The Future of AI: The loss of certainty

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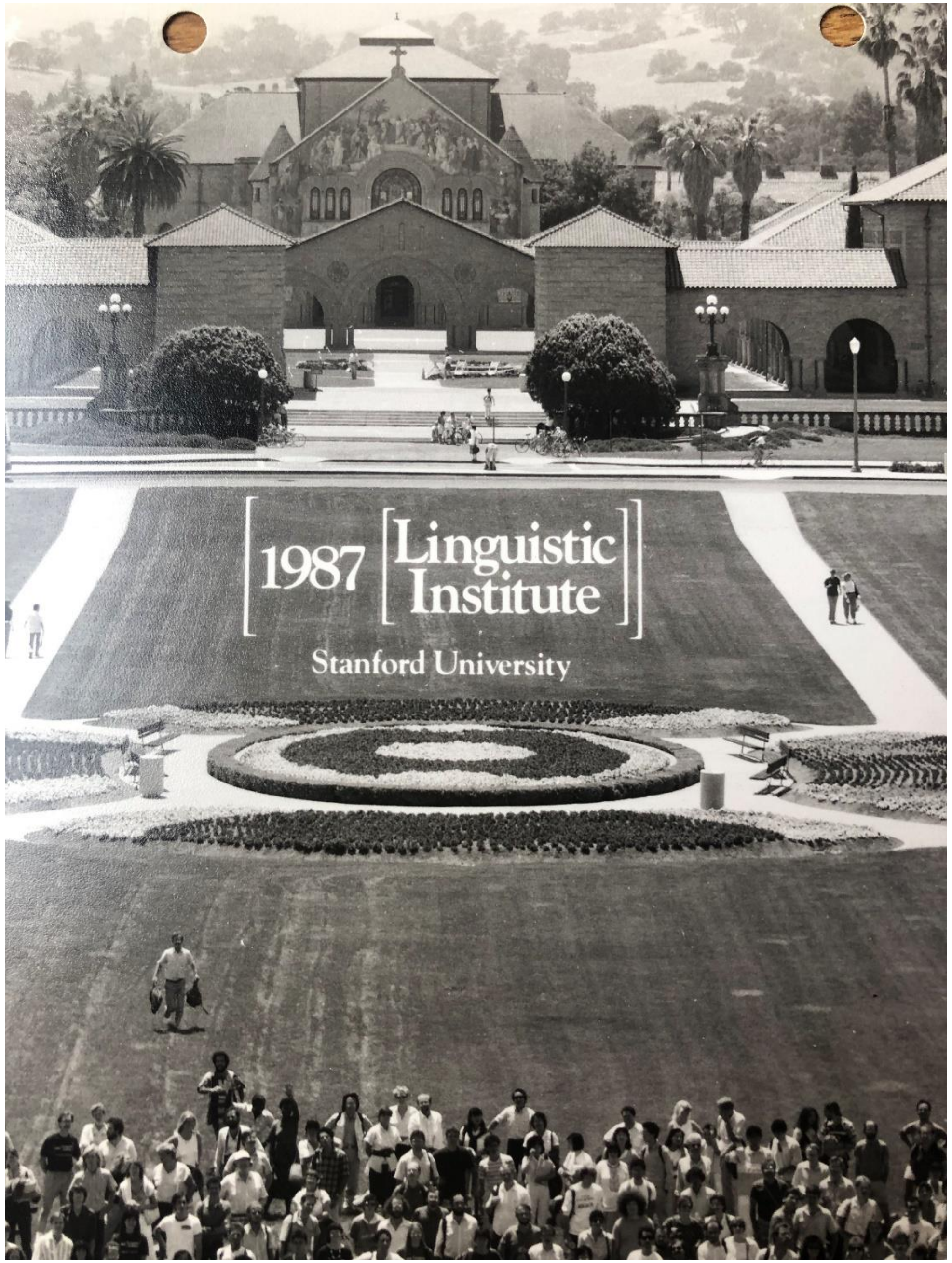
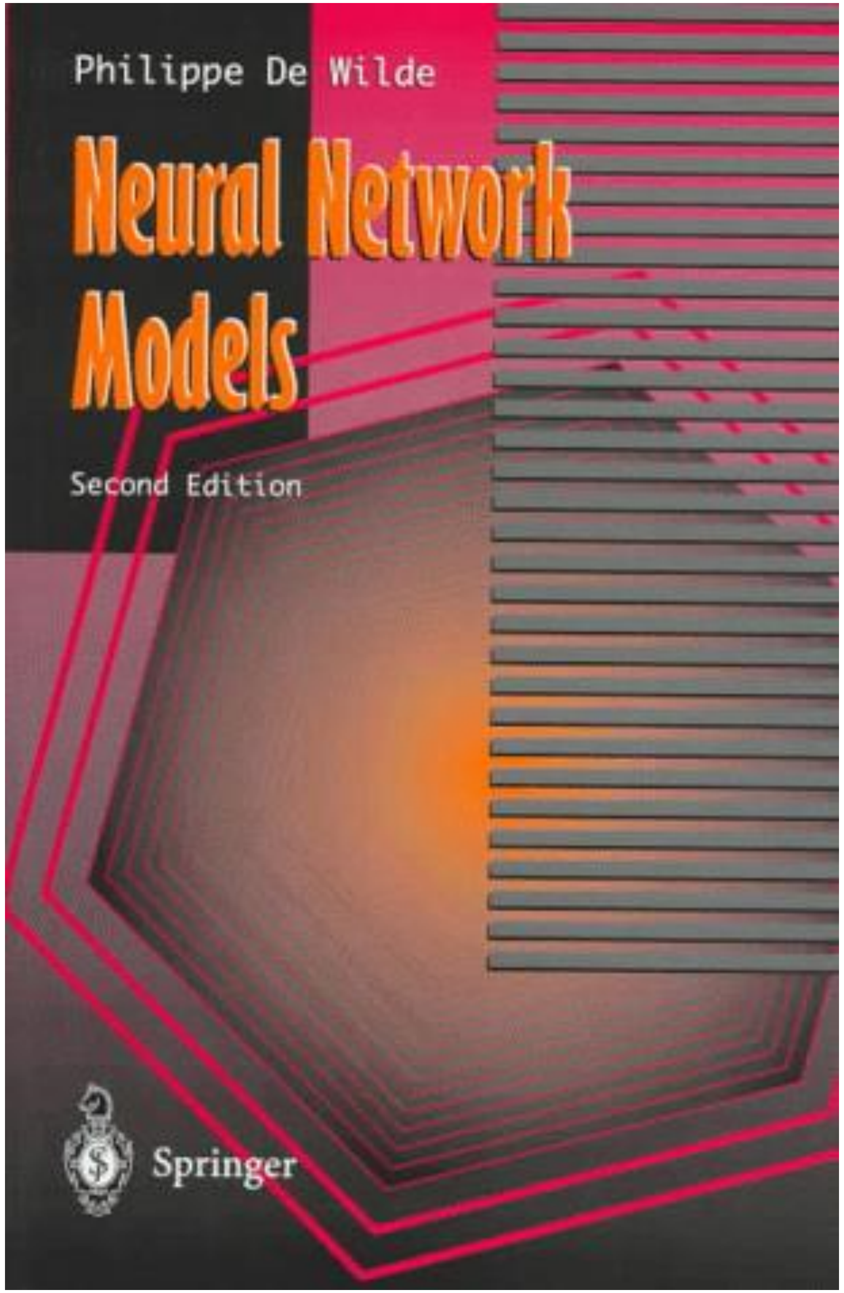
My experience I

