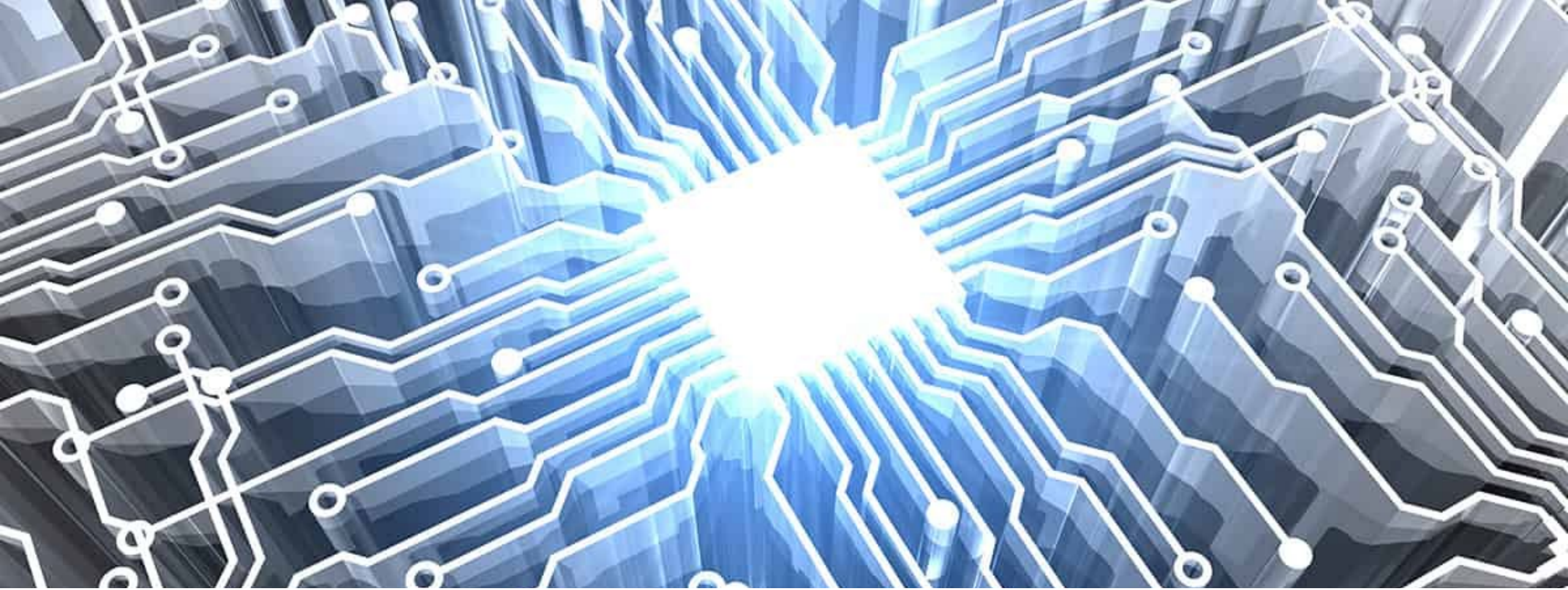


ADVANCES IN AI

Lecturer: Mark Gillan

THE TECHNOLOGICAL ENGINES OF AI

The Foundation: AI doesn't just "happen"; it requires a specific combination of physical and digital technologies.

The Recipe: AI = Powerful Hardware + Massive Data + Fast Connectivity + Clever Algorithms.

Modern Context: We have more computing power in a modern watch than NASA had to land on the moon.

Hardware Evolution: Moving from standard desktop PCs to specialised AI "supercomputers".

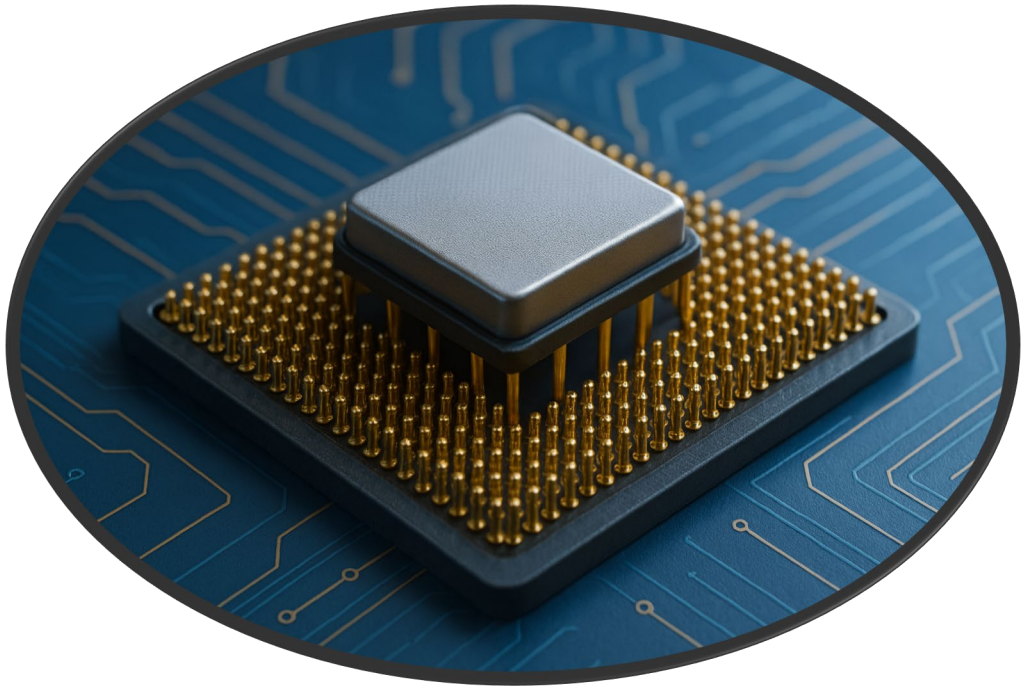
Software Shift: Moving from fixed "written rules" to "self-learning" systems.

