Engineering Institute of Technology.

Watch Seminar Recording Here

Transforming Engineering with AI

Presented by the Dean, Dr Steve Mackay

The Dean - Dr Steve Mackay

FIE(Aust) CPEng GCC BSc(ElecEng), BSc(Hons), MBA, MMR, PhD

Engineering Institute of Technology.

Steve has 40 years of engineering experience across four continents - in electrical, mechanical, chemical and industrial automation - and in a range of industries: mining, oil and gas, building, power plants and industrial software.

He is a chartered professional electrical, mechanical and chemical engineer.

His curiosity and love of learning helps him stay abreast of the exciting and ever-changing developments in engineering and science.

An Overview: 1991 – 2023

IDC Technologies and the Engineering Institute of Technology

1. We are a dual sector engineering education and training provider, with a global reach.
2. We have clearly articulated engineering qualifications - from diplomas through to a doctoral degree.
3. Our teaching and learning is industry-driven.
4. Our micro-credentials provide professional development. They can also be run (and customized) for groups of employees on worksites (or online).
5. Our platforms of learning: face-to-face and online. (The blended, online methodology of learning is live and interactive; it was launched in 2008.)
6. We run engineering conferences in Australia, NZ, South Africa, the UK and Canada…. And now virtually too.
7. We have global partnerships and accreditation - from IEEE to ISA.

Our Approach

Engineering Institute of Technology.

Online Learning
Synchronous, online learning results in good, globally composite class sizes and suppresses attrition rates.

Student Support
Lecturers, online students, and those based on campus have dedicated Learning Support Officers (LSOs).

Research
Research and on-going monitoring helps EIT to continuously improve.

Lecturers/Instructors
Selected from around the world for their sound industry experience

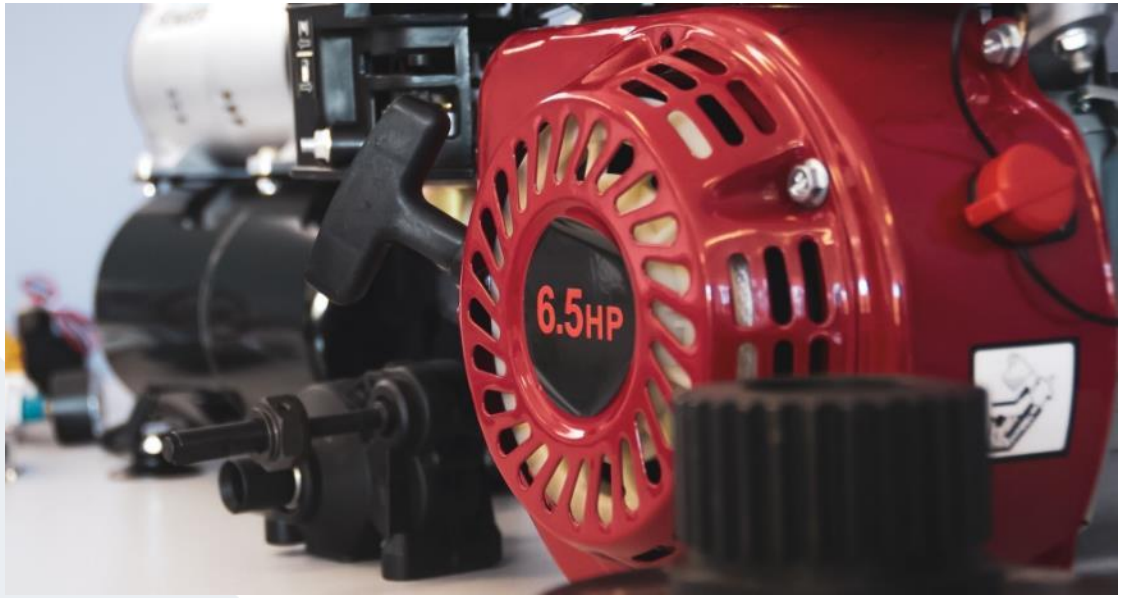
Industry Input
EIT qualifications are driven by industry to prepare students for the workplace.

Libraries
EIT students have access to substantial online libraries.

Labs
EIT students access high quality and realistic virtual and remote labs for their applied learning, and physical labs for on-campus.

Value for Money
Students get value for money with competitive fees and careful international pricing.

Physical, Remote and Virtual Labs



- **Stimulating experiments –** virtual labs.
- **Remotely operated plants –** remote labs.
- **Engineering education 4.0** – the traditional lab with an innovative twist.

The accurate representation of **current industry practice**

- **High availability and asynchronous** – anytime.
- Access to **specialized equipment in a safe and near-limitless testing environment**.
- **No geographical barriers** with diverse and global teams.

Student Experience Survey Results

Engineering Institute of Technology.

#1 Provider in Australia for Quality of Entire Educational Experience for Undergraduate Engineering Programs*

#2 Provider in Australia for Student Support for Undergraduate Engineering Programs*

#2 Provider in Australia for Teaching Quality for Postgraduate Engineering Programs*

Ranked in the **Top 6** Providers in Australia for Skills Development for Postgraduate Engineering Programs*

**2019/2020 aggregated data from the Student Experience Survey - qilt.edu.au*

QILT
Quality Indicators for Learning and Teaching

Agenda

1	Today’s objective
2	Why we need to apply Artificial Intelligence (AI)
3	AI versus Machine Learning
4	Essentials of AI and ChatGPT
5	Demonstrations of AI at EIT
6	Case Studies
7	Wrap Up

1. Today's Objective

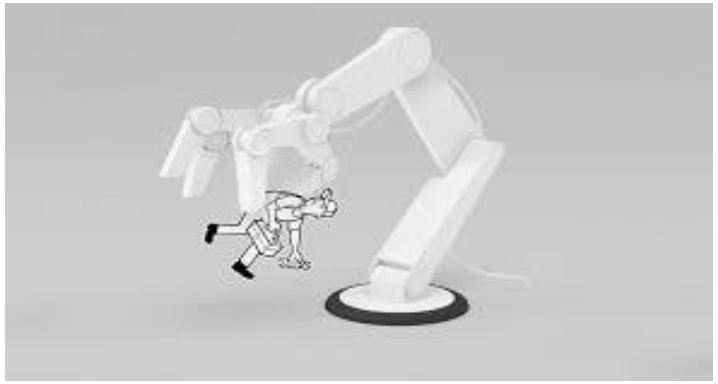
My focus:

Explore how Artificial Intelligence (AI) and Machine Learning (ML) are being harnessed by industry and how these technologies can empower you to drive change in a sustainable ways in engineering.

