Important Notes

- Failed Modules (Contact lecturers for repeat course work)

- There are 2 electives :

  Robotics and Autonomous Systems (COMP9069)

  Machine Vision (COMP9074) [Online Only]

- Final date for enrollment in elective module is Friday Feb 7th

- Reminder of Plagiarism

- Advice on Project

  Project is 15 credits, worth 25% of your overall grade (same as 3* 5 credit modules!).

  Meet with your supervisor each week.

  No classes on Friday (Should aim to devote at least 2 days to project work)

CRNs

BLOCK	CRN	CRED	MODULE	MODULE DESC	M/E
KARIN_9_Y5	**27381**	15	COMP9068	AI Research Project	M
KARIN_9_Y5	**27380**	5	COMP9057	Decision Analytics	M
KARIN_9_Y5	**27379**	5	COMP9067	Deep Learning	M
KARIN_9_Y5	**27382**	5	COMP9069	Robotics and Autonomous Systems	E
KARIN_9_Y5	**28569**	5	COMP9074	Machine Vision (Online Only)	E

CORK INSTITUTE OF TECHNOLOGY
INSTITIÚID TEICNEOLAÍOCHTA CHORCAÍ

Deep Learning

Deep Learning

Lecture: Introduction

Ted Scully

Contents

- Recap of Important Concepts from Practical ML
- Overview of Deep Learning Module
- A Brief History of AI and the Emergence of Deep Learning
- Introduction to Deep Learning
- Reasons for Success

Practical ML Recap - ML Process

Machine learning (ML) provides a means by which programs can infer new knowledge from observational data.

Practical ML Recap - ML Process

Data Exploration

Understand the feature data

Visualization (boxplots, scatter plots, correlations matrix,) etc

Data Preprocessing

Feature encoding (encoding categorical features) and feature selection

Feature scaling, Dealing with missing values, outliers

Handling data imbalance

Building and Evaluating Models

Train many models from different categories and evaluate performance

Debug if necessary

Optimization

Perform hyper-parameter optimization

Try ensembles

Assess unbiased generalization capability of a model

Practical ML Recap – Evaluation Methodology?

1. Train, Test and Validation Set

Practical ML Recap – Evaluation Methodology?

2. Cross Validation (Nested cross fold validation)

You will notice that much of the time Deep Learning models using the train, test, validation. It is less common to use cross fold validation. Why do you think this might be?

