WASP | WALLENBERG AI, AUTONOMOUS SYSTEMS AND SOFTWARE PROGRAM

ICARUS

Intelligent Cell-free Access for wiReless Ubiquitous Services

WASP Expedition Project

Emil Björnson, LiU

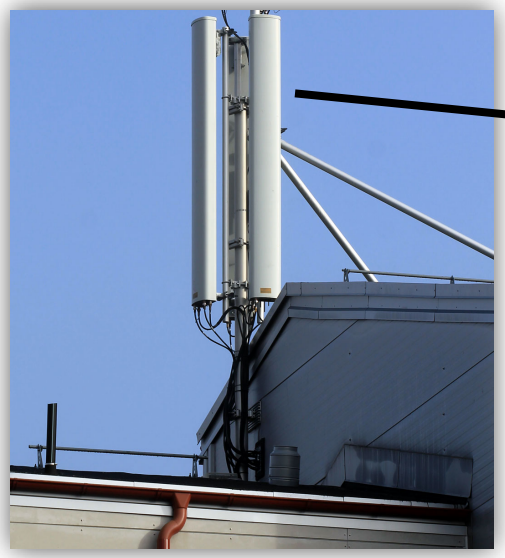
Pontus Giselsson, LU

LINKÖPINGS UNIVERSITET

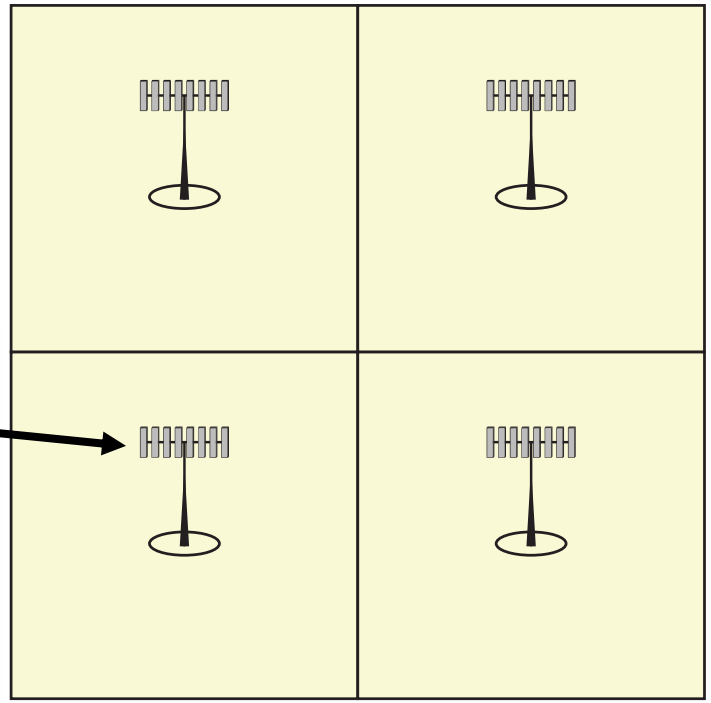
LUNDS UNIVERSITET

What is Cell-Free Access?

