AI'S ADVENTURES IN WONDERLAND

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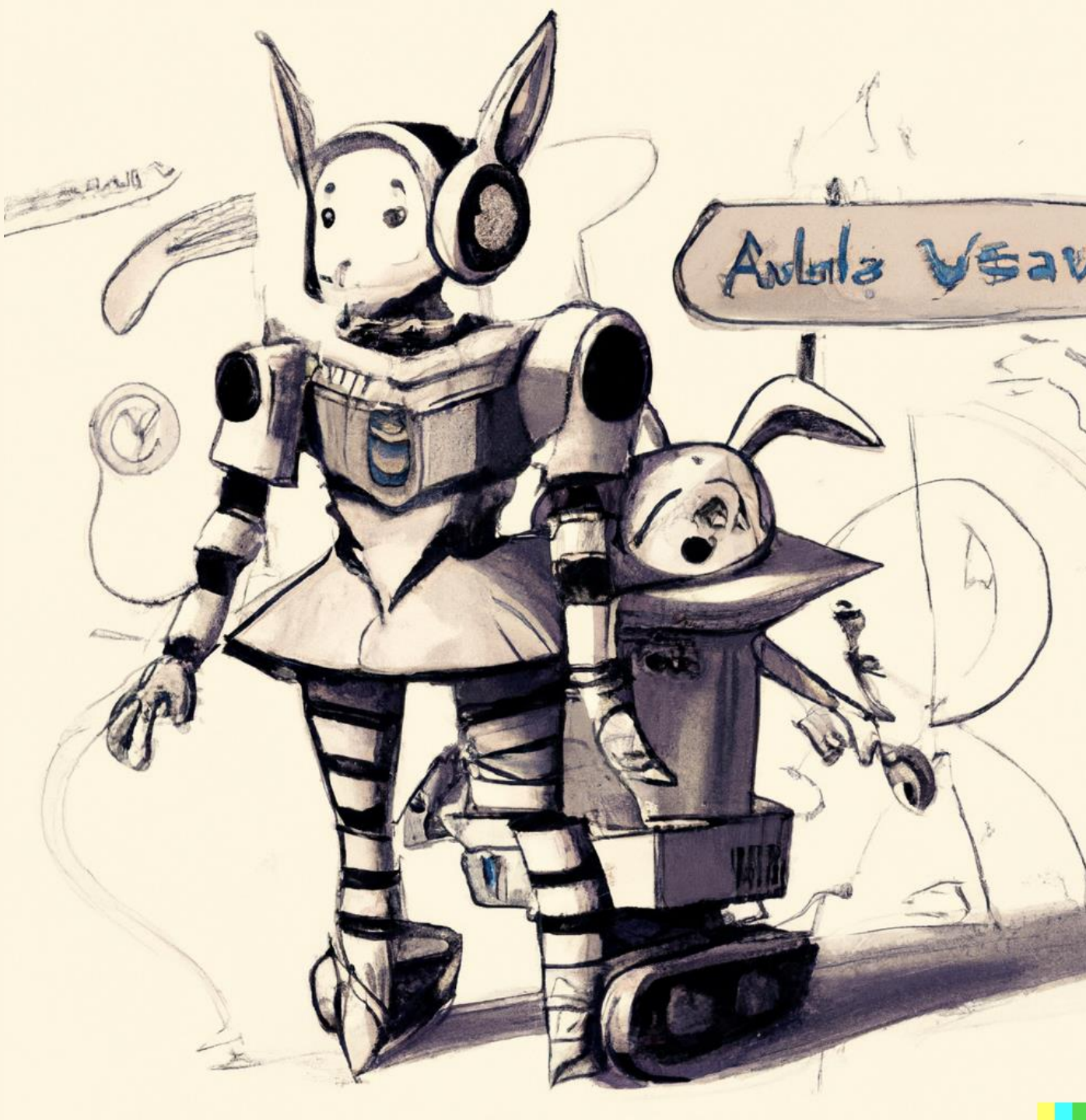


From Lovelace and Turing…

All starts with so-called *Lady Lovelace's objection* [Turing, 1950]:

> «The Analytical Engine has **no pretensions to originate anything**. It can do whatever we know how to order it to perform» [Menabrea and Lovelace, 1843]

