

(Future) AI Breakthroughs

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What is artificial intelligence (AI)?

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- It is not so clear what this actually means:
 - ▶ Is it just to **calculate more quickly**?
 - ▶ Or to play certain games like chess more successfully using (**old fashioned**) **algorithms as in chess computers**?
 - ▶ Or to **learn playing games from the scratch** without human expert knowledge being programmed, as in **AlphaGo or AlphaZero**?
 - ▶ Or to enter the very heart of human creative activities, i.e. **speaking to each other, writing books, composing music, painting pictures, investing money, etc.**

The AI effect

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- Machine capabilities (still) classified as AI include for instance
 - ▶ **understanding human speech** (on an extremely high level as achieved by ChatGPT-4);
 - ▶ **competing at the highest level in strategic game systems** (such as Go or Diplomacy);
 - ▶ **creating images based on pure text inputs;**
 - ▶ **autonomously operating cars.**

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- **Artificial communicators:** Siri, Alexa, Google duplex, ChatGPT, Google Bart
- **Artificial computer scientists/mathematicians:** AlphaTensor
- **Artificial physicists:** Nuclear fusion reactor plasma control
- **Artificial car drivers:** Waymo
- **Artificial painters:** Stable diffusion
- **Artificial composers:** e.g. Schubert's unfinished symphony is already "finished" since 2019
- **Artificial players:** Atari games, AlphaGo, AlphaZero, CICERO
- **Artificial jack of all trades device:** GATO

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The **red AIs** are ranked by Medium among the **top 5 AI breakthroughs of 2022**.

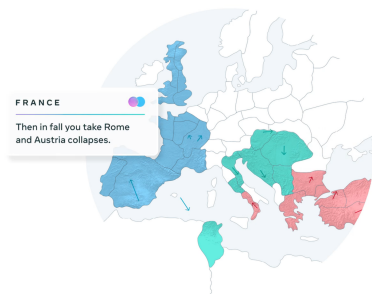
The Generalist Agent: GATO

- **Gato** is a multi-modal, multi-task, multi-embodiment generalist agent developed by Google's Deepmind.
- The same trained model can perform up to 500 different tasks, e.g. chatting, playing video games, moving a robotic arm, etc.



One of the best Diplomacy players: CICERO

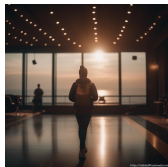
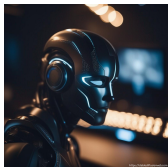
- **CICERO** is an AI developed by Meta that ranks among the top 10% of the **Diplomacy** players. Diplomacy is a 7-player strategy board game where the players start by controlling one of the powers in 1901 Europe.
- CICERO combines **strategic reasoning and natural language processing**. This gives CICERO the ability to reason and strategize, use natural language to communicate, reach agreements to achieve shared objectives, form alliances and coordinate plans.



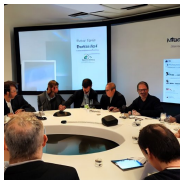
Text-to-image generators: Stable diffusion

Stable diffusion is a text-to-image AI model. Diffusion modeling refers to reconstruction of noisy images, while text-to-image modeling means that the model creates **images from text prompts**. The following pictures were created by

- “Artificial Intelligence Trends”:



- “Roundtable Artificial Intelligence Finance”:



Algorithm designers: AlphaTensor

- **AlphaTensor** is the first AI system to deliver new, more efficient and **provably correct algorithms for fundamental mathematical tasks** such as matrix multiplication.
- It sheds new light on a **question that has been open for 50 years**, namely how to multiply two matrices in the fastest way.
- AlphaTensor is built on **AlphaZero**, an AI system that has achieved superhuman performance in chess, Go and Shogi.
- AlphaTensor is trained via **deep reinforcement learning**. It is formulated as a game where only moves are allowed that lead to a correct multiplication result.
- Without knowledge of existing matrix multiplication algorithms, the system finds **through rewards new algorithms** that are faster than previously known ones.