- Predictions of the future depend on the past of the speaker…
- 1985: Quantum Mechanics PhD, Univ. Gent, Belgium (ARWU: 84)
- 1986: Microelectronics, Univ. Leuven, Belgium (ARWU: 86)
- 1987: Summer School Stanford (ARWU: 2) David Rumelhart, Backpropagation
- 1989-2005: Imperial College London (ARWU: 23) Electrical Engineering, Neural Systems Engineering
- 1993: Invented Hamiltonian Neural Networks


1987
Linguistic
Institute
Stanford University

My experience II

- 1996: British Telecom: United Kingdom transition to mobile data
- 1999: Sabbatical Berkeley (ARWU: 5) Fuzzy Games
- 2000: Invented Digital Ecosystems
- 2005-2014: Dean of Mathematics, Statistics and Computer Science Heriot-Watt University Edinburgh (ARWU: 901-1000)
- 2014-2020: Vice President Research & Innovation, University of Kent (ARWU: 401-500)


Philippe De Wilde
Neural Network Models
Second Edition
Springer

Current Research

- Convolutional Neural Networks (CNN) for document reading, analysis and classification.
- CNN for breast cancer image analysis (with University of Nottingham: ARWU 101-150).
- Transformers and GAN for medical image analysis (funded by China Scholarship Council).
- Synthetic data for machine learning (with United Nations University Macao).
- The future of large AI models. Sustainable AI.

