Challenges and Future Directions

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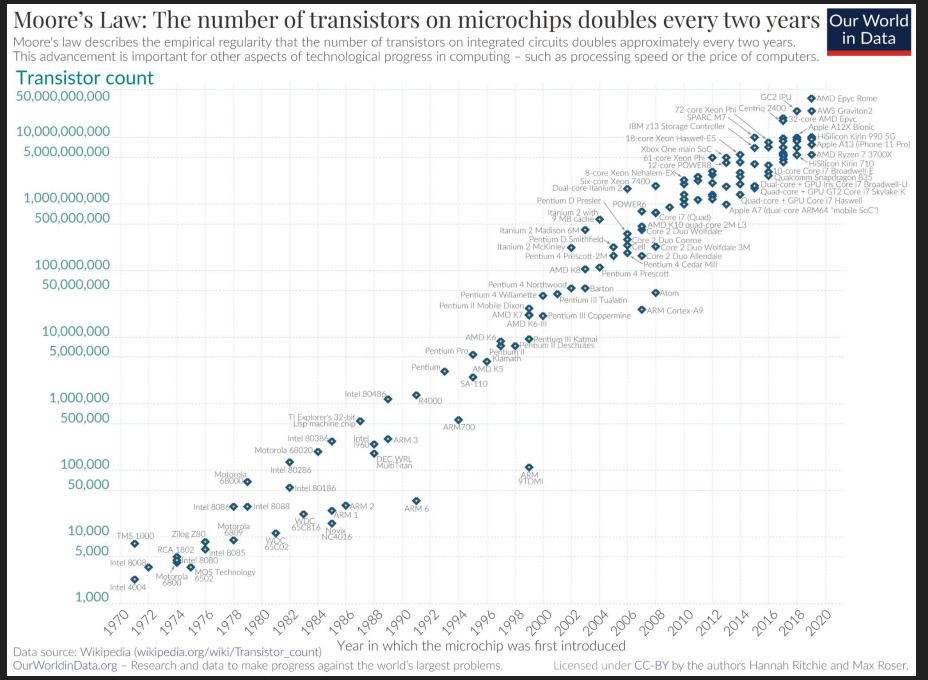
AGENCIA ESTATAL DE INVESTIGACIÓN
CEFCA
Centro de Estudios de Física del Cosmos de Aragón
Ayuda ICTS-MRR-2021-03-CEFCA, financiada por:
MINISTERIO DE CIENCIA E INNOVACIÓN
Plan de Recuperación, Transformación y Resiliencia
ESPAÑA PUEDE.
Financiado por la Unión Europea
NextGenerationEU

Scalability

We started with 10^3 objects in 3 filters

Now we have 10^6 objects in 57 filters

You cannot have a program which takes 10 minutes to derive the parameters of an object.



Data Management

Archiving:

We are used to keep everything but this is going to change: the Square Kilometer Array (SKA) is not keeping its “raw” data

Provenance:

We want to know what happened to each part of information which arrives to us

Reproducibility and open science:

Everyone should be able to reproduce your results: publish your code!

Challenges

Real time astrophysics

Gamma Ray Bursts and the Gravitational Waves have pushed astronomy to the limit

The brokers for LSST (e.g. Fink) and initiatives like AstroColibri mark an important path forward

Multi-messenger astrophysics

This actually started in 1987; the Cherenkov telescopes are part of this. Do we need a new framework?

Artificial Intelligence

The most recent advancement is due to the “Attention is all you need” paper https://arxiv.org/abs/1706.03762

It allows Generative AI; we are going towards Artificial General Intelligence.

This has sparkled a series of ethical, legal and existential issues.

What if the AI deceives us?
Former colonizers are afraid because they expect the colonized to behave like the colonizers did.

The OpenAI 5 steps towards AGI:

Level 1: Chatbots, AI with conversational language

Level 2: Reasoners, human-level problem solving

Level 3: Agents, systems that can take actions

Level 4: Innovators, AI that can aid intervention

Level 5: Organisations, AI that can do the work of an organisation

https://www.linkedin.com/posts/a-banks_openai-has-developed-a-5-tier-framework-to-activity-7218947503533010945-IbXX/

From “Encounter at farpoint”; S1E1 of Star Trek - The Next Generation

RIKER: Your file says that you're an

DATA: Machine, Correct, sir. Does that trouble you?

RIKER: To be honest, yes, a little.

DATA: Understood, sir. Prejudice is very human.

RIKER: Now that does trouble me. Do you consider yourself superior to us?

DATA: I am superior, sir, in many ways, but I would gladly give it up to be human.