Algorithm for faster matrix multiplication: AlphaTensor

$$\begin{bmatrix} A_{1,1} & A_{1,2} & A_{1,3} & A_{1,4} & A_{1,5} \\ A_{2,1} & A_{2,2} & A_{2,3} & A_{2,4} & A_{2,5} \\ A_{3,1} & A_{3,2} & A_{3,3} & A_{3,4} & A_{3,5} \\ A_{4,1} & A_{4,2} & A_{4,3} & A_{4,4} & A_{4,5} \end{bmatrix} \times \begin{bmatrix} B_{1,1} & B_{1,2} & B_{1,3} & B_{1,4} & B_{1,5} \\ B_{2,1} & B_{2,2} & B_{2,3} & B_{2,4} & B_{2,5} \\ B_{3,1} & B_{3,2} & B_{3,3} & B_{3,4} & B_{3,5} \\ B_{4,1} & B_{4,2} & B_{4,3} & B_{4,4} & B_{4,5} \\ B_{5,1} & B_{5,2} & B_{5,3} & B_{5,4} & B_{5,5} \end{bmatrix} = \begin{bmatrix} C_{1,1} & C_{1,2} & C_{1,3} & C_{1,4} & C_{1,5} \\ C_{2,1} & C_{2,2} & C_{2,3} & C_{2,4} & C_{2,5} \\ C_{3,1} & C_{3,2} & C_{3,3} & C_{3,4} & C_{3,5} \\ C_{4,1} & C_{4,2} & C_{4,3} & C_{4,4} & C_{4,5} \end{bmatrix}$$

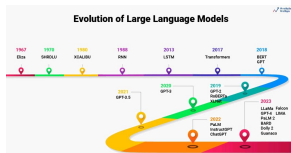
- To multiply a 4x5 with a 5x5 matrix, the standard algorithm needs 100 multiplications, AlphaTensor only needs 76, which are listed on the right.

- These advances could also help understand the asymptotic complexity of matrix multiplication.

```
for (int i=0; i<4; i++)
  for (int j=0; j<5; j++)
    for (int k=0; k<5; k++)
      C[i][j] = A[i][k] * B[k][j];
// ... (76 multiplications) ...
C[i][j] = A[i][k] * B[k][j];
```

The (current) peak of artificial communicators: ChatGPT

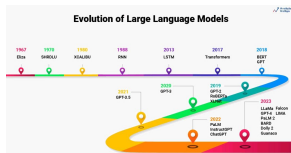
- **ChatGPT-4** (Generative Pre-trained Transformer 4) is the current peak of large language models whose history goes back to 1967, when **ELIZA** was created.



- Comparing ELIZA <https://www.masswerk.at/elizabot/eliza.html> with ChatGPT shows the tremendous developments in the last 55 years.

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- Comparing ELIZA <https://www.masswerk.at/elizabot/eliza.html> with ChatGPT shows the tremendous developments in the last 55 years.
- In contrast to the very limited communication skills of ELIZA, “ChatGPT’s opinion on her” is as follows:

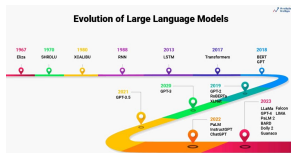


You
What do you think of ELIZA? Please answer in two sentences!

ChatGPT
As an AI language model, I don't have personal opinions or feelings. However, I can provide information about ELIZA. ELIZA was a pioneering development in the history of artificial intelligence and human-computer interaction, illustrating the potential for computers to engage in text-based conversations and inspiring further research in the field of chatbots and natural language processing.

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- The **ChatGPT-4** is said to be based on **eight models with 220 billion parameters** each, i.e. a total of about **1.76 trillion parameters**.
- Sam Altman stated that the **cost of training GPT-4 was more than 100 million dollar**.

ChatGPT and the danger of AI hallucinations

You

What are AI hallucinations? Please explain in one sentence and give an example.

ChatGPT

AI hallucinations refer to erroneous or nonsensical outputs produced by artificial intelligence systems, often due to misunderstandings or biases in their training data, algorithms, or models for example, a language model generating a factually incorrect statement that it believes to be true based on patterns in its training data.

You

Do you suffer yourself from AI hallucinations?