Glossary – Hardware: The physical parts of a computer (chips, wires, boards).

Glossary – Software: The programmes and instructions that tell the hardware what to do.

THE SPEED REVOLUTION

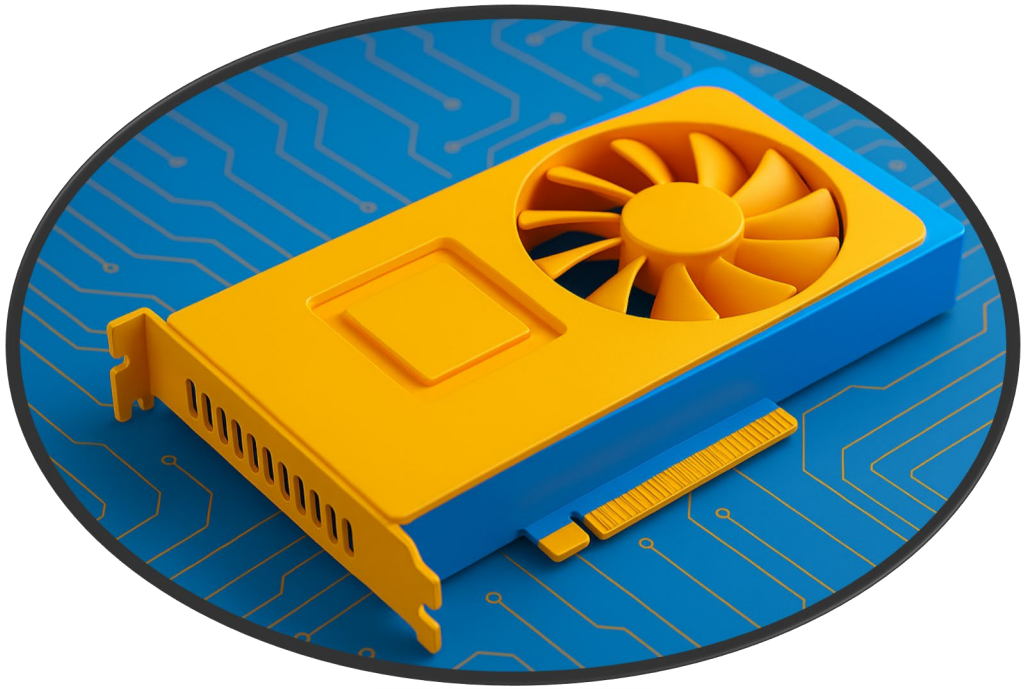
- **Faster and smaller**
- **Who was Gordon Moore?** An American engineer and co-founder of Intel. In 1965, he noticed a trend in how quickly technology was advancing.
- **The Observation:** Moore predicted that the number of transistors (tiny electronic switches) on a chip would double roughly every two years.
- **Exponential Growth:** This means computing power doesn't just grow steadily; it doubles, then doubles again, leading to explosive capability.
- **Miniaturisation:** We can now fit billions of transistors on a chip the size of a fingernail.
- **The Result:** Modern AI requires billions of calculations per second; Moore's Law made the chips small and cheap enough to do this.
  - **Glossary – Transistor:** A tiny component that acts as a gate for electricity; the "brain cell" of a computer chip.



THE GPU – AI'S HEAVY LIFTER

- **CPU vs GPU:** A CPU is like a high-speed delivery van (one package at a time); a GPU is like a massive cargo train (thousands of packages at once).
- **Parallel Processing:** AI needs to do millions of tiny maths problems simultaneously—exactly what GPUs were built for.
- **Gaming Roots:** Originally made for rendering 3D video game graphics, researchers realised GPUs were perfect for AI maths.
- **Speed:** A GPU can train an AI model in hours, whereas a standard CPU might take weeks.
- **Hardware Leaders:** Companies like NVIDIA now design "Tensor Cores" inside GPUs specifically for AI tasks.