Our focus:

- Power
- Water

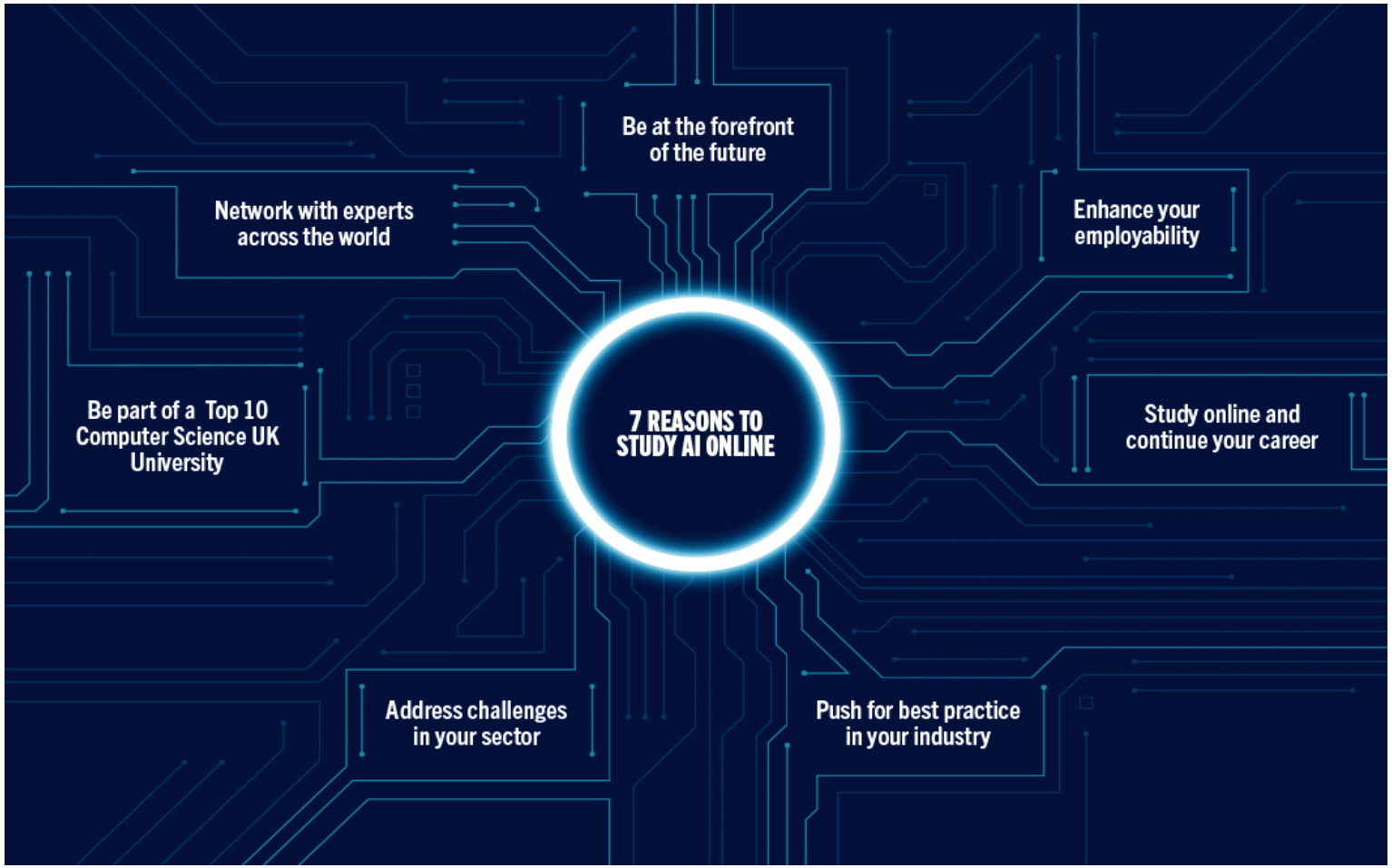
You will be broken into groups and each group will be allocated a case study.



Your mission:

- To explain how you will tackle your allocated scenario sustainably
- To outline how you will use AI and ML to improve efficiencies.

2. Why we need to apply AI

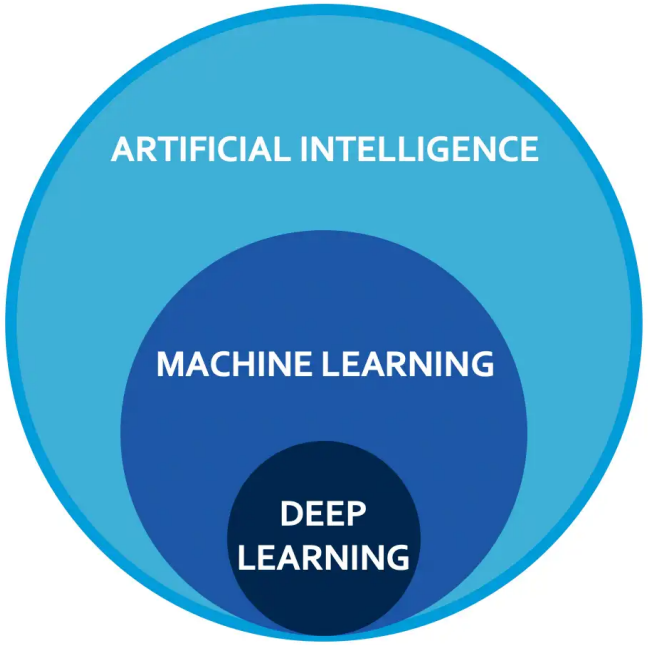


Acknowledgement to University of Leeds Promotional Poster

“We are continually faced by great opportunities brilliantly disguised as insoluble problems”

- Lee Lacocco

3. AI vs Machine Learning



Artificial Intelligence
The science of making machines smarter, which in turn augments human knowledge and capabilities.

Machine Learning
Application of artificial intelligence (AI) that provides systems the ability to automatically learn and improve from experience.

Deep Learning
The next generation of machine learning that employs multiple layers of learning from massive data-sets.