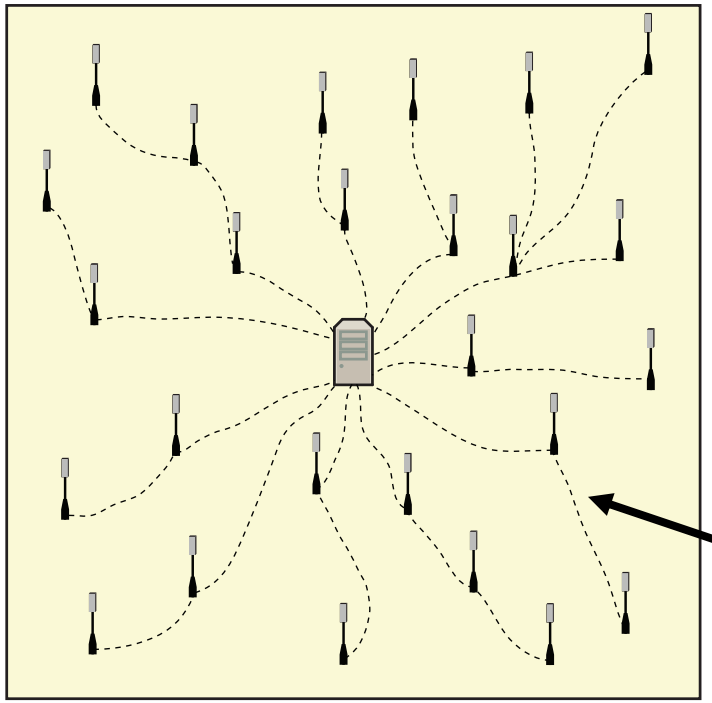
Base station



Cellular network



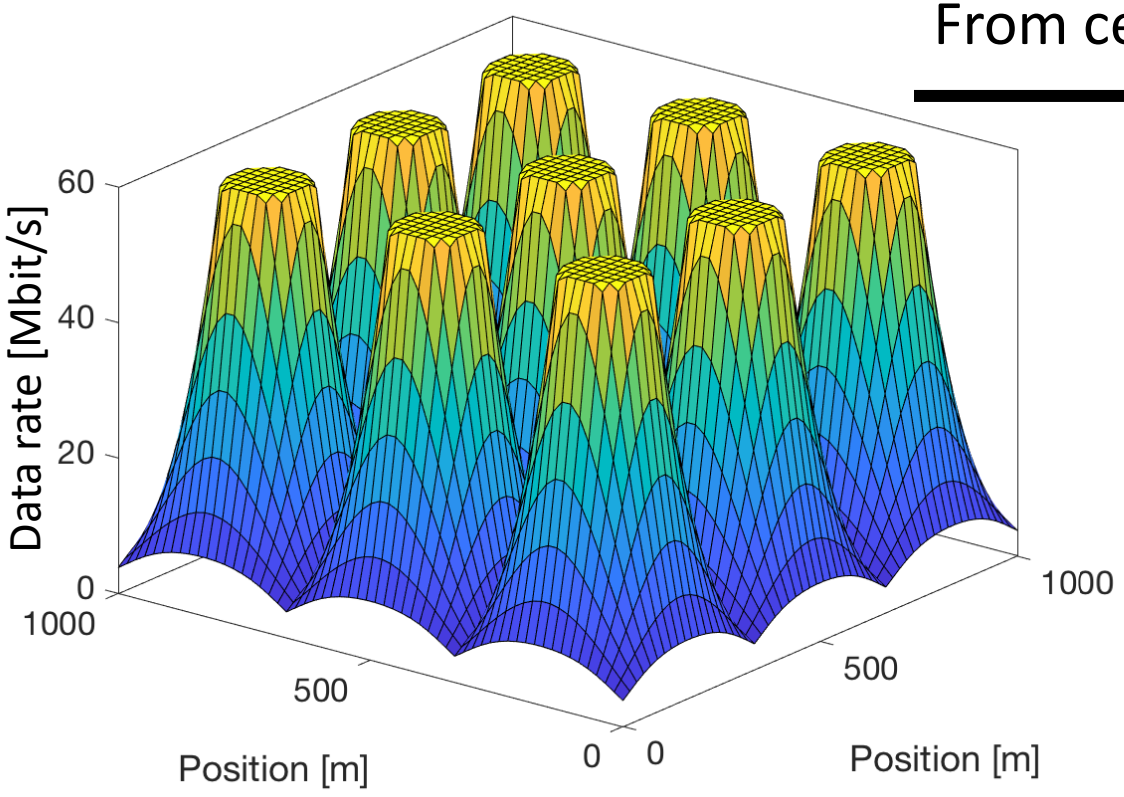
Cell-free network

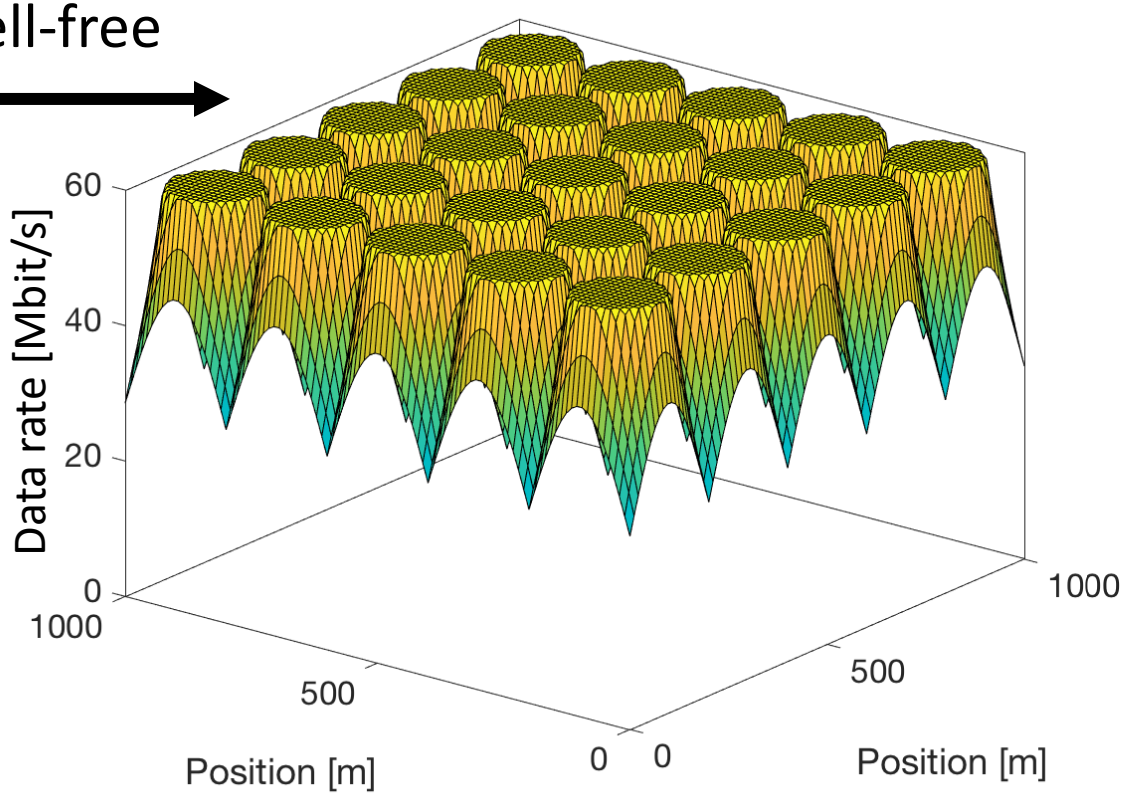


Ericsson
Radio stripe

Overall Goal: Good Connectivity – Everywhere

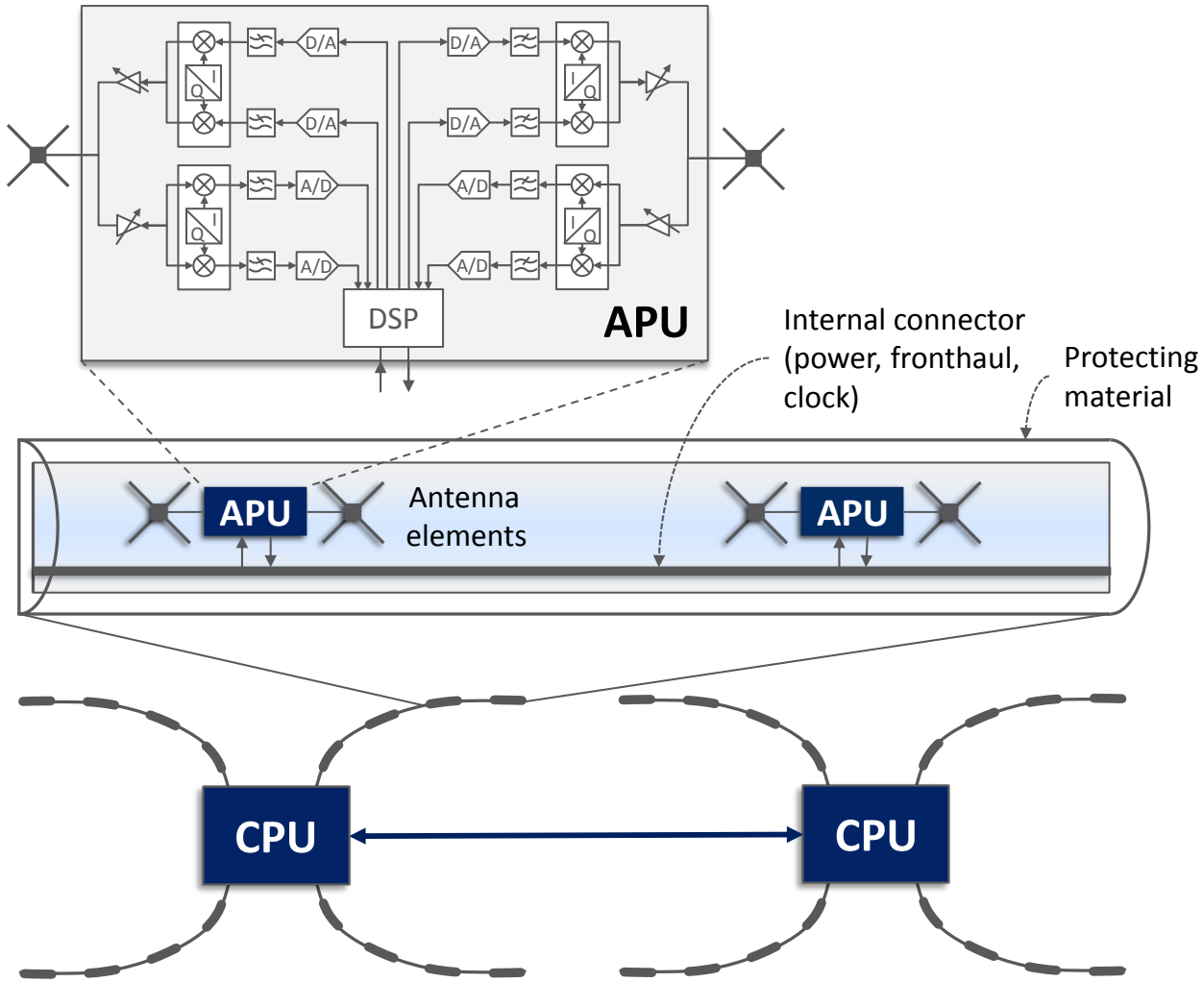