  - **Glossary – Parallel Processing:** The ability of a computer to carry out many different tasks or calculations at the same time.
  - **Glossary – CPU** (Central Processing Unit), **GPU** (Graphics Processing Unit)



BIG DATA – THE FUEL FOR AI

The Concept: AI needs "examples" to learn. Big Data refers to the massive collections of information we create every day.

The 3 Vs: Engineers describe Big Data using

Volume (how much)
Variety (different types)
Velocity (how fast it's created)

Data Types: It isn't just text; it's photos, videos, GPS coordinates, and even your heart rate from a fitness tracker.

The Purpose: Without this "fuel", an AI algorithm is like a car with no petrol—it has the engine but cannot go anywhere.

Labelling: Much of this data is "labelled" by humans so the AI knows what it is looking at (e.g., tagging a photo as "Dog").

Glossary – Petabyte: A massive unit of data storage (1,000 Terabytes). One petabyte could hold about 500 billion pages of standard printed text.

IOT: THE EYES AND EARS OF AI

- **The Internet of Things (IoT)** – Eyes and Ears of AI
- **Connected Devices:** Everyday objects like smart kettles, fridge cameras, and industrial sensors that are connected to the web.
- **Data Collection:** These devices act as "sensors" that feed real-world data (temperature, light, movement) back to AI systems.
- **Example:** A smart thermostat learns your routine by sensing when you move through the house.
- **Predictive Maintenance:** Sensors on a factory machine can tell an AI when a part is vibrating oddly, allowing for a repair before it breaks.
- **Smart Cities:** Sensors in bins can tell an AI when they are full, so the council only sends bin lorries when needed.
  - **Glossary – Sensor:** A device that detects or measures a physical property (like heat or light) and records it as data.

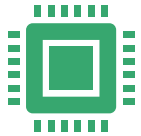
CLOUD COMPUTING – AI EVERYWHERE

- **The Cloud** – Infinite Computing Power
- **No Hardware Needed:** You don't need a supercomputer at home to use AI; you "rent" power over the internet.
- **On-Demand Power:** Services like Amazon (AWS) or Microsoft Azure let companies use thousands of computers at once for a few hours.
- **Scalability:** If an AI needs more "brainpower" for a big task, the cloud can provide it instantly without buying new parts.
- **Accessibility:** This is why you can use ChatGPT on a cheap phone—the "thinking" happens on a powerful server miles away.

- **Glossary – Server:** A powerful computer that stays on 24/7 to provide data or "thinking power" to other computers over the internet.
- **Glossary – Latency:** The delay or "lag" between sending a request and getting a response from a server.

5G AND FIBRE – SPEED OF THOUGHT

The Need for Speed: AI (like self-driving cars) needs to make decisions in milliseconds. If the connection is slow, the car crashes.



Bandwidth: High-speed fibre and 5G allow massive AI models to be sent and received in seconds rather than hours.

Real-Time AI: Fast internet allows your phone's voice assistant to "think" and answer you almost instantly.

Edge Computing: This is where the AI does the "thinking" on the local device (like a car) but uses the fast network to get updates.

Global Impact: High-speed satellites (like Starlink) allow AI to be used in remote Scottish Highlands for tracking wildlife or weather.

Glossary – Bandwidth: The maximum amount of data that can pass through an internet connection in a certain amount of time.

THE DIGITAL INSTRUCTIONS

- **Algorithms** – The “Logic” of AI
- **What is an Algorithm?** A set of step-by-step instructions for a computer to follow to solve a specific problem.
- **Recipe Analogy:** Think of it like a recipe. If you follow the steps exactly, you get a cake.
- **From Rules to Learning:** Old algorithms were "If/Then" rules written by humans. AI algorithms "write" their own rules by looking at data.
- **Efficiency:** A clever algorithm can do the same job as a poor one using much less electrical power and time.
- **The Mathematical Core:** Everything in AI—from identifying a cat to writing a poem—is based on complex maths and statistics.
  - **Glossary – Logic:** A system of reasoning where a conclusion is reached based on specific "true" or "false" steps.