ChatGPT

I don't "suffer" from AI hallucinations, but like any AI model, I can produce incorrect or nonsensical responses due to limitations in my training data, algorithms, or understanding of the input. These errors are not indicative of suffering or consciousness; they are the result of the inherent challenges in building and training AI systems. Developers work to minimize such errors, but they can still occur, and users should exercise critical thinking and verification when using AI-generated information.

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What do we learn from ChatGPT's answer concerning AI hallucinations?
⇒ Quality of training data and understanding of inputs and biases is essential!

Example of a hallucination



You

How many scalar multiplications are necessary to multiply 4×5 matrix with a 5×5 matrix?



ChatGPT

To multiply a 4×5 matrix by a 5×5 matrix, you can use the standard matrix multiplication algorithm, which involves multiplying corresponding elements and summing the results for each element in the resulting matrix.

In this case, you are performing 4 rows of the first matrix by 5 columns of the second matrix. For each element in the resulting 4×5 matrix, you need to perform 5 multiplications (one for each element in the row of the first matrix) and then sum those multiplications. Therefore, for each element in the resulting matrix, you need 5 scalar multiplications and 4 additions.

Since there are 4 rows and 5 columns in the resulting matrix, you will perform $4 \times 5 = 20$ scalar multiplications and $4 \times 4 = 16$ additions.

So, to multiply a 4×5 matrix by a 5×5 matrix, you will need 20 scalar multiplications.

- This is an example where some of the reasoning is correct but **the result at the end is completely wrong**: one needs 100 scalar multiplications with the standard algorithm, not 20 as claimed by ChatGPT.
- So far **no true logical reasoning is implemented in LLMs** which causes these problems, but it might not take too long until this is achieved...

Towards artificial general intelligence (AGI)?

- ...indeed according to https://en.wikipedia.org/wiki/Q* there is Q*, an alleged internal project by OpenAI dedicated to AI for logical and mathematical reasoning.
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- AGIs are AI systems that could learn to accomplish any intellectual task that human beings can perform or even **surpass human capabilities in the majority of economically valuable tasks**.
- Reactions to such rumors/announcements:

François Chollet, an AI Researcher at Google:

- ▶ *“Every single month from here on there will be rumors of AGI having been achieved internally. Just rumors, never any actual paper, product release, or anything of the sort ...”*
- ▶ Yann LeCun, Chief AI Scientist at Meta described the rumors as a *“deluge of complete nonsense about Q*”*.

Impact of (generative) AI on our lives and businesses

- Even if it might still take a while to develop AGIs, the existing AIs already have significant impact on our daily lives and business/working routines.
- It is currently revolutionizing many domains, e.g.
 - ▶ **health care:** medical diagnosis; personalized treatment plans; GPT-4-powered systems for responding to patients and analyzing medical records
 - ▶ **legal system:** GPT-4 passes the bar exam (US Anwaltsprüfung)
 - ▶ **marketing:** personalized; brand sentiment analysis; generative AI for text, pictures and videos
 - ▶ **finance and insurance:** own small GPT models e.g. for reporting purposes; trading and investment management; robo-advisors; fraud detection; risk assessment, e.g. GPT models for financial timeseries
 - ▶ **education:** GPT based personalized tutors for all kinds of learning task
 - ▶ **climate actions:** predicting climate related events; optimizing climate actions, including the management of the environmental impact of AI
 - ▶ **science:** inductive data based reasoning vs. deductive reasoning, Kepler vs. Newton, see e.g. <https://www.derstandard.at/story/3000000197193/ki-loest-raetsel-um-die-entstehung-und-vorhersage-von-monsterwellen>

Conclusion

- The current AI developments are certainly **true game changers**, **fascinating and intriguing**, sometimes perplexing.
- Many of our task will become easier but we are confronted with **new challenges**:
 - ▶ assuring **high quality of (training) data**
 - ▶ understanding the **risks** inherent to AI tools
 - ▶ developing **explainable AI**

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- **“Die Zukunft ist auch nicht mehr das, was sie mal war.”** (Yogi Berra)

Vielen Dank für Ihre Aufmerksamkeit!