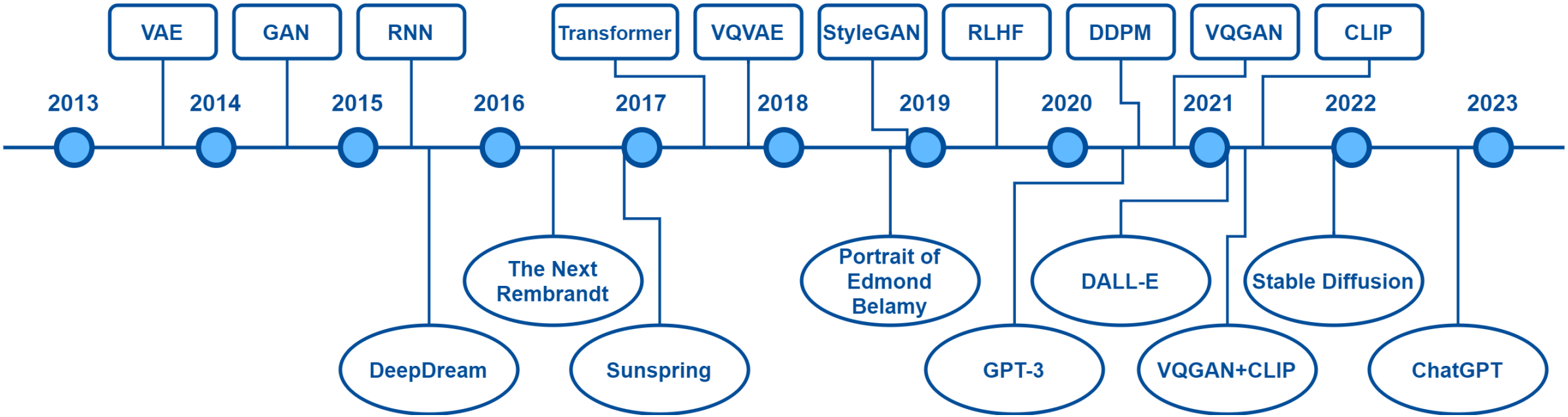
After that, several attempts in late '900 of doing machines to *originate something* by means of coding, rule-based systems, dynamic programming, ecc.

[Menabrea and Lovelace, 1843] L. F. Menabrea and Ada Lovelace. 1843. Sketch of The Analytical Engine Invented by Charles Babbage. In *Scientific Memoirs. Vol. 3*. Richard and John E. Taylor, 666–731

[Turing, 1950] A. M. Turing. 1950. Computing Machinery and Intelligence. *Mind* LIX, 236 (1950), 433–460

… to ChatGPT and Stable Diffusion

The «big bang» of **generative AI** comes in the new millennium.



Computational Creativity

Computational creativity is the study of the relationship between creativity and artificial systems [Cardoso, 2009].

Top-down approach: we have some highly theoretical concepts we want our system to have, let's try to define architectures that satisfy them.

[Cardoso, 2009] A. Cardoso, T. Veale, and G. A. Wiggins. 2009. Converging on the Divergent: The History (and Future) of the International Joint Workshops in Computational Creativity. *AI Magazine* 30, 3 (2009), 15

Generative Deep Learning

Given a dataset of observations X, and assuming that X has been generated according to an unknown distribution p_{data}, a **generative model** p_{model} is a model able to mimic p_{data}. By sampling from p_{model}, observations that appear to have been drawn from p_{data} can be generated [Foster, 2019].

Bottom-up approach: we have architectures that work really well, let's hope what they do can be considered as creative.

[Foster, 2019] D. Foster. 2019. *Generative Deep Learning*. O'Reilly, Sebastopol, CA

Generative ≠ Creative

But are we sure that generative modeling can actually sample creative data?

We have defined generative modeling, but not creativity…

Defining Creativity

Boden's three criteria: «creativity is the ability to generate ideas or artifacts that are **new**, **surprising** and **valuable**» [Boden, 2003]

[Boden, 2003] M. A. Boden. 2003. *The Creative Mind: Myths and Mechanisms*. Routledge, London, UK

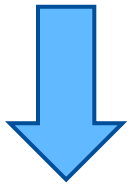
The Three Forms of Creativity

Depending on the kind of surprise, we can have:

- **Combinatorial** creativity, i.e., making unfamiliar combinations of familiar ideas
- **Exploratory** creativity, i.e., exploring the conceptual space defined by the cultural context considered
- **Transformational** creativity, i.e., changing that space in a way that allows for new and previously inconceivable thoughts to become possible

Is then Generative AI also Creative?

Remember that generative modeling samples from *inside* the learned, approximate distribution



Transformational creativity is incompatible *per sé*, while combinatorial and exploratory creativity are possible.

Classic Generative Learning Methods

- **Training** procedure: maximize log-probability per-sample (self-supervised learning) or maximize log-probability of in-distribution classification (adversarial learning)
- **Sampling** procedure: execute the learned model on a random (in-distribution) vector or on user prompts (that might introduce creativity!)