Sci-Fi as an exercise on the future

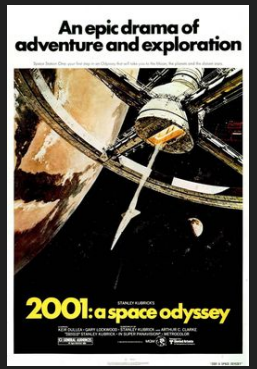
https://en.wikipedia.org/wiki/WarGames

https://en.wikipedia.org/wiki/Blade_Runner

Vs

https://en.wikipedia.org/wiki/The_Terminator

https://en.wikipedia.org/wiki/2001:_A_Space_Odyssey



The human intelligence vs artificial intelligence

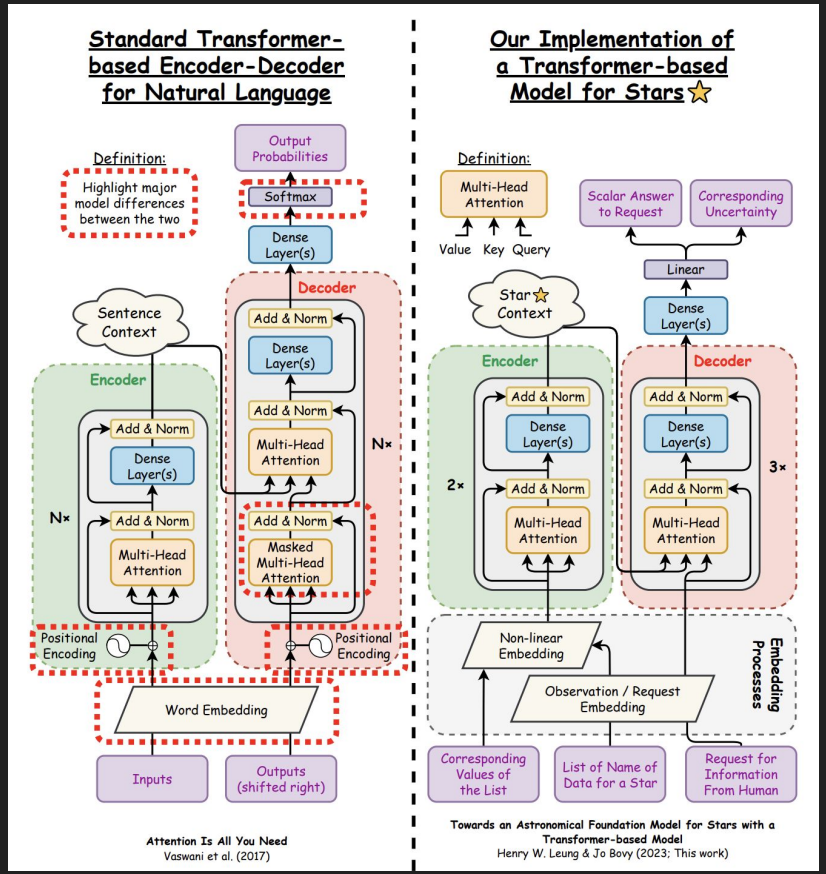
- The eye is a 2D detector
- The brain reconstructs a 3D environment via experience (i.e. training)
- We behave in our 3(+1)D space using:
  - teaching (i.e. training)
  - Experience (i.e. reinforcement learning)
  - Making hypothesis (bayesian)

Transformers are a great opportunity!

https://arxiv.org/abs/2308.10944

We had text-to-text, text-to-image, text-to-video… now we are moving to multi-modal…

We can have text-to-photometry, text-to-image, text-to-catalogue,...



For those concerned about privacy and/or bandwidth: one can use local models

https://huggingface.co/

You can create your own program to interact with the LLM of your choice on your laptop.
You can ask an LLM to act as different “characters” to provide you different perspectives on a problem.

ChatGPT and their siblings

You all know ChatGPT
Do you know Perplexity?
Do you know Gemini?
Do you know Julius AI?

If you are unimpressed because of hallucinations. They will go away.

If you just ask a question and complain about the answer, you may not be using them properly. Try to use them as a 24/7 assistant.

Conclusions

Astronomical data are becoming larger and more complex.

Artificial intelligence can help:

- Being our assistants helping our work
- Do part of our work

The role of the scientist is not threatened (yet).

Exercise!

Form two groups (ideally balanced between astromers, computer scientists, senior and junor…)

Over lunch, each group come up with two of three problems that you feel you are currently facing or you think are going to be important to you in the next year.

After lunch, we will discuss these problems.

Ideally, we will try to dig into the Gaia Nearby Stars catalogue.