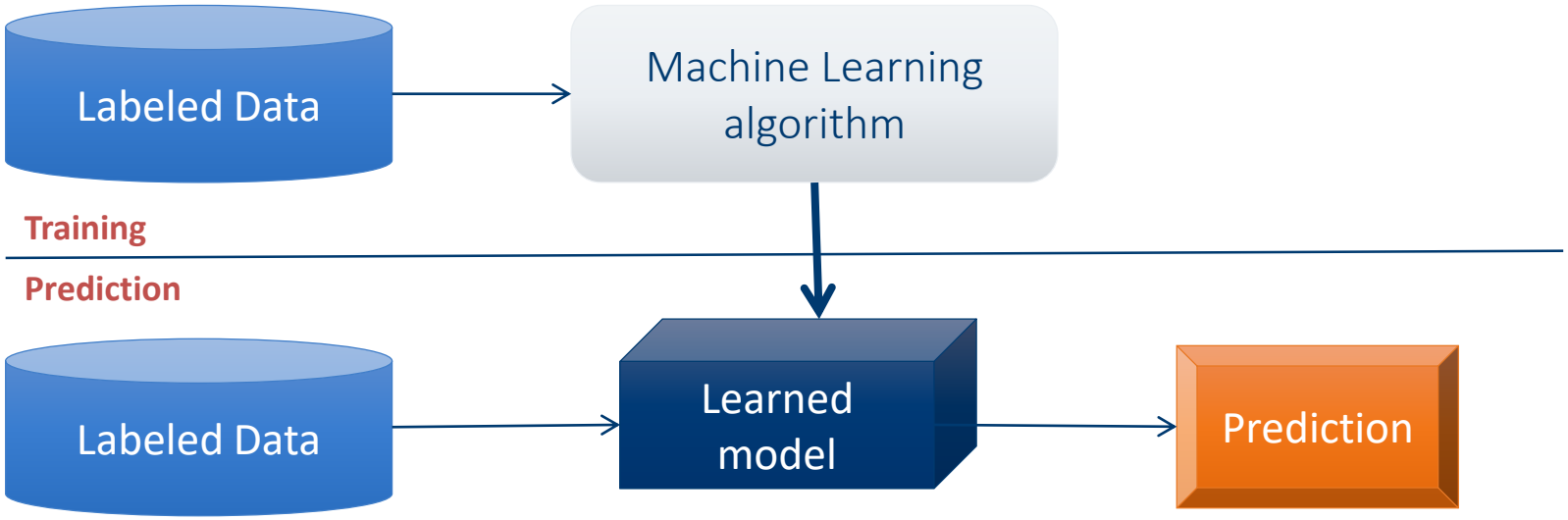
Chatbots and Conversational AI
AI Natural language processing and deep learning helps give users factoids based on their queries

*Chatbots such as **ChatGPT** produce text like output*
The next generation of Conversational AI may include voice

BRIGHTEDGE

Machine Learning Basics

Artificial Intelligence is a scientific field concerned with the development of algorithms that allow computers to learn without being explicitly programmed. **Machine Learning** is a branch of Artificial Intelligence which focuses on methods that learn from data and make predictions on unseen data.



Acknowledgement to University of Idaho: CS404/504 - Picture from: Ismini Lourentzou – Introduction to Deep Learning

Machine Learning Types

Supervised: learning with labeled data

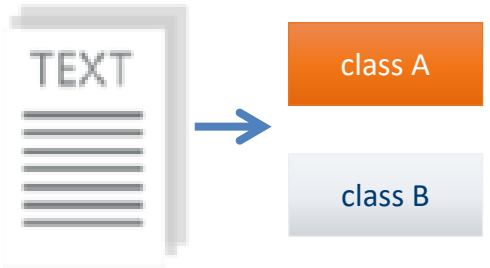
- Example: email classification, image classification
- Example: regression for predicting real-valued outputs

Unsupervised: discover patterns in unlabeled data

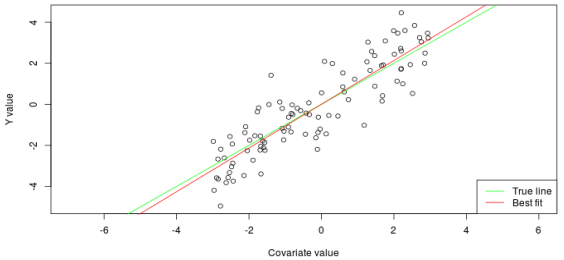
- Example: cluster similar data points

Reinforcement learning: learn to act based on feedback/reward

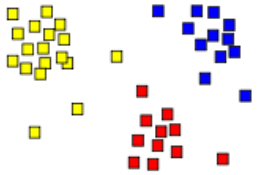
- Example: learn to play Go



Classification



Regression



Clustering

Acknowledgement to University of Idaho: CS404/504 - **Slide credit: Ismini Lourentzou – Introduction to Deep Learning**

Supervised Learning

Supervised learning categories and techniques

Numerical classifier functions

- Linear classifier, perceptron, logistic regression, support vector machines (SVM), neural networks

Parametric (probabilistic) functions

- Naïve Bayes, Gaussian discriminant analysis (GDA), hidden Markov models (HMM), probabilistic graphical models

Non-parametric (instance-based) functions

- k-nearest neighbors, kernel regression, kernel density estimation, local regression

Symbolic functions

- Decision trees, classification and regression trees (CART)

Aggregation (ensemble) learning

- Bagging, boosting (Adaboost), random forest

Acknowledgement to University of Idaho: CS404/504 - **Slide credit: Y-Fan Chang – An Overview of Machine Learning**

Unsupervised Learning

Unsupervised learning categories and techniques

Clustering

- k-means clustering
- Mean-shift clustering
- Spectral clustering

Density estimation

- Gaussian mixture model (GMM)
- Graphical models

Dimensionality reduction

- Principal component analysis (PCA)
- Factor analysis

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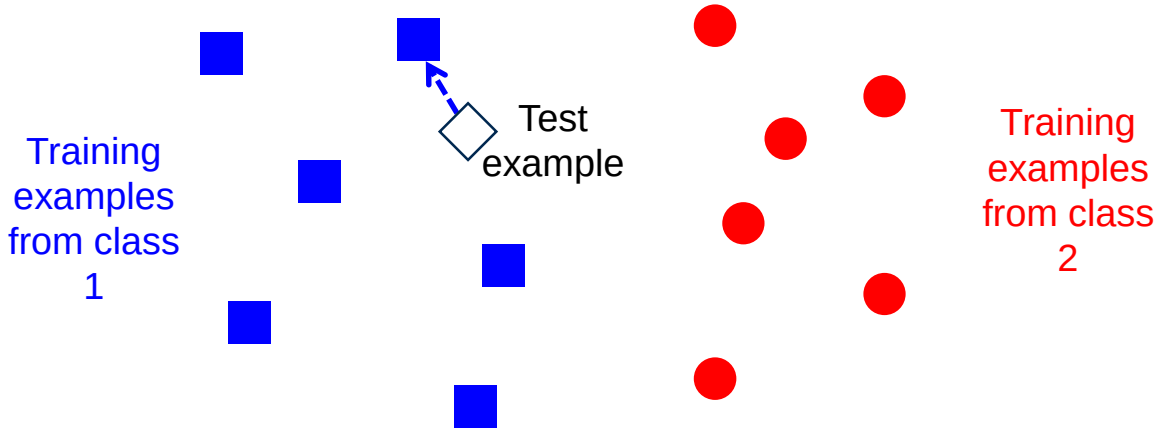
Nearest Neighbor Classifier

Nearest Neighbor – for each test data point, assign the class label of the nearest training data point

- Adopt a distance function to find the nearest neighbor
  - Calculate the distance to each data point in the training set, and assign the class of the nearest data point (minimum distance)
- It does not require learning a set of weights