Evaluation Metrics

Classification

1. Accuracy
2. Confusion Matrix
3. Precision (TP/(TP+FP)), Recall (TP/(TP+FN)), F1 Score, etc

Evaluation Metrics

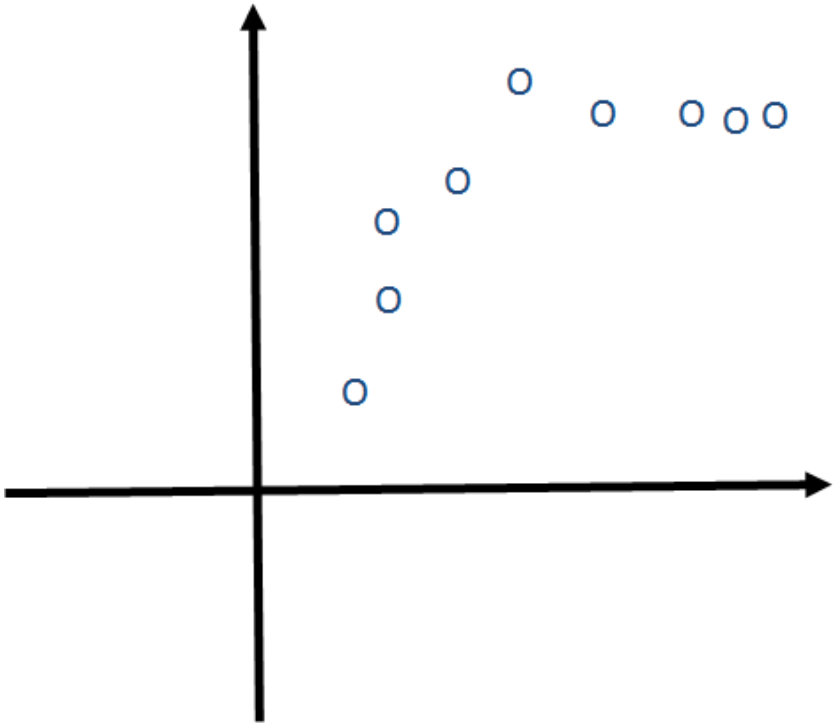
Regression Metrics

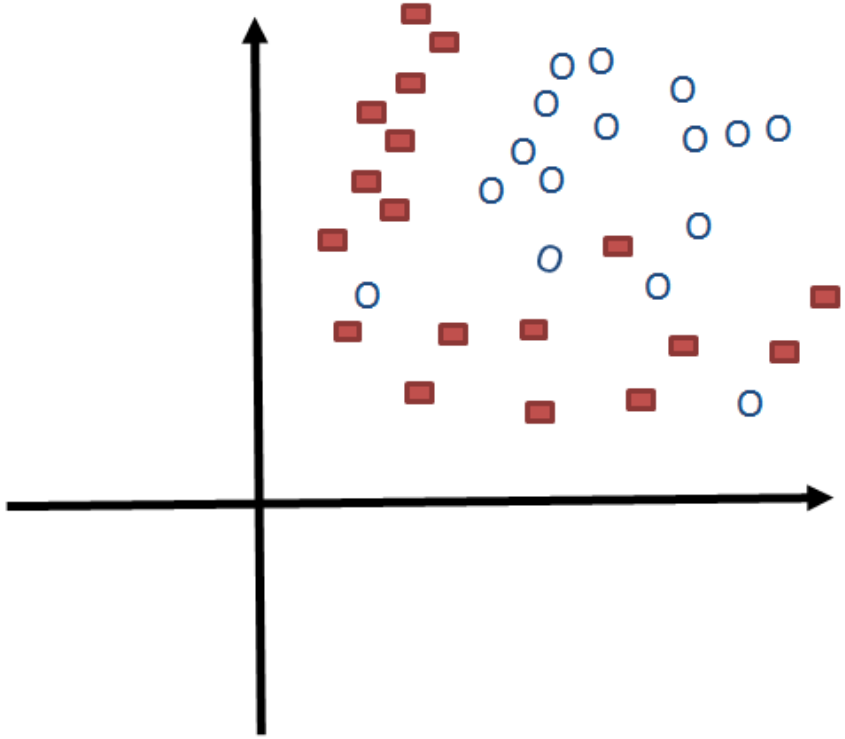
1. MSE
2. RMSE
3. MAE
4. R Squared

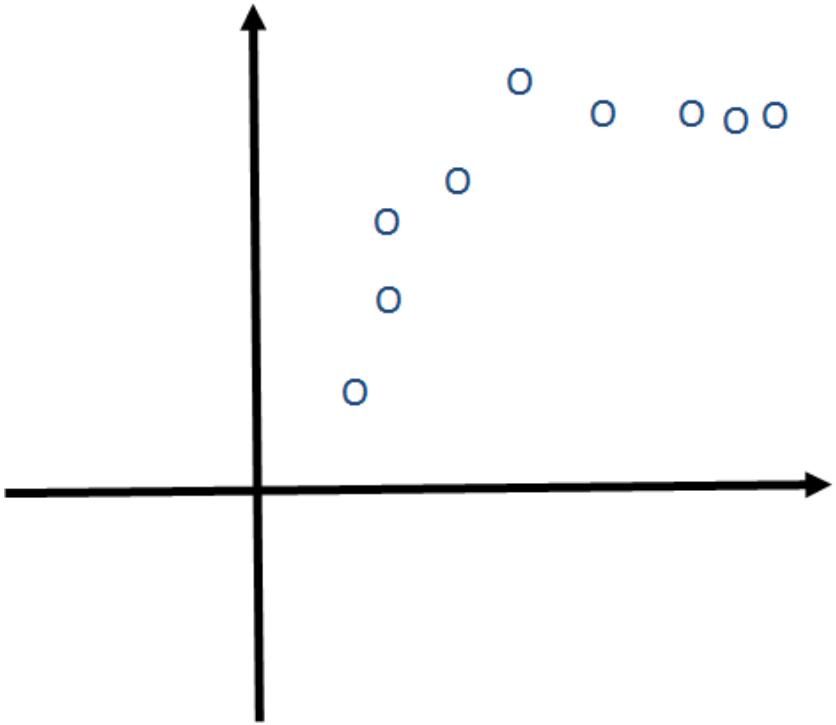
Practical ML Recap - Overfitting

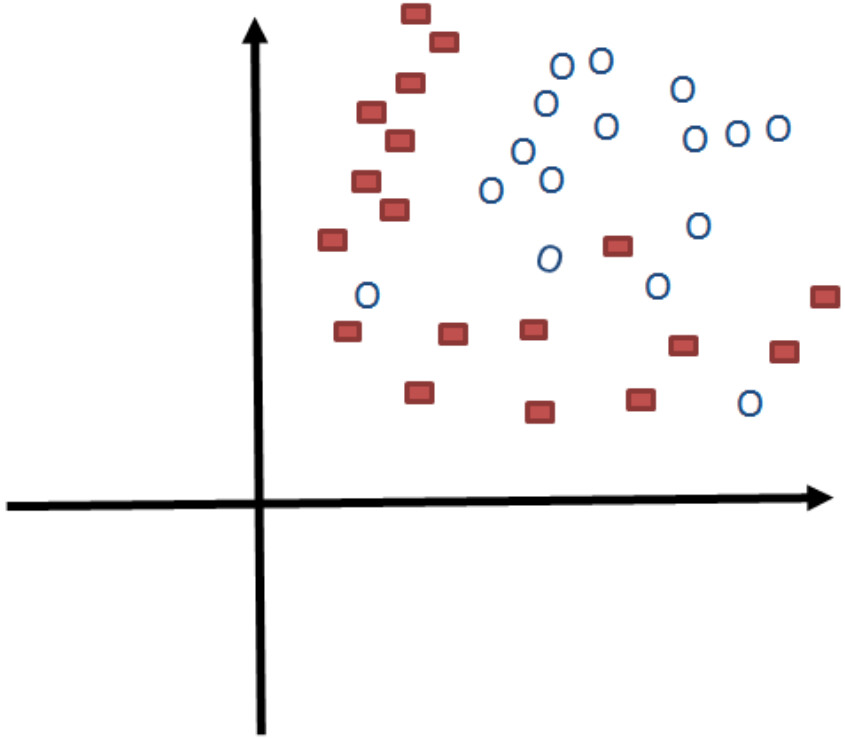
Overfitting generally occurs when a model/**function is excessively complex**, such as having too many parameters relative to the number of labelled training data.

A model/**function which has been overfit will generally have poor predictive performance (it doesn't generalize well to unseen examples)**.









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Deep Learning Content

The indicative content of the module is as follows:

- Regression and Gradient Descent.
  - Introduction to linear regression and gradient descent. Multiple linear regression and metrics for evaluating regression models. Logistic regression and activation functions. Using a vectorized implementation.

- Build and evaluate deep neural networks.
  - Build and train shallow neural networks. Key parameters for neural networks. Create and train a fully connected deep learning model. Initialization, L2 and dropout regularization, batch normalization. Convergence algorithms.

Deep Learning Content

The indicative content of the module is as follows:

- Convolutional neural network.
  - Overview of convolutional neural networks. Methodology for stacking layers in a deep network to address multi-class image classification problems. Object detection and image segmentation.

- Generative Adversarial Models.
  - Overview of training generator and discriminator. Implementation of GAN for image generation.

- Recurrent Neural Networks (RNNs).
  - LSTM (long short-term memory) unit. Overview of the GRU (gated recurrent unit). Build and train recurrent neural networks.