The search for certainty

- Uncertainty in the environment causes stress to humans, animals, and even plants.
- Stress helps with survival, but the brain gets rewarded (dopamine, endorphins) when stress is relieved.
- As a result, humans have always searched for certainty.

Logic as a source of certainty

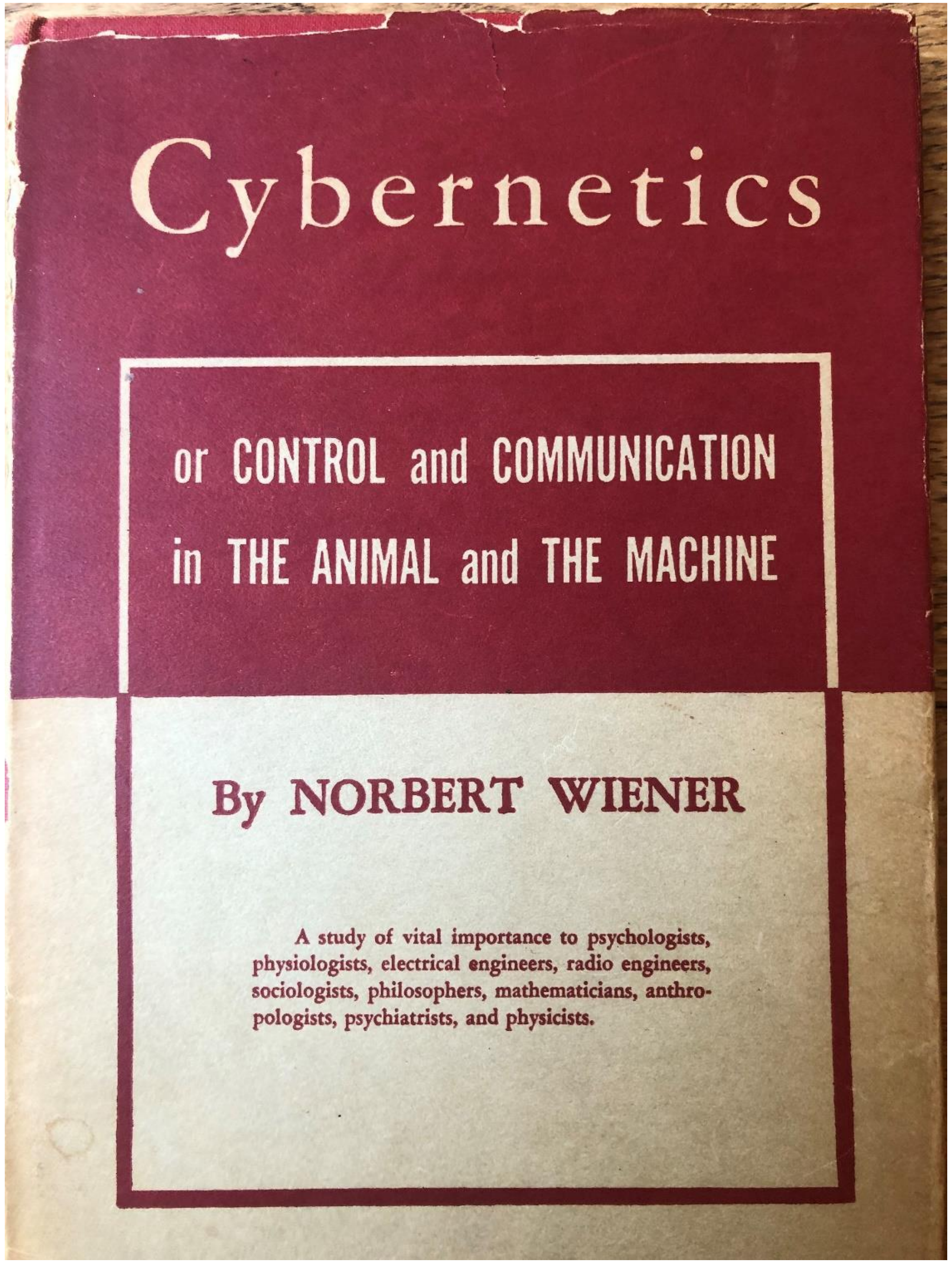
- Aristotle (350 BCE), Boole (1850), claimed that reasoning followed logical rules.
- 孔子 (500 BCE) you can learn the rules of good behaviour.
- Expert systems are collections of if-then-else and other logical rules.
- Expert systems had enormous promise: medical diagnosis, scheduling, robot navigation, home advice and much more.
- Expert systems would learn from human experts.
- … until it was realised (1990's) that human experts do not follow logical rules.

