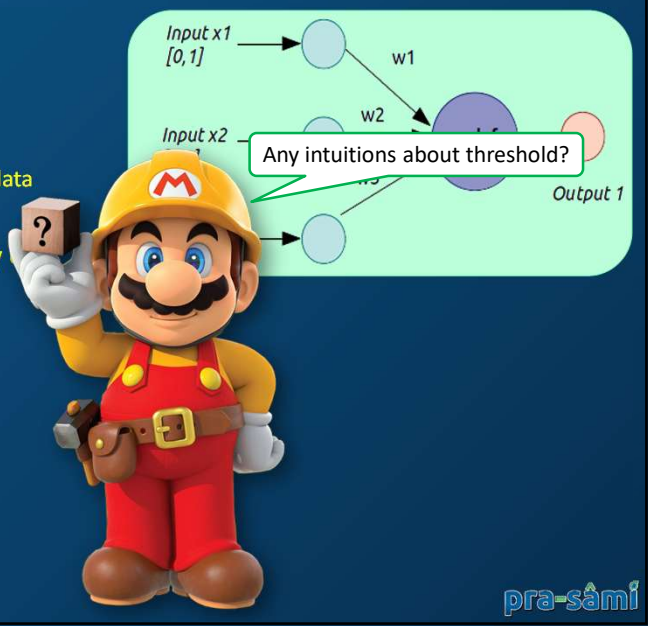
## Code Example1 – MP Neurons

- Need a dataset with plenty of features and binary output
- Load modified Breast Cancer dataset
  - This dataset is based on scikit-learn breast cancer data
- Its features are a continuous and we need binary
  - For b in range [0, num_features+1]
    - Sum it by row and compare with b
- Converted file is in the shared folder



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## Next Session

- Perceptron
- Single Layer Neural Network
- Overview of back propagation of errors



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ADDITIONAL MATERIAL

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## Biological Neural Nets

- Pigeons as art experts (Watanabe et al. 1995)

- Experiment:
  - Pigeon in Skinner box
  - Present paintings of two different artists (e.g. Chagall / Van Gogh)
  - Reward for pecking when presented a particular artist (e.g. Van Gogh)



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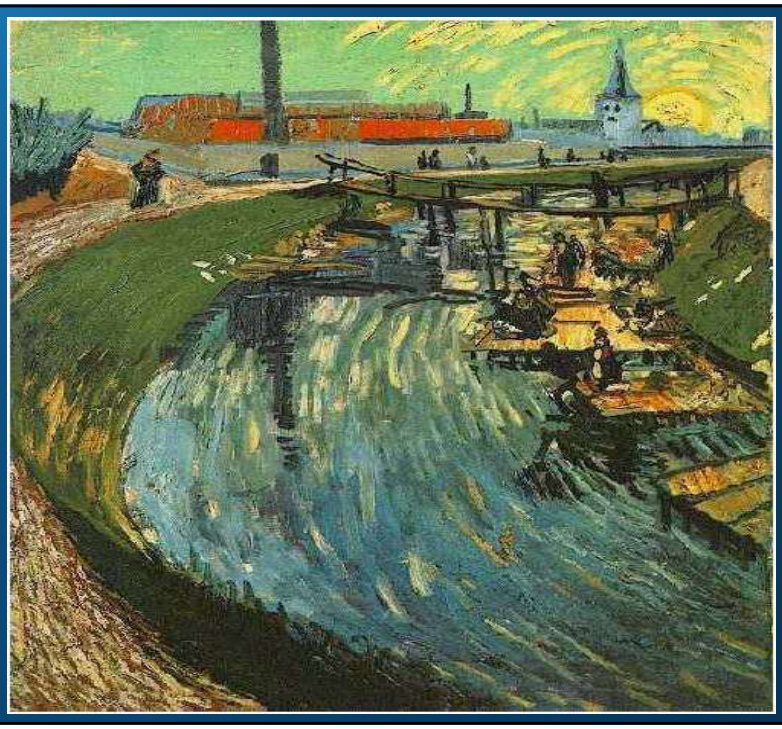

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## 35 Biological Neural Nets

- Pigeons were able to discriminate between Van Gogh and Chagall
  - With 95% accuracy on train set (when presented with pictures they had been trained on)
  - Discrimination, still 85% successful for previously unseen paintings of the artists

- Pigeons do not simply memorise the pictures
- They can extract and recognise patterns (the 'style')
- They generalise from the already seen to make predictions

- This is what neural networks (biological and artificial) are good at (unlike conventional computer)



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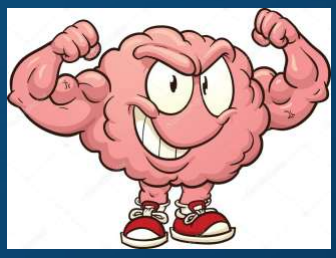
## 36 Brain and Machine

- The Brain
  - Pattern Recognition
  - Association
  - Complexity
  - Noise Tolerance



- The Machine
  - Calculation
  - Precision
  - Logic



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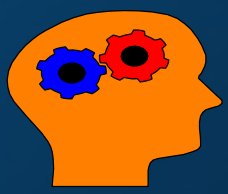
## The contrast in architecture

- The Von Neumann architecture uses a single processing unit;
  - Tens of millions of operations per second
  - Absolute arithmetic precision

- The brain uses many slow unreliable processors acting in parallel





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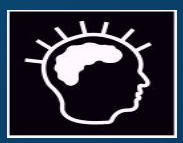
## The biological inspiration

- Features of the Brain
  - Ten billion ($10^{10}$) neurons
  - On average, several thousand connections
  - Hundreds of operations per second
  - Die off frequently (never replaced)
  - Compensates for problems by massive parallelism



- The brain has been extensively studied by scientists
- Vast complexity prevents all but rudimentary understanding
- Even the behavior of an individual neuron is extremely complex
- Single “percepts” distributed among many neurons

- Localized parts of the brain are responsible for certain well-defined functions (e.g. vision, motion).



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