Deep Learning Content

Assessments

- Implementation based assessment. Perform a comparative analysis between a basic gradient descent-based machine learning model and a deep learning neural network applied to a dataset from a specific application domain **(50%)**.
- Build and train a convolutional or recurrent neural network and apply to a dataset from a specific application domain. A comprehensive evaluation should be completed **(50%)**.

Resources

- DL moves very quickly but the following book resources are useful references:
- Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow: Concepts, Tools, and Techniques to Build Intelligent Systems. Aurelien Geron
- Deep Learning with Python – Francois Chollet (2017) – Focused on use of Keras and a little older.
- Deep Learning (Ian Goodfellow and Yoshua Bengio). Available here and here.

- There are also excellent video lectures on deep learning. The two I recommend are by:
- Stanford Computer Vision
- Andrew Ng – Deep Learning

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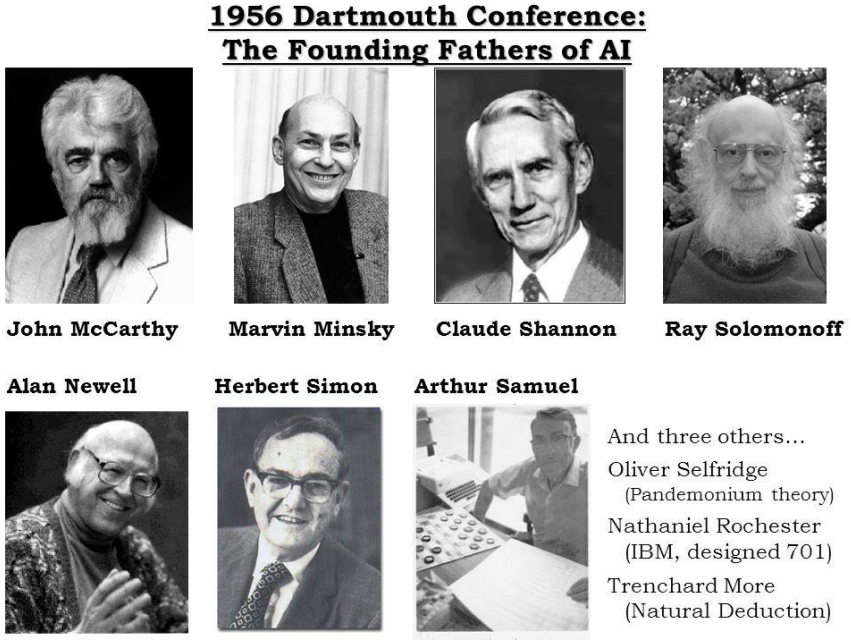
A brief history of AI

1. Many consider the famous **Dartmouth Summer Research Project** of the 1950s to be the birthplace of artificial intelligence.
2. The workshop was organized by John McCarthy and was attended by a number of influential academics such as Marvin Minsky and Claude Shannon.
3. The objectives from the meeting included the following statement: “The study is to proceed on the basis of the conjecture that every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it.”
4. After the Dartmouth conference an era of discovery and advancement. Programs were developed to solve algebra problems, prove theorems, play checkers etc.
5. There was widespread optimism, which was fed by many of the high profile researchers.
6. In 1967 Marvin Minsky famously stated “**Within a generation ... the problem of creating 'artificial intelligence' will substantially be solved**.”