Game rules as a source of certainty

- Go, chess: fixed game rules lead to certainty about who is the winner.
- 正名 words must correspond to reality.
- Wittgenstein, Chomsky, Searle thought that language would be clear if it followed clear rules.
- This was the basis for 1980’s machine translation systems, which failed.

Uncertainty

- Arcesilaus (250 BCE): there is no truth, only what is reasonable or probable.
- Development of mathematical probability around 1650.
- Norbert Wiener: Cybernetics (1948): the brain does optimal control in an uncertain environment.
- Neural coding: groups of neurons represent probabilities.
- Bayesian Machine learning, Boltzmann Machine, Stochastic Gradient Descent: all probabilistic: different runs can give different outcomes.


Cybernetics
or CONTROL and COMMUNICATION
in THE ANIMAL and THE MACHINE
By NORBERT WIENER
A study of vital importance to psychologists, physiologists, electrical engineers, radio engineers, sociologists, philosophers, mathematicians, anthropologists, psychiatrists, and physicists.

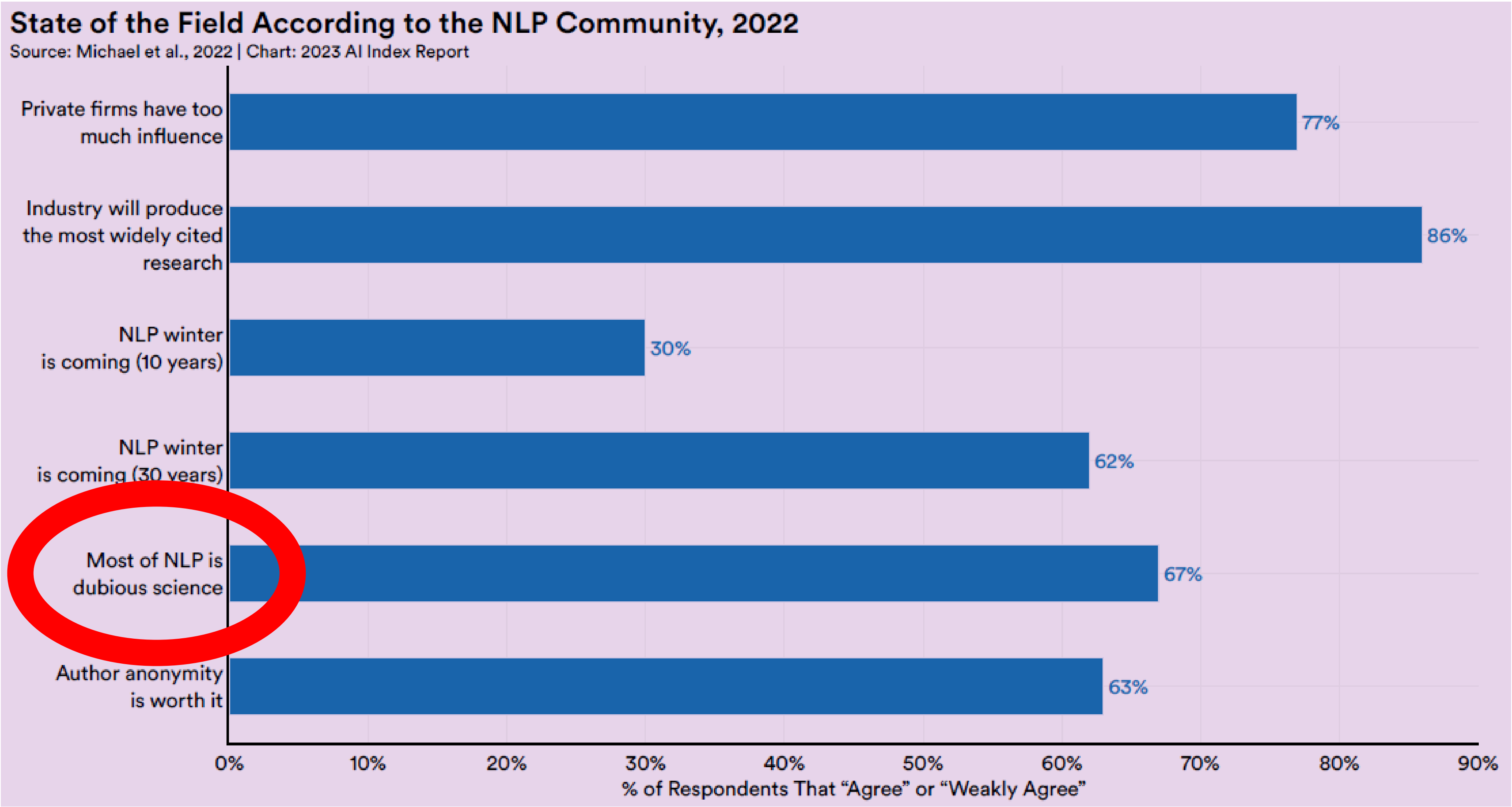
AI is statistical

- 1980's: machine translation attempts using grammatical analysis of sentences, logical analysis of semantics, plus a dictionary. This failed.
- 2006: Google Translate uses statistical machine learning to translate, and does not use logic to understand the meaning of the text.
- Google Translate uses a layered neural network to learn patterns in translation.
- Since then, all successful AI has been based on neural networks.

Transformers and diffusion models

- Transformers: GPT, Microsoft Copilot, Erniebot, ChatGLM
- Vision Transformers
- Diffusion models: DALL-E, Stable Diffusion
- All are using random weight initialization, and stochastic gradient descent or diffusion processes from thermodynamics.
- All have billions of parameters and are not explainable.

Stanford 2023 AI Index



Caveats about deep learning

- The more layers and the more parameters, the better? Benign overfitting seems to work.
- Huge variety in type of layers: dense, pooling, max, skip, etc.
- Choice in level of stochasticity, batch size, error functions.
- All this without scientific basis.
- Bias can be controlled in the dataset, but not in the algorithm (implicit bias).
- Explainability in such a system is very hard, half of practitioners think explainability is on the wrong track.

The future of AI is …

- Large models that are not explainable (low trust in forecasts).
- Large models that are costly to train (on huge astronomy datasets).
- Outputs that are not reproducible (generally not acceptable in science).
- Outputs that are plausible, but not true or false (not falsifiable).
- Loss of certainty.
- The solution is … smaller and sustainable systems (topic of another talk).

References

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- P. Bartlett, A. Montanari, A. Rakhlin, Deep learning: A statistical viewpoint. *Acta Numerica,* **30,** 87-201, 2021.
- G. Vardi, On the Implicit Bias in Deep-Learning Algorithms. *Commun. ACM* **66,** 6, 86–93, 2023.
- *LaMDA: Language Models for Dialog Applications.* R. Thoppilan + 59 co-authors, arXiv:2201.08239.
- *On the Dangers of Stochastic Parrots: Can Language Models Be Too Big?* Emily M. Bender, Timnit Gebru, Angelina McMillan, Shmargaret Shmitchell, FAccT '21: Proceedings of the 2021 ACM Conference on Fairness, Accountability, and Transparency, March 2021 Pages 610–623, https://doi.org/10.1145/3442188.3445922.
- Gabriel Tarde, *Les lois de l'imitation,* 2nd ed. 1895, Alcan, Paris, https://gallica.bnf.fr/ark:/12148/bpt6k6128916f/f13.item