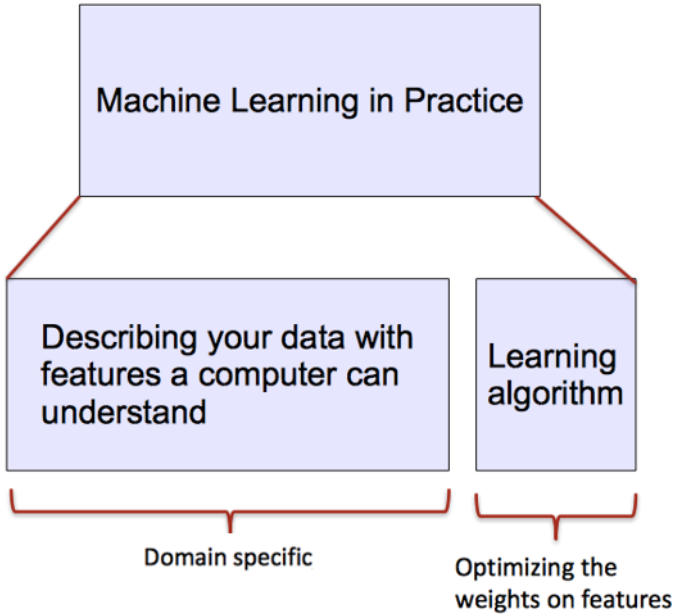


Acknowledgement to University of Idaho: CS404/504 - Picture from: James Hays – Machine Learning Overview

ML vs. Deep Learning

Conventional machine learning methods rely on **human-designed feature representations**

- ML becomes just optimizing weights to best make a final prediction

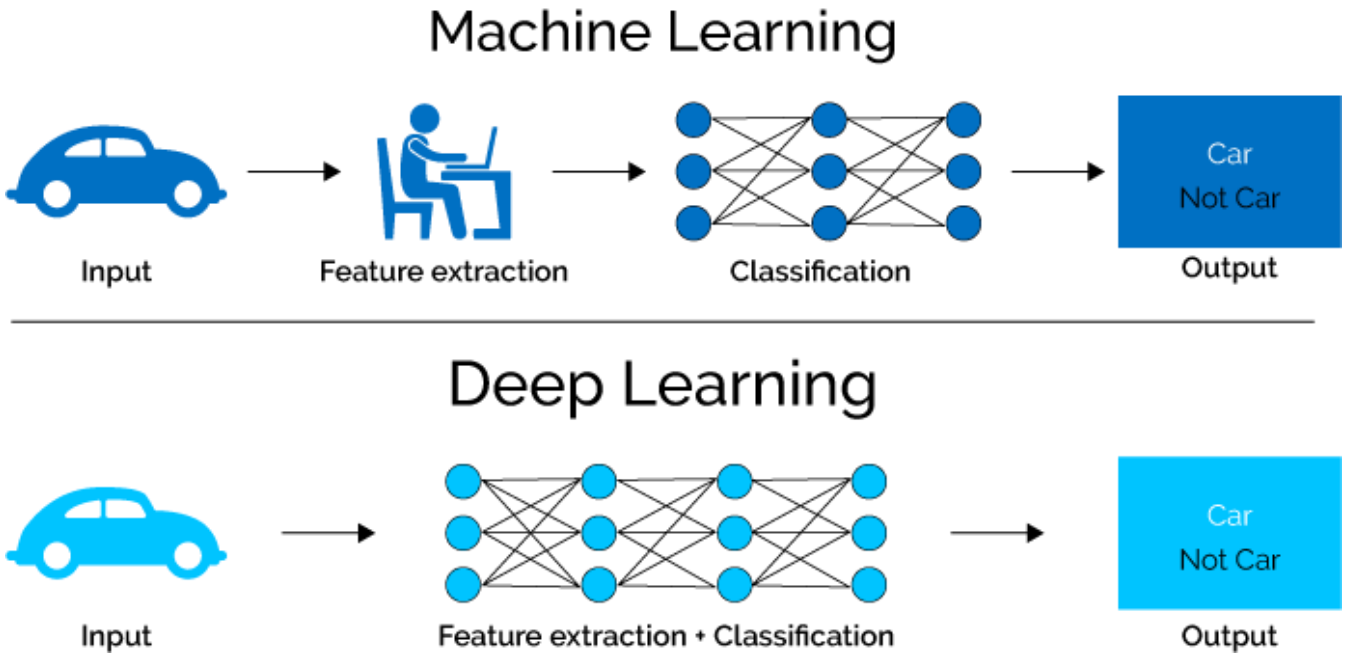


Acknowledgement to University of Idaho: CS404/504 - **Picture from: Ismini Lourentzou – Introduction to Deep Learning**

ML vs. Deep Learning

Deep learning (DL) is a machine learning subfield that uses multiple layers for learning data representations

- DL is exceptionally effective at learning patterns

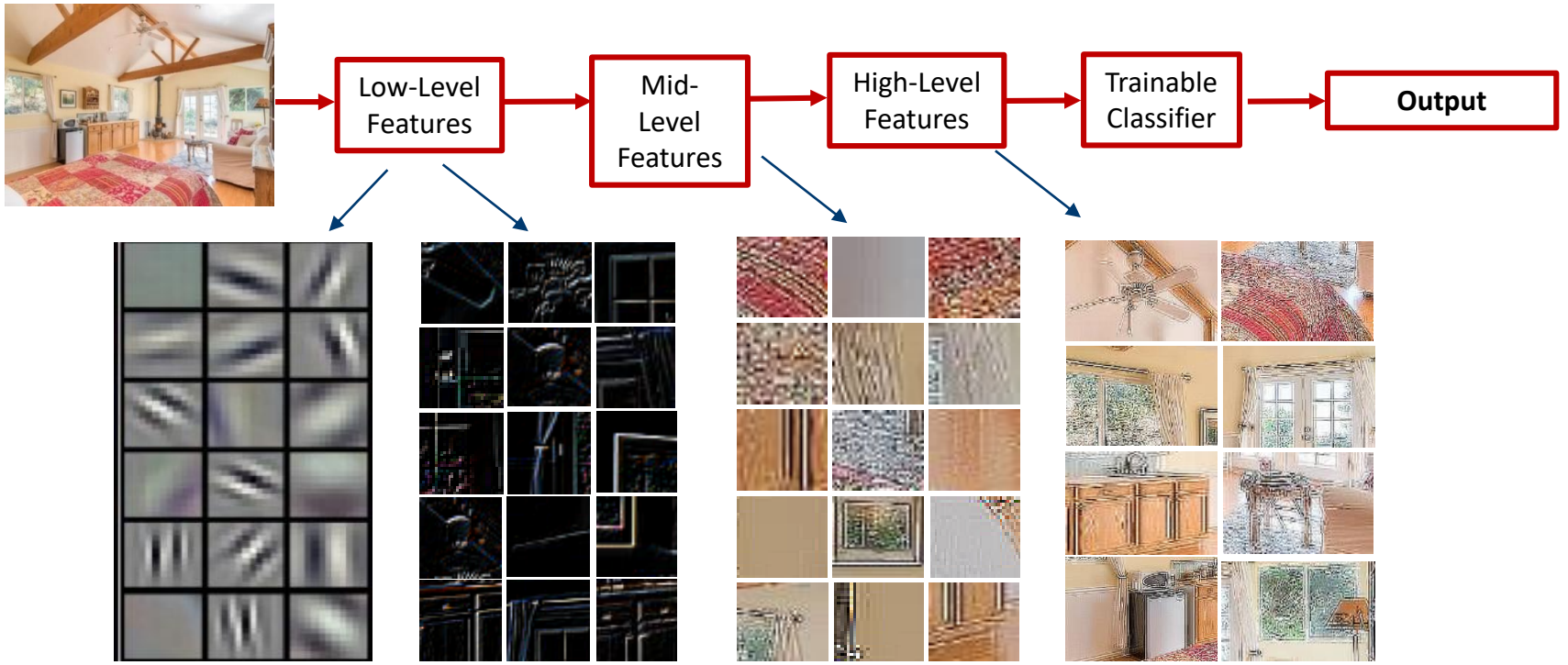


Picture from: https://www.xenonstack.com/blog/static/public/uploads/media/machine-learning-vs-deep-learning.png

