



# HIGH PERFORMANCE COMPUTING AND ARTIFICIAL INTELLIGENCE

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## A Short Primer

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## HIGH PERFORMANCE COMPUTING AND ARTIFICIAL INTELLIGENCE PRIMER

Hi and welcome.

This primer gives an introduction and overview of what High Performance Computing (HPC) and Artificial Intelligence (AI) are, how they help shape our world and benefit humankind. They are exciting and interconnected fields having a profound impact on our lives, even if we don't realise it.

I've written this primer with the help of an AI model, and the AI model was trained on a large HPC system. I used ChatGPT from OpenAI to provide some inspiration and ideas. I've then reviewed and edited the ChatGPT output and added my 25+ years of experience in both HPC and AI. The result is this primer. It is entirely attributable to me, and is current as of October 2023. I hope you enjoy reading it and gain some insight into these fascinating areas.

If you are interested in the ChatGPT AI model you can access it here.

<https://chat.openai.com>.

Once you've signed up or logged in, you can try the input I used:

"Write a short explanation of HPC and AI in simple terms."

You can click on the 'regenerate' button to get different answers to your question. Have fun.

***Technical note:***

ChatGPT is a large language model (LLM), which has been trained to understand and generate human language. It was trained on most of the text on the world wide web - about 74TB of data. Like us, it understands context. However, it was only trained on data available up to September 2021, so it is not up to date with, for example, current affairs, and cannot access the internet. You can ask ChatGPT how it was trained, you can ask it to write a piece of Python code, you can ask it to write a story or create a knitting pattern, but it doesn't know who the current UK Prime Minister is.

*OpenAI. (2023). ChatGPT [Large language model]. <https://chat.openai.com>*

## What is High Performance Computing?

HPC systems are the elite Olympic athletes of the computing world. Designed to solve really tough problems, HPC helps scientists, researchers, and businesses solve problems that regular computers just can't handle because they need a lot more "thinking" power.

These problems could be anything from predicting the weather accurately, simulating the behaviour of molecules for drug discovery, or even creating amazing special effects in movies. COVID-19 vaccines were designed and simulated on HPC systems. Auto and aerospace manufacturers use HPC to create virtual prototypes, and energy researchers are using HPC systems to harness new energy sources like fusion energy.

Even the humble Pringles potato chip was designed on an HPC system. Proctor and Gamble wanted a new snack chip that could be manufactured quickly and transported efficiently. The shape of a Pringles chip allows it to travel on the manufacturing conveyor belt without flying off, and the shape also allows it to be packaged densely with very little breakage. All thanks to HPC.

In the past HPC systems were extremely expensive and used lots of unique hardware. These days HPC systems are typically made up of many tens, hundreds or even thousands of standard servers (powerful computer systems found in datacentres and in the cloud) with special software and hardware linking them together to provide awesome compute power. HPC systems are also often called grid systems, supercomputers, compute clusters or compute farms.

If you want to see the fastest HPC systems in the world, take a look at <https://top500.org/>. This lists the 500 fastest HPC systems in the world and is updated twice yearly.

## What is Artificial Intelligence?

HPC makes computers really fast. AI makes computers really smart. With AI, computers can learn, make decisions, and create.

If you've ever asked a personal assistant like Siri, Alexa, Google or Cortana to do something, you've interacted with AI. A simple thing like 'Hey Siri, where am I?' sparks off a chain of events; the device needs to recognise your voice, listen to your words, interpret them and convert them into computer language, then carry out your request by checking your location using GPS, perhaps fetching a map of your area, displaying it on the screen and telling you where you are. And it does this in less than a second! In addition, the more you use the assistant the better it gets at understanding you, it learns as you use it. That's AI in action.

One of the key techniques for creating an AI is called Deep Learning, a branch of Machine Learning. Deep Learning consists of two parts, first you have to train the computer model (software), then you have to deploy the model.

Training is generally very compute intensive, it involves processing and analysing vast amounts of data. For example, if you are training an AI model to analyse x-ray images you show it thousands or millions of examples of x-rays and it learns how to recognise normal and abnormal scans. Training is generally done on a large HPC system.

Once the model is trained it can be deployed - put into action. This requires much less compute power, and this is what you interact with when you use ChatGPT or any other deployed model. And the interaction you have with the deployed model can be passed back to the training system for further learning.

One of the most exciting uses of AI is in autonomous vehicles, often called self-driving cars. These are robots on wheels that can drive themselves without a human being in control. They can see the road, make decisions, steer and brake, just like a human driver.

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These cars can follow traffic rules, stay in the correct lane, stop for red lights, and avoid obstacles like other cars, bicycles or people. They use a combination of sensors, like radar and cameras, to "see" everything around them, and computer programs help them make smart decisions about how to drive safely.

Autonomous vehicles are still a few years away from being commonplace, but many of the technologies are already available in today's vehicles. Driver assistance aids like traffic sign recognition, lane departure warning and adaptive cruise control, are all helping to reduce the number of accidents, injuries and fatalities on our roads, making the world a safer place.

## AI and HPC Together, an Awesome Force

We've seen how AI and HPC are powerful on their own, putting them together makes them true computing superpowers.

HPC makes AI possible, by providing the raw power to train extremely large AI models quickly and efficiently.

AI can make HPC far more productive and powerful by analysing and optimising HPC simulations, reducing energy consumption and even improving the algorithms used.

In the pharmaceutical industry HPC and AI are together helping to speed up the process of developing new drugs in many ways. These include analysing vast amounts of chemical and biological data to identify potential drug targets such as proteins and genes associated with diseases, simulating the compounds at high speed, and even working out the best way of administering the drug - for example using implants with nanoparticles of the drug - to get to the target area effectively.

Engineering and product design can benefit from AI enhanced HPC by analysing huge amounts of data produced during a simulation run and providing guidance on modifying the simulation to get better results faster.

And HPC can help in AI training for self-driving cars by simulating weather phenomena such as snow, rain, morning haze and fog, improving the ability of the AI model to deal effectively with all sorts of driving conditions.

## Summary

Whilst HPC and AI have been around for decades, the last few years have seen massive improvements in computer performance and software development that make AI and HPC both practical and accessible.

We use these technologies every day without realising it, and we will continue to see advances in these two technologies in the future. But we need to remember that any technology can be used for good and bad, and we must continue to be vigilant and put processes in place to protect us against misuse of these technologies, to ensure that they benefit humankind and lead to a better future for all of us.

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