



Seminar Hora Informaticae

Institute of Computer Science, Prague

Tuesday, October 8, 2024, 14.00 – 15.30 (2 – 3:30 PM) CEST

Meeting Room 318, Address: Pod Vodárenskou věží 2, Prague 8

ZOOM Meeting ID: 954 7823 4977 , Passcode: 712564

ZOOM: <https://cesnet.zoom.us/j/95478234977?pwd=dXoyekFHbDJ0MkNrTjVVS3F2STZqUT09>



**Jiří Wiedermann, Institute of Computer Science, Prague:**

### **Large Languages Models and Automata Theory.**

The Extended Church-Turing Thesis (ECTT) posits that all effective information processing, including unbounded and non-uniform interactive computations, can be described in terms of interactive Turing machines with advice. Does this assertion also apply to the abilities of contemporary large language models (LLMs)? From a broader perspective, this question calls for an investigation of the computational power of LLMs by the classical means of computability and computational complexity theory, especially the theory of automata [1]. Along these lines, we establish several fundamental results. Firstly, we argue that any fixed (non-adaptive) LLM is computationally equivalent to a, possibly very large, deterministic finite-state transducer. This characterizes the base level of LLMs. We extend this to a key result concerning LLMs' simulation of space-bounded Turing machines. Secondly, we show that lineages of evolving LLMs are computationally equivalent to interactive Turing machines with advice. The latter finding confirms the validity of the ECTT for lineages of LLMs. From a computability viewpoint, it also suggests that lineages of LLMs possess super-Turing computational power. Consequently, in our computational model knowledge generation is generally a non-algorithmic process realized by lineages of LLMs. Finally, we discuss the merits of our findings in the broader context of several related disciplines and philosophies.

### **References:**

[1] Wiedermann, J., & Van Leeuwen, J. (2024). Large Language Models and the Extended Church-Turing Thesis. ArXiv. <https://doi.org/10.4204/EPTCS.407.14>

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**Jiří Wiedermann** ([www.cs.cas.cz/wieder](http://www.cs.cas.cz/wieder)) belongs to the first generation of pioneers in computer science in former Czechoslovakia. Between 2000-2012 he served as the director of the Institute of Computer Science of the Czech Academy of Sciences. He is a member of the Learned Society of the Czech Republic and Academia Europaea. In recent years he focuses mainly on algorithms and models for AI inspired by modeling human higher-level cognitive abilities such as machine consciousness, experience, understanding, and other semantic properties of AI systems.

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**HORA INFORMATICAЕ** (meaning: TIME FOR INFORMATICS) is a broad-spectrum scientific seminar devoted to all core areas of computer science and its interdisciplinary interfaces with other sciences and applied domains. Original contributions addressing classical and emerging topics are welcome. Founded by Jiří Wiedermann, the seminar is running since 1994 at the Institute of Computer Science of the Czech Academy of Sciences in Prague.

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