ML vs. Deep Learning (DL)

DL applies a multi-layer process for learning rich hierarchical features (i.e., data representations)

- Input image pixels → Edges → Textures → Parts → Objects



Acknowledgement to University of Idaho: CS404/504 - **Slide credit: Param Vir Singh – Deep Learning**

Why is DL Useful?

DL provides a flexible, learnable framework for representing visual, text, linguistic information

- Can learn in supervised and unsupervised manner

DL represents an effective end-to-end learning system

DL requires large amounts of training data

Since about 2010, DL has outperformed other ML techniques

- First in vision and speech, then NLP, and other applications

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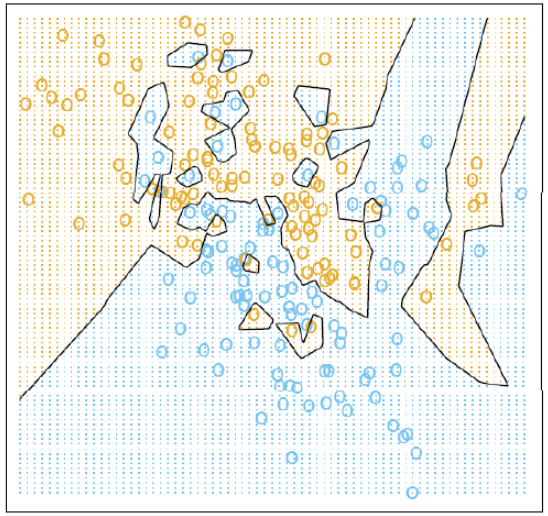
Representational Power

Neural Networks (NN), with at least one hidden layer, are **universal approximators:**

- Given any continuous function h(x) and some $\epsilon > 0$, there exists a NN with one hidden layer (and with a reasonable choice of non-linearity) described with the function f(x), such that $\forall x, |h(x) - f(x)| < \epsilon$
- I.e., NN can approximate any arbitrary complex continuous function



NNs use nonlinear mapping of the inputs x to the outputs f(x) to compute complex decision boundaries.

But then, why use deeper NNs?

- The fact that deep NNs work better is an empirical observation
- Mathematically, deep NNs have the same representational power as a one-layer NN

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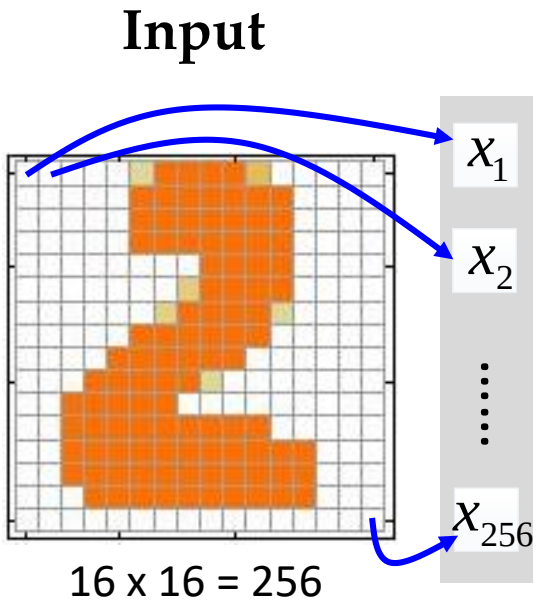
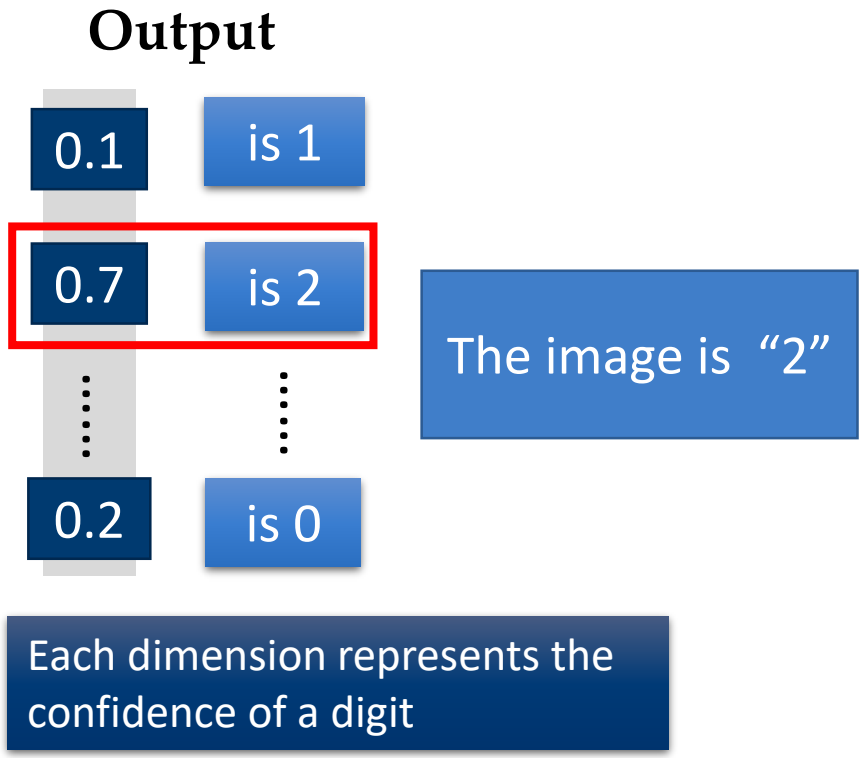
Introduction to Neural Networks

Handwritten digit recognition **(MNIST dataset)**

- The intensity of each pixel is considered an **input** element
- **Output** is the class of the digit