From cellular to cell-free






Stadium
Brasil
FIFA
SONY

Intelligent Implementation



Centralized implementation infeasible
Huge amount of information to exchange

Distributed processing capability
Available close to antennas

Learn how to utilize it most effectively!

APU = Antenna processing unit
CPU = Central processing unit

Objectives and Organization

Research objectives

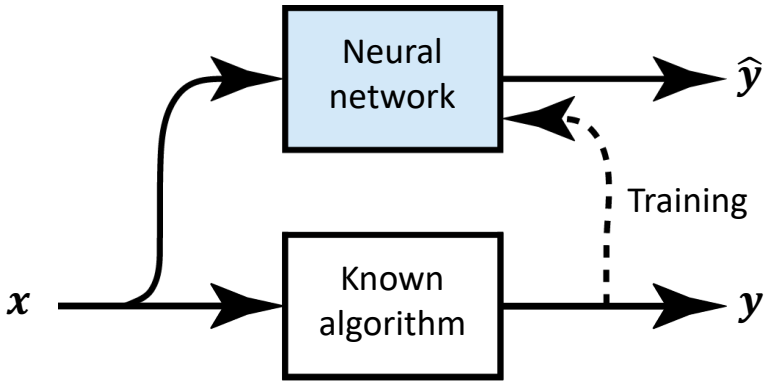
- Identify/demonstrate applications of machine learning in
  a) physical layer
  b) medium access control layer
- Develop optimal benchmarks
- Develop optimization tools to enable efficient learning