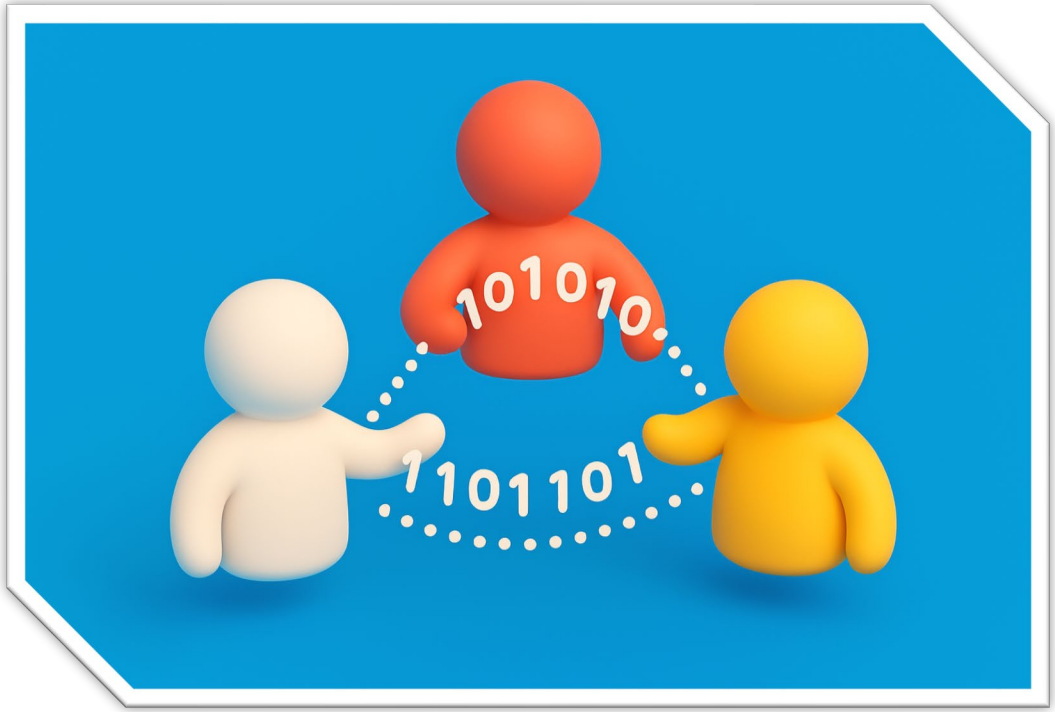
NEURAL NETWORKS: INSPIRED BY THE HUMAN BRAIN

- **Mimicking Nature**
- **Biologically Inspired:** Software designed to mimic how neurons (nerve cells) and synapses work in a human brain.
- **Layers of Thinking:** Information passes through "hidden layers" that look for increasingly complex patterns.
- **Deep Learning:** This refers to neural networks with many layers (the "Deep" in Deep Learning).
- **Weights and Biases:** The AI adjusts the "strength" of connections between these digital neurons to learn from its mistakes.
  - **Glossary – Neuron:** In AI, this is a mathematical function that receives data, processes it, and passes it to the next layer.
  - **Glossary – Deep Learning:** A type of machine learning that uses many-layered neural networks to solve very complex problems.

SPECIALISED CHIPS – BUILT FOR AI

- **Going Beyond GPUs:** General chips try to do everything. Specialised chips (ASICs) are built for only *one* job: AI.
- **TPUs (Tensor Processing Units):** Custom chips built by Google specifically to speed up the maths used in neural networks.
- **Energy Efficiency:** These chips use much less electricity than a standard computer, which is better for the environment.
- **Smartphone AI:** Your phone likely has a "Neural Engine" or "NPU" chip just for FaceID and photo enhancement.
  - **Glossary – ASIC:** Stands for "Application-Specific Integrated Circuit"—a chip designed for one particular use rather than general use.
  - **Glossary – NPU:** Stands for "Neural Processing Unit"—a chip inside a phone or laptop dedicated to AI tasks.

STANDING ON THE SHOULDERS OF GIANTS
OPEN SOURCE & COLLABORATION



Open Source: This is software where the "source code" is free for anyone to see, change, and share (e.g., Python).

Global Collaboration: Developers across the world share their AI code on sites like GitHub so others can build on it.

Pre-trained Models: You don't have to spend millions training an AI; you can download a "foundation model" that already understands language.

Standardisation: Sharing tools ensures that an AI built in Scotland can work with data from a system built in Japan.

Glossary – Source Code: The original list of computer instructions that a human writes in a programming language.
Glossary – GitHub: A massive website where programmers store their code and work together on projects.

SUMMARY – THE PERFECT STORM

- **The Perfect Storm - Convergance:** AI is exploding now because we finally have the hardware, the data, and the algorithms all at the same time.
- **Interconnectedness:** None of these technologies work alone; the Cloud needs Fibre, and AI needs Big Data.
- **The Speed of Change:** Because hardware is getting faster and software is getting smarter, AI will look completely different in 5 years.
- **Economic Impact:** These advancements are creating new jobs in Scotland, from data engineering to AI ethics.
- **Your Future:** Mastering these "building blocks" is the first step to understanding the modern world.
  - **Glossary – Convergence:** The process where different technologies come together to create something brand new and more powerful.