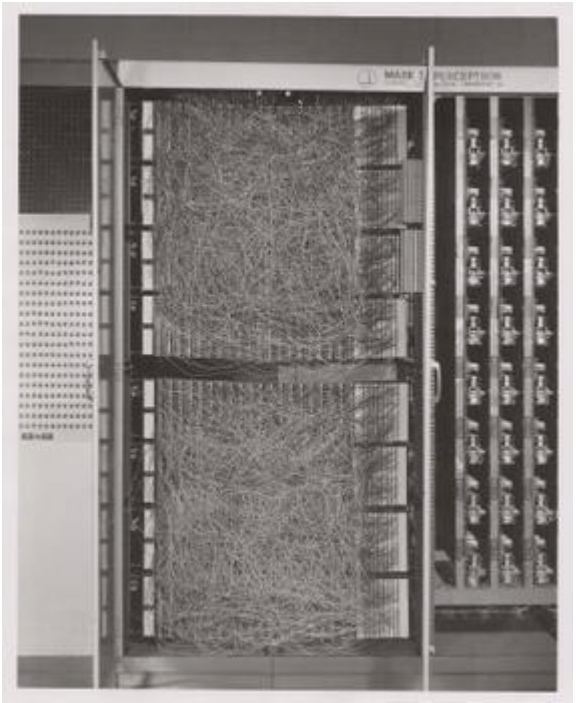


A brief history of AI

- In 1958, Frank Rosenplatt created the perceptron learning algorithm, the simplest type of neural network with only one layer of neurons connecting inputs to outputs.

- On the right is the first implementation of a perceptron called the Mark I that was able to recognise tiny images 20*20 pixels.

- The New York Times sensationally reported the perceptron to be “the embryo of an electronic computer that … will be able to walk, talk, see, write, reproduce itself and be conscious of its existence.”

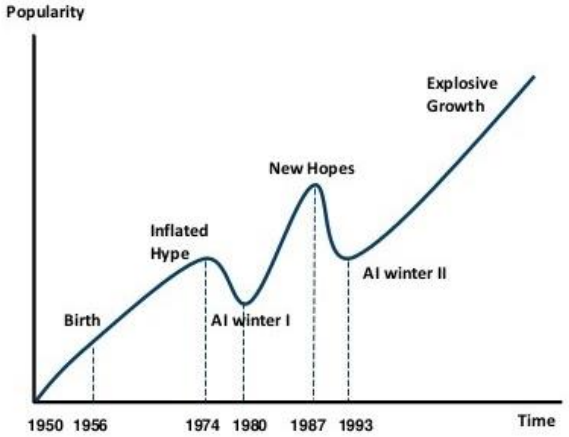


A brief history of AI

- In the 1970s, AI applications had not lived up to the incredible **hype**.
- In 1973, the UK Science Research Council criticised the failure of AI to achieve its “grandiose objectives” and noted that “in no part of the field have the discoveries made so far produced the major impact that was then promised.”

- AI researchers and media had raised unrealistic expectations and when they could not deliver funding for AI-based project effectively dried up.

- At the same time, research work on neural nets was shut down almost completely for 10 years by Marvin Minsky's devastating criticism of perceptrons.
- AI researchers at the time did not fully grasp the complexity of solving problems such as machine vision (Moravec's paradox).
- Also researchers at this time also faced real difficulties due to limited processing power and memory.
- This lack of progress led to what is now referred to as the first AI winter, which occurred around 1974.



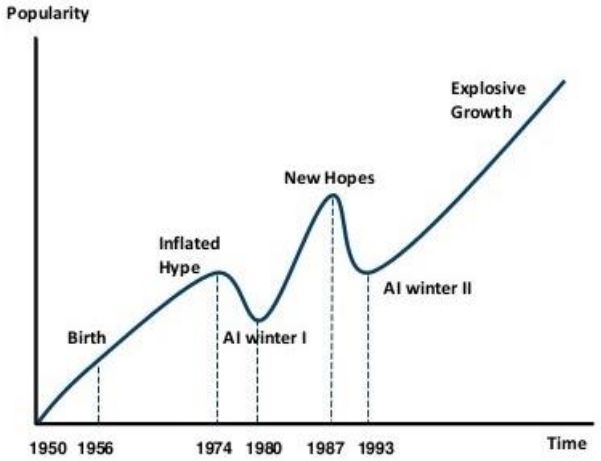
A brief history of AI

- In the **1980s** AI was revived through the use of knowledge representation and "**expert systems**" which were widely adopted by global industry.

- Some very significant advances were made during this time by Geoffrey Hinton and David Rumelhart who applied **back propagation** for training multi-layer neural networks (this still underpins modern neural networks).

- AI experienced renewed optimism. Funding again began to flow back into AI projects.