We can get combinatorial or exploratory creativity, but more accurate the training, less creative the output [Franceschelli and Musolesi, 2021].

[Franceschelli and Musolesi, 2021] G. Franceschelli and M. Musolesi. 2021. Creativity and Machine Learning: A Survey. arXiv:2104.02726 [cs.LG]

Towards Creativity-Oriented Solutions

- Creative Adversarial Networks [Elgammal, 2017]: add a «novelty»-like **objective function** to make generator learning a divergent distribution
- Active divergence [Berns, 2020]: perform **optimization over inputs** at sampling time in order to maximize divergence
- Curiosity-based RL [Schmidhuber, 2010]: train the generative model in order to **maximize its curiosity**

[Berns, 2020] S. Berns and S. Colton. 2020. Bridging Generative Deep Learning and Computational Creativity. In *Proc. of the 11th International Conference on Computational Creativity (ICCC'20)*

[Elgammal, 2017] A. Elgammal, B. Liu, M. Elhoseiny, and M. Mazzone. 2017. CAN: Creative Adversarial Networks, Generating "Art" by Learning About Styles and Deviating from Style Norms. In *Proc. of the 8th International Conference on Computational Creativity (ICCC'17)*

[Schmidhuber, 2010] J. Schmidhuber. 2010. Formal Theory of Creativity, Fun, and Intrinsic Motivation (1990–2010). *IEEE Transactions on Autonomous Mental Development* 2, 3 (2010), 230–247

Is this all?

Can we say **someone** has been creative because their **product** is creative?

Four P’s of Creativity

Product is only one of different possible facets of creativity.

It is now broadly accepted that there are four P’s [Rhodes, 1961] defining creativity:

- **Product**
- **Process**
- **Press**
- **Person**

[Rhodes, 1961] M. Rhodes. 1961. An analysis of creativity. *The Phi Delta Kappan*, 42(7):305–310

AI and the Creative Process

The typical creative process [Amabile, 1983] involves:

× **Motivation**

✓ Preparation

✓ Generation

× **Validation**

~ Communication

[Amabile, 1983] T. M. Amabile. 1983. The social psychology of creativity: A componential conceptualization. *Journal of Personality and Social Psychology*, 45(2):357–376

AI and the Creative Press

Creators are not isolated from society. Instead, creativity happens because of a **never-ending cycle**: *individuals* always base their works on knowledge from a *domain*, which constantly changes thanks to new artifacts (considered worthy from the *field*) [Csikszentmihalyi, 1988].

However, generative models are **immutable** entities, not influenced by new works from their domain.

[Csikszentmihalyi, 1988] M. Csikszentmihalyi. 1988. Society, culture, and person: A systems view of creativity. In *The nature of creativity: Contemporary psychological perspectives*, pages 325–339. Cambridge University Press.

AI and the Creative Person

The previously mentioned limitations are **easy** problems, i.e., they can be solved by correcting the underlying training and optimization processes.

The person perspective requires instead to consider a series of aspects related with consciousness and self-awareness: they are **hard** problems [Franceschelli and Musolesi, 2023] …

… Or, back to [Turing, 1950] and this time *The Argument from Consciousness*, a machine should «not only write it but know that it had written it».

[Franceschelli and Musolesi, 2023] G. Franceschelli and M. Musolesi. 2023. On the Creativity of Large Language Models. arXiv:2304.00008 [cs.AI]

[Turing, 1950] A. M. Turing. 1950. Computing Machinery and Intelligence. *Mind* LIX, 236 (1950), 433–460

Beyond the Charm of Creativity

While it is amazing to study and develop creative AI tools, we need to take care of potential risks, mainly from two sides.

- **Ethics** [Tamkin et al., 2021]: Job replacement? Human's idea exploitation? Misleading? Environmental cost?
- **Law** [Franceschelli and Musolesi, 2022]: Copyright of generated works? Copyright of training materials? Sharing licences? User privacy?

[Tamkin et al., 2021] A. Tamkin, M. Brundage, J. Clark, and D. Ganguli. 2021. Understanding the capabilities, limitations, and societal impact of large language models. arXiv:2102.02503 [cs.CL]

[Franceschelli and Musolesi, 2022] G. Franceschelli and M. Musolesi. 2022. Copyright in generative deep learning. *Data & Policy*, 4:e17

Conclusions

- Generative AI is on the rise now and its creative applications are only at the beginning
- Nonetheless, talking about *Creative* AI is both controversial and full of unexplored research paths
- Ethical and legal questions are not secondary aspects and must be taken into great consideration.