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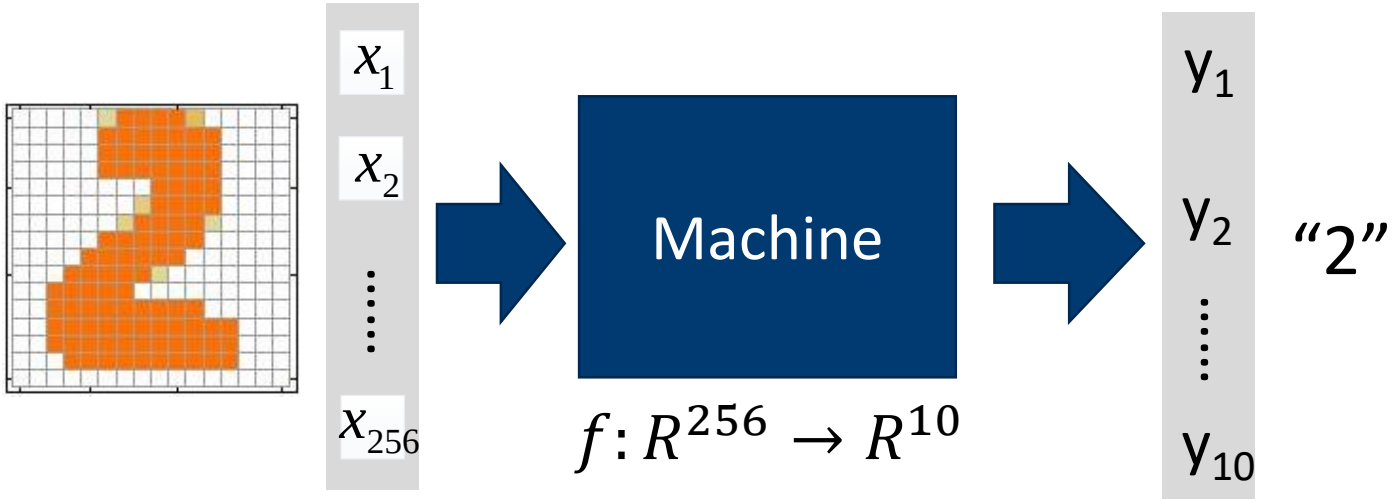
Introduction to Neural Networks

Handwritten digit recognition



The function f is represented by a neural network

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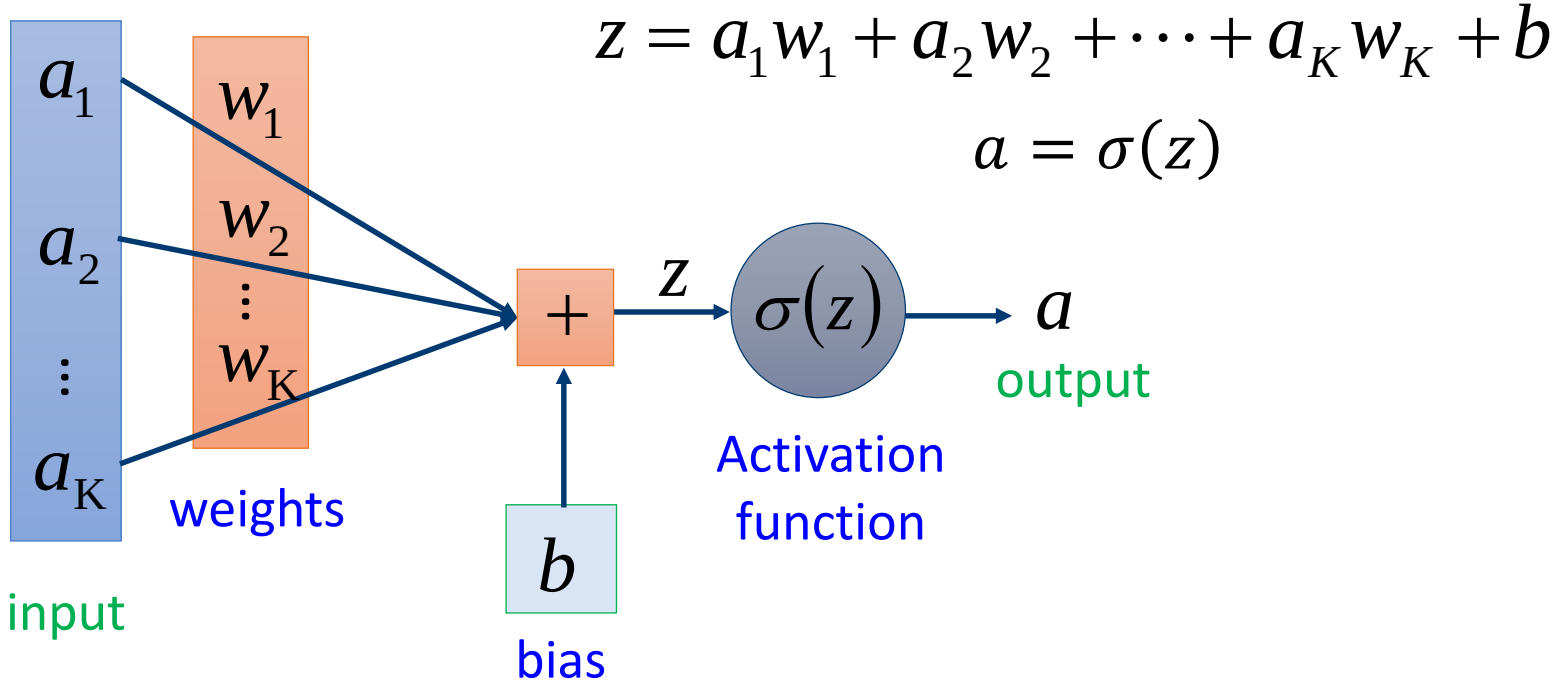
Elements of Neural Networks

NNs consist of hidden layers with neurons (i.e., computational units)
A single **neuron** maps a set of inputs into an output number, or $f: R^K \rightarrow R$



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4. Essentials of AI and ChatGPT

- ChatGPT has taken the world by storm.
- Use Prompt Engineering with it - a key technique.
- Use a human to check the results.
- Do not use it to do something we can't do ourselves.
- If you can't verify the accuracy or quality of the result; don't use ChatGPT.
- Avoid using sensitive or private data.
- Use data with the best interest of the individual and society.
- Legal ownership will play out in due course.

ChatGPT is useful

- It is great for summarizing text.
- It can remember previous discussions in a specific session.
- It saves time and money.

However:

- It is trained on data (books, articles and web sites) – BUT only up until September 2021.
- There is the potential bias in data.
- It can only cope with conversations pertaining to one topic.
- Hallucinations can occur.