- Unfortunately this revival was short lived. Expert systems proved to be **difficult to maintain** and again the high expectations of the public and industry were not met. Funding was again cut and AI slipped into a second winter around 1987.

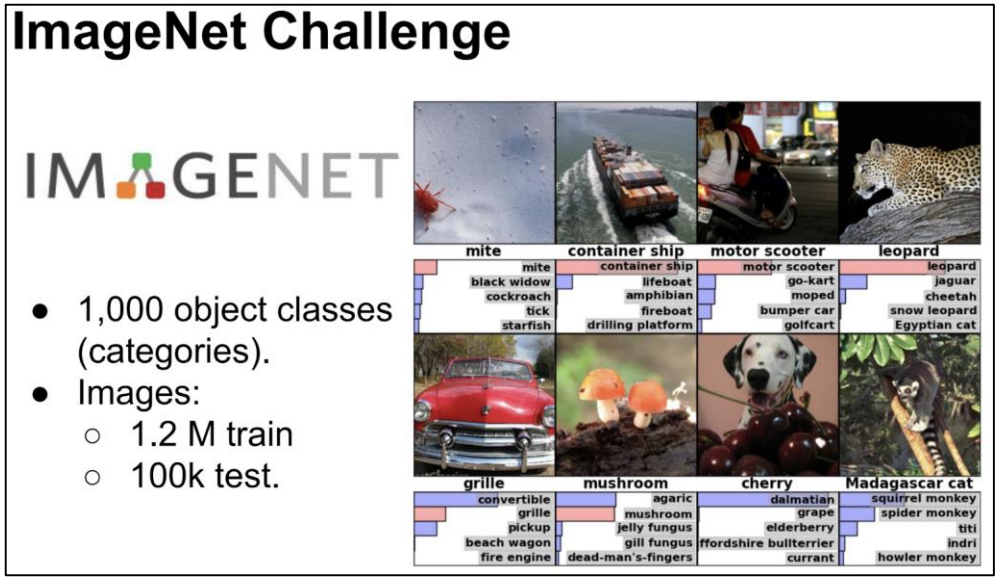


A brief history of AI

- AI began it's most recent revival in the late 1990s.
- In 1997, Deep Blue became the first computer chess-playing system to beat a reigning world chess champion, Garry Kasparov.
- In 2005, a Stanford self-driving car won the DARPA Grand Challenge by driving autonomously for 131 miles along an unrehearsed desert trail.
- In February 2011, in a Jeopardy! quiz show exhibition match, IBM's question answering system, Watson, defeated the two greatest Jeopardy! Champions.
- It's also interesting to note that during these years AI techniques quietly appears in a range of different application areas from **Google search**, **logistics**, **recommender systems, reinforcement learning** etc.
- Around 2010, **neural networks were still mostly ignored** by the scientific community at large, a number of people still working on neural networks started to make important breakthroughs.

