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INICJATYWA DOSKONAŁOŚCI
UCZELNIA
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Machine Learning Workshop #2

Center for Machine Learning
Faculty of Physics UW
Warsaw, 26.03.2022 and 2.04.2022

A bit of history and a bit of future

- **1997**, World chess champion Garry Kasparov lost to IBM Deep Blue playing chess.
- **2017**, Chinese GO grandmaster, Ke Jie, being the best player in the World, lost the duel with the AlphaGo program, created by DeepMind - a company owned by Google.
- **2020**, 14th *Critical Assessment of Protein Structure Prediction* (CASP14), AlphaFold2 predicts protein structures, with the knowledge of their amino acid sequences, better than the best teams in the world (Deep Mind, London in collaboration with Google), see J. Jumper et al., *Highly accurate protein structure prediction with AlphaFold*, Nature, 596, 583-589, 2021.
- Generally, systems based on the so-called Deep Learning (DL), express their advanced capabilities - often exceeding human skills.
- **BUT** it should be noted that artificial intelligence (AI) has its limitations, because by personalizing a bit its properties – **when AI does something wrong, it is not always aware of it** – more on the next slide.

- Recently, several quite advanced mathematical works analyzing the "intellectual capabilities" of neural networks have been published - incl. an article published less than two weeks ago by mathematicians from Cambridge and Oslo: M. J. Colbrook, V. Antun & A. C. Hansen, *The difficulty of computing stable and accurate neural networks: On the barriers of deep learning and Smale's 18th problem*, PNAS, 119 (12) e2107151119, 2022.
- The outstanding mathematician **Stephen Smale**, winner of the Fields Medal and the Wolf Prize, proposed at the turn of the 20th and 21st centuries a list of 18 unresolved mathematical problems of the 20th century, where in the last point he asks the question of what are the limits of artificial and human intelligence ?
- The current strong optimism about the possibilities of AI is comparable to the optimism surrounding mathematics at the beginning of the 20th century, including optimism of David Hilbert, who believed that mathematics could prove or disprove any theorem, and that there was also no limit to solving problems with algorithms. **Gödel and Turing** turned Hilbert's optimism upside down. In the course of the analyzes, they came to the conclusion that it is impossible to prove whether some of the statements are true or false. Also some computational problems cannot be solved with algorithms.
- By extending the methodologies initiated by Gödel and Turing, **Colbrook, Antun and Hansen** identified some limitations of neural networks. They sketched a similar program for modern AI in which they formulated a classification theory describing the conditions needed for the existence of algorithms that can compute **stable and accurate NNs**.
- **Many AI/ML systems are unstable**, which becomes a serious problem - especially as they are increasingly used in high-risk areas such as disease diagnosis, autonomous vehicle control, and military applications. If AI/ML systems are used in areas where they can cause harm, trust in them must be a top priority when designing such systems.

Center for Machine Learning

It is I.3.7 action (project) as part of the IDUB initiative

- IDUB - „Inicjatywa Doskonałości – Uczelnia Badawcza” is a program that gives the University of Warsaw the opportunity to raise the level of scientific activity and the level of quality of education.
- Center for Machine Learning - this belongs to the second priority research area (POB II, at the base of the Micro and Macro World).
- The main purpose of establishing the Center is to support the University's research teams in the development and application of machine learning methods in research and education.
- For this purpose, the Center organizes or co-organizes at least one workshop in machine learning methods every year. This workshop is the second in our activity.
- The Center will also try, on its own or in cooperation, to conduct interesting scientific research in the areas of AI/ML.

Contractors, employees and associates of the Machine Learning Center

1. Dr hab. Artur Kalinowski, prof. UW, main contractor, physics of elementary particles and fundamental interactions.
2. Dr Marek Bukowicki, IT specialist, incl. specialist in the field of material research
3. Dr Szymon Nowakowski, IT specialist, incl. specialist in the field of bioinformatics.
4. Dr Przemysław Olbratowski, IT specialist, incl. computer science and nuclear physics.
5. Mgr inż. Anna Śliwińska, IT specialist, incl. specialist in the field of geophysics
6. Dr hab. Jarosław Żygierewicz, prof. UW, assistant contractor, biomedical physics and neuroinformatics.
7. Grzegorz Firlik, assistant contractor, IT specialist responsible for the functioning of the IT infrastructure.
8. Dr Maciej Dziubiński, associate, volunteer, bioinformatics, currently dealing with autonomous vehicle control.
9. Prof. dr hab. Bogdan Lesyng, head of operations, computational science, theoretical biophysics and bioinformatics.



The goals of this workshop

We want to describe the basics of Machine Learning (ML)
in a practical way.

During the first day:

- We will present you the basic tools and packages used in the ML environment,
- we will introduce you to the leading PyTorch and TensorFlow development environments, and
- we will describe examples of neural networks that implement, among others, practical classification tasks.

During the second day (in one week):

- We will present you topics related to autoencoders and their implementations, as well as to recurrent NNs.