ChatGPT Prompt Formula

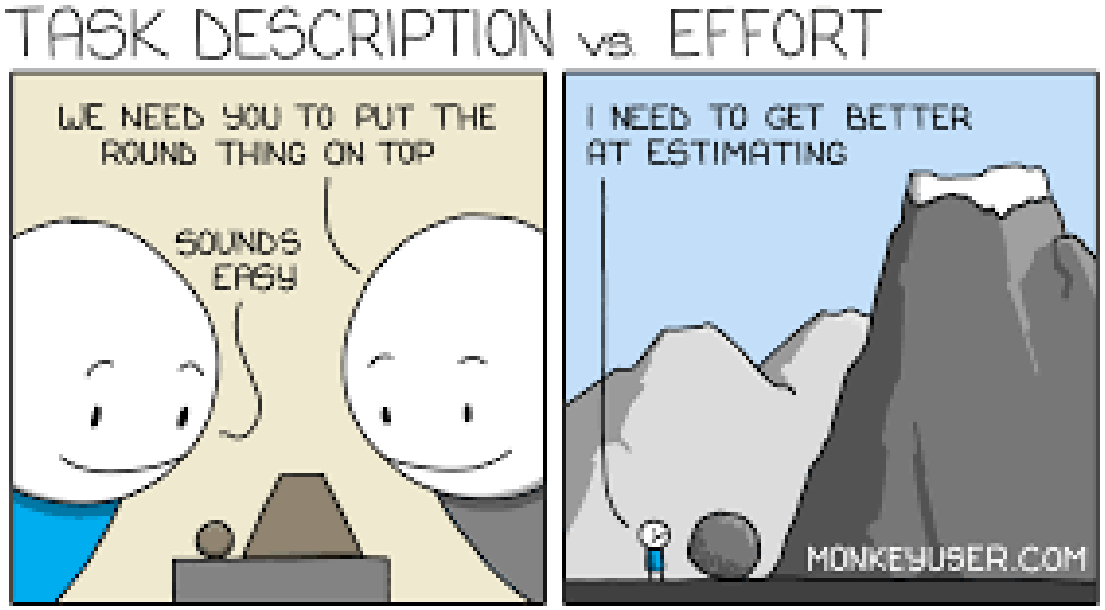
You are a top engineer in …… I want you to design the following system:

1. Recursion
2. Requirement 1
3. Requirement 2
4. Requirement 3
5. Requirement 4
6. These are the following boundary settings

Acknowledgement to Medium.com for the catchy image.

Task Description

- Be detailed and specific.
- Include all necessary information.
- Specify the desired length of the response.
- Use correct grammar and spelling.
- Do not be ambiguous or nebulous.
- Be concise.
- Provide examples.



Acknowledgement to Monkeyuser.com for the image.

System Level Boundary

- What you DO NOT want ChatGPT to do.
- Have specific constraints.

Acknowledgement to Forbes for the image.

Recursion

- Ask ChatGPT to provide a step-by-step reasoning of why it is making a particular decision.
- When asking for recursion – you tend to get far better results.

An extraordinarily simple example..1

What are the steps in building a line following robot in Arduino

ChatGPT
Building a line-following robot using Arduino involves several steps. Here's a general outline of the process:
1.Gather the necessary components:
- •Arduino board (e.g., Arduino Uno)
- •Motor driver module (e.g., L298N)
- •DC motors (2 or more)
- •Line sensor module (e.g., infrared line sensors)
- •Wheels and chassis
- •Jumper wires
- •Breadboard or PCB (Printed Circuit Board)
- •Power supply (e.g., battery pack)

2.Design the circuit:
- •Connect the Arduino board to the motor driver module using jumper wires.
- •Connect the motor driver module to the DC motors.
- •Connect the line sensor module to the Arduino board.
- •Make sure to provide appropriate power connections to all components.

3.Set up the Arduino development environment:
- •Install the Arduino IDE (Integrated Development Environment) if you haven't already.
- •Connect the Arduino board to your computer via USB.

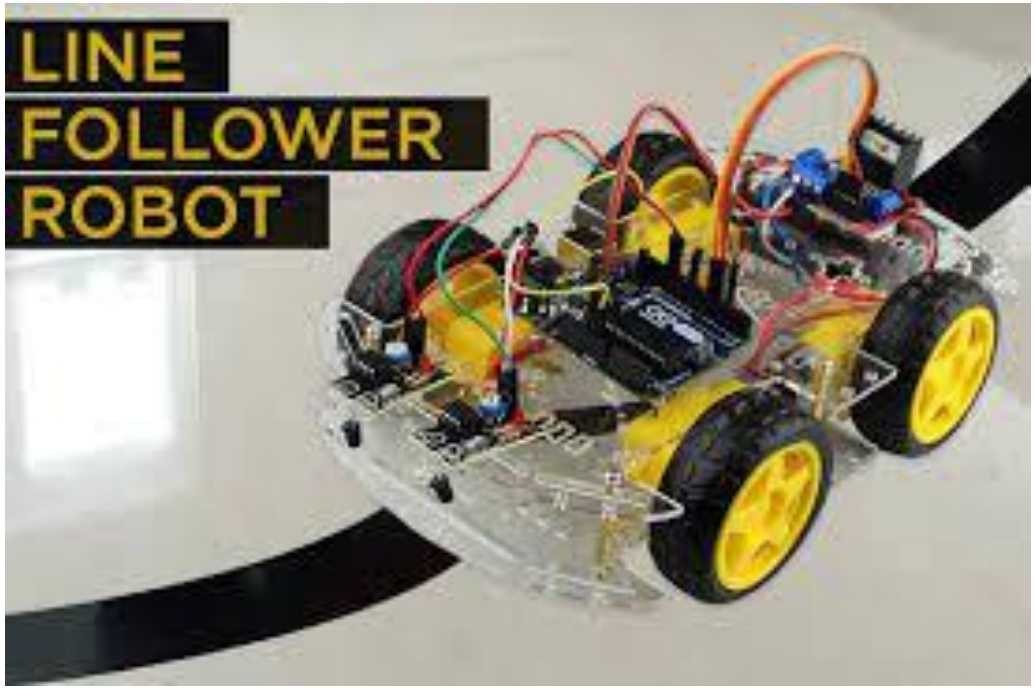
An Extraordinarily simple example …2

4.Write the code:
- •Open the Arduino IDE and create a new sketch.
- •Define and initialize the required variables and pin assignments.
- •Set up the line sensor module and motor driver module.
- •Write the main program loop:
  - •Read the line sensor values.
  - •Make decisions based on the sensor readings.
  - •Control the motors accordingly (e.g., adjust speed and direction).
  - •Repeat the loop continuously.

5.Upload the code:
- •Verify that the code does not contain any errors.
- •Select the correct board and port in the Arduino IDE.
- •Click the "Upload" button to upload the code to the Arduino board.

6.Assemble the robot:
- •Connect the motors to the wheels and attach them to the chassis.
- •Mount the line sensor module on the front of the robot.

7.Test the robot:
- •Power on the robot using the appropriate power supply.
- •Place the robot on a line or track.
- •Observe its behavior and make adjustments if necessary.



This is a general overview of the steps involved in building a line-following robot with Arduino. Depending on the specific components and design choices you make, the process may vary slightly. It's important to consult the documentation and datasheets for your specific components to ensure proper connections and functionality.