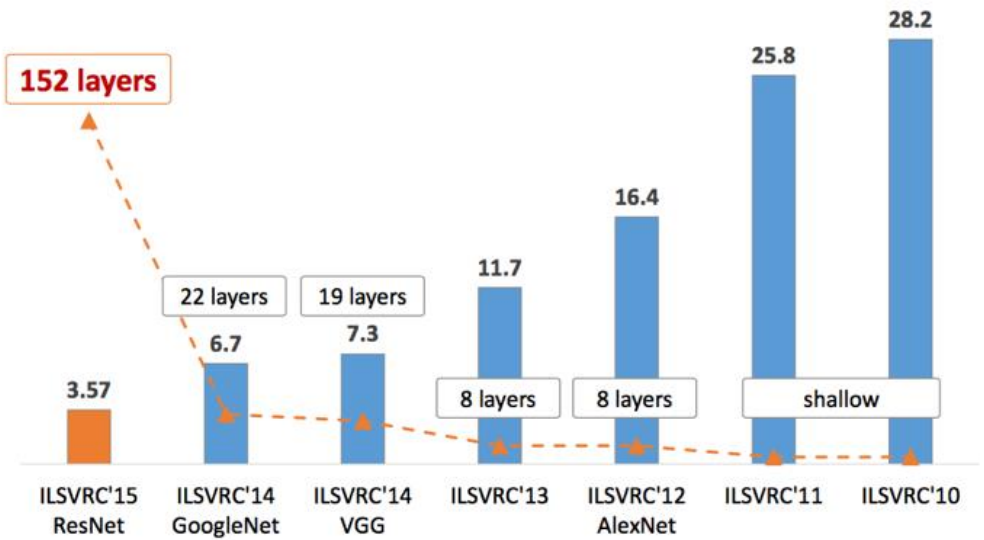
ImageNet

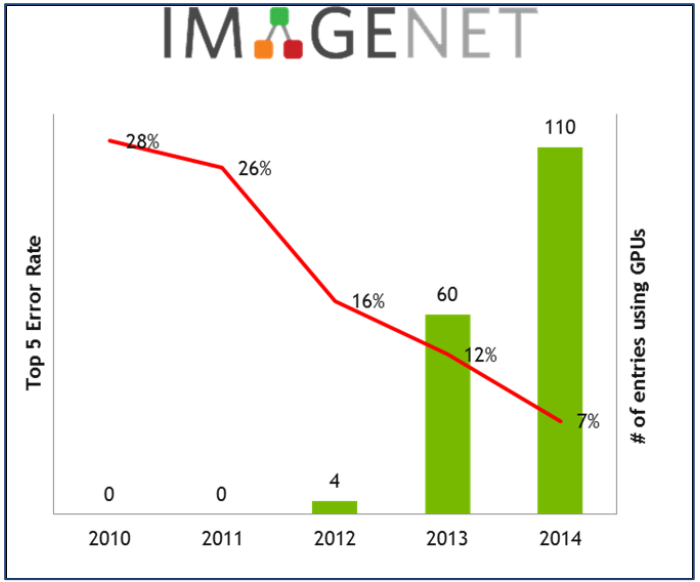
- Since 2010, the ImageNet project ran an annual software contest, the ImageNet Large Scale Visual Recognition Challenge (ILSVRC), where software programs compete to correctly classify and detect objects and scenes.
- In 2012 a submission called AlexNet, which was a deep learning convolutional neural network, achieved a top-5 error of **16%,** more than **10.8** percentage points ahead of the runner up.
- This was a seminal moment and grabbed world wide attention.
- As of Jan 2020 the AlexNet paper has been cited over 55,000 times.



ImageNet Challenge

- GoogLeNet (also called Inception V1) won the ImageNet competition in 2014.
- ResNet won in 2015 ResNet won the ILSVRC 2015 competition with an unbelievable 3.57% error rate (**human performance is 5-10%**).





Deep Learning

- In the past few years deep neural networks have made incredible progress.
- In particular, deep learning has achieved the following breakthroughs, all in historically difficult areas of machine learning:
  - Near-human-level image classification.
  - Near-human-level speech recognition (Google reduced speech recognition error rate by over 30% since 2012).
  - Improved machine translation (By 2016 MS, Google, IBM all used deep neural networks for machine translation)
  - Near-human-level autonomous driving (deep learning is core to autonomous driving, perception, route planning and behaviour arbitration)
  - Face Recognition (In 2014 facebook researchers published deepface, a deep learning based system for face recognition. It achieved of 97.35% on the Labeled Faces in the Wild (LFW) dataset, reducing the previous best error rate by more than 27%, closely approaching human-level performance.)
  - Improved ad targeting (According to Microsoft researchers a 0.1 increase in accuracy in ad-targeting can yield millions in additional revenue)

Reality v’s Hype

“Artificial Intelligence is the new electricity” - Andrew Ng

“AI doesn’t have to evil to destroy humanity” – Elon Musk.

Red C survey finds 39% worried that robots or artificial intelligence will take over their work.

Expectations (and fears) for what the field of AI will be able to achieve in the next decade tend to run much higher than what will likely be possible.

Many goals will likely remain elusive for a long time, such as believable dialogue systems and human-level machine translation. In particular claims of human-level general intelligence should not be taken seriously.