Never forget the Human

- You can never trust ChatGPT.
- Never assume everything is correct – do not expect precise and truthful responses.
- YOU - the human - are always critical; ChatGPT needs checking (unfortunately).

Acknowledgement to Wired Magazine for Graphic

ChatGPT can help Engineering Professionals as follows

Engineering Institute of Technology.

(thanks to Nirav Modha with youtube clip:7 Ways ChatGPT will help Electrical engineers)

- Answering Technical Questions e.g. electrical circuits/component budgets
- Providing simpler explanations of complex or difficult concepts in simple English
- Provide suggested solutions to difficult problems and assisting with troubleshooting
- Project management – timeslines/budgeting/scheduling
- Latest research in emerging technologies and research (but…)
- Career Development and job opportunities
- Suggestions on communicating and collaborating with other engineering professionals.

Revision on Prompt Engineering (from BusinessInsider)

(from https://www.businessinsider.com/how-to-use-get-better-chatgpt-ai-prompt-guide

- Assign a specific role to ChatGPT.
- Be specific about the task – don't confuse it with multiple tasks.
- Fine-tune the prompts.
- Provide it with context.
- Avoid long prompts – try and do it in small bites.
- Ask ChatGPT how to improve your prompts.
- Demand 100% clarity and precision.
- Rephrase – use different words to improve results.
- Use the imperative or commands rather than round-about prompts.
- Be direct – don't be obtuse.
- Use short sentences/simple English is always the best.
- Define what output you want from ChatGPT.

5. Demonstrations of AI at EIT

- Demonstrations for a course on Electrical Engineering.
- Assist instructor.
- Interact with students.
- ChatGPT is problematic – further training required – see https://www.edsurge.com/news/2023-06-22-georgia-tech-is-trying-to-keep-a-chatgpt-powered-teaching-assistant-from-hallucinating for how EIT is dealing with (lying and hallucinating) chatbots.

6. Case Studies

“Education is what remains after one has forgotten what one has learned in school”
- Albert Einstein

1. Water Resources Engineering Project

You are a top water resources civil engineer - ask ChatGPT to help you with the following design problem:

> A borehole and water treatment plant, in a remote part of South Africa, for the provision of clean water for a community of 300 people.

- Consider the specifics and the constraints of the project when formulating the design.
- Critically assess the response from ChatGPT.
- Make some suggestions for the design of the picture of the works that you have created.

2. Bridge Construction Engineering

You are a top bridge construction engineer - ask ChatGPT to help you with the following design problem:

> A bridge across a river of 30 meters wide, for a remote community in South Africa, using local materials.

- Consider the specifics and the constraints of the project when formulating the design.
- Critically assess the response from ChatGPT.
- Make some suggestions for the design of the picture of the works that you have created.

3. Solar Energy Panel Design

You are a top solar power designer - ask ChatGPT to help you with the following design problem:

> A solar panel installation, for 30kW, for a building two floors high, in Midrand, with roof panels.

- Consider the specifics and the constraints of the project when formulating the design.
- Critically assess the response from ChatGPT.
- Make some suggestions for the design of the picture of the works that you have created.

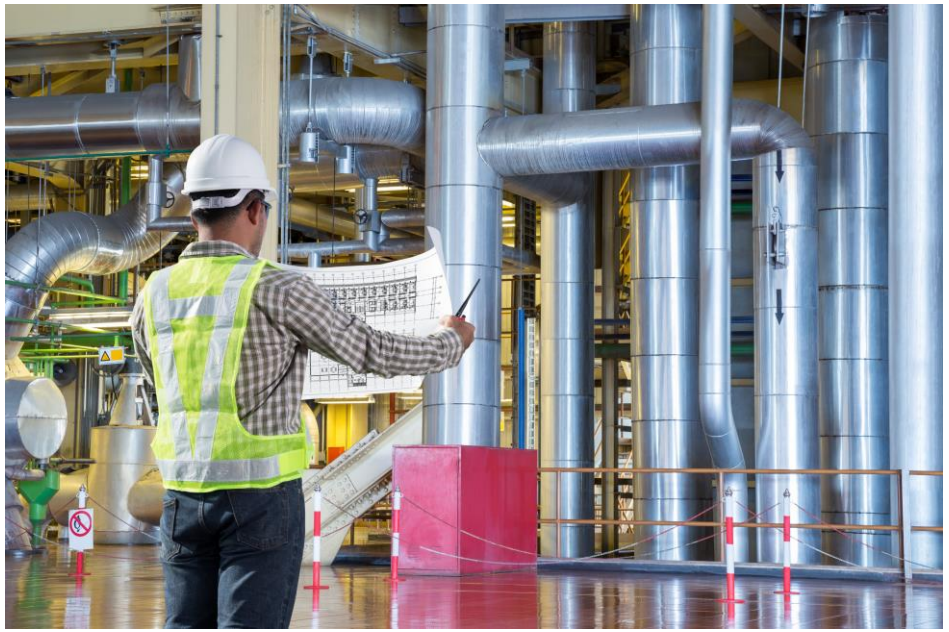
4. Road Building Project

You are a top road construction engineer - ask ChatGPT to help you with the following design problem:

A relatively flat 15km road in the Cedarberg region of the Western Cape. It penetrates a mountain and uses local materials.

- Consider the specifics and the constraints of the project when formulating the design.
- Critically assess the response from ChatGPT.
- Make some suggestions for the design of the picture of the works that you have created.

5. Control and Instrumentation Design



You are an expert control and instrumentation engineer - ask ChatGPT to help you with the following design problem:

> A pump station to pump sea water at the rate of 400 cubic meters per hour into a mineral processing plant off the coast of the Sperrgebiet region of Namibia. Detail the control and instrumentation strategy that will be required to control this pump station.

- Consider the specifics and the constraints of the project when formulating the design.
- Critically assess the response from ChatGPT.
- Make some suggestions for the design of the picture of the works that you have created.

Some Dall-E suggestions

Some indications of the drawn out process in trying to create a building image…..

- A curvilinear architecture mud villa with artificial lighting in an African prairie landscape with a pond during a bright foggy sunrise
- A curvilinear architecture mud villa with arched openings and modern aluminium with glass windows artificial lighting in an African prairie landscape with a pond during a bright foggy sunrise
- An organic curvilinear architectural mud terra cotta villa with formwork striations and wooden framed arched openings and glass windows with artificial accent lighting in an African savannah landscape with native trees and a pond during a bright foggy sunrise

(Courtesy of Stephen Coorlas in DALL·E 2 Tutorial and the Future of Architecture.)

7. Wrap Up

Acknowledgement

A fervent vote of thanks to

Datacamp.com - for their courses on Python, AI and Machine Learning which I attended.

Certificate of Attendance for South Africa

Engineering Institute of Technology.

To receive your digital certificate of attendance for participating in this seminar, please scan the QR Code.

qrco.de/be8avy

Please note that Certificate of Attendances will be sent out in the next 2 business days.

SCAN ME

Q&A

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Thank you for attending.

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