Collaboration

- Two productive face-to-face meetings during the autumn
- Joint publications under way

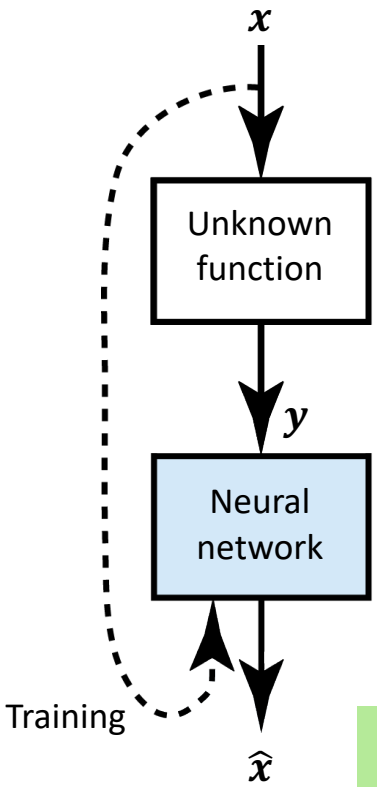
Two Prospective Applications of Deep Learning

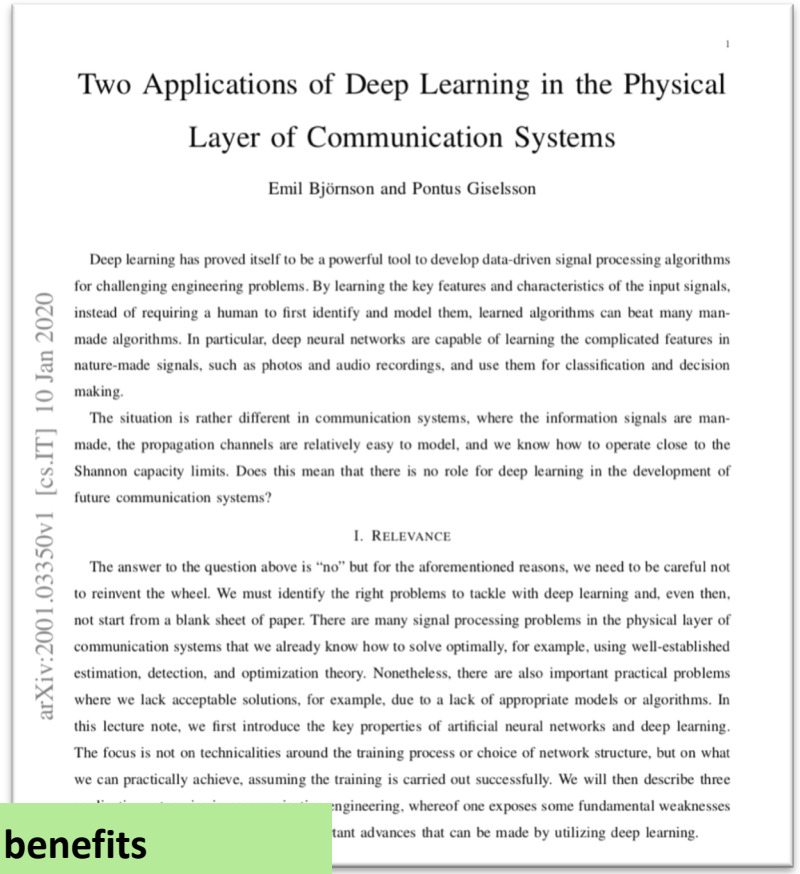
1) Algorithmic approximation



Potential benefits
Complexity reduction
No need to develop dedicated circuits

2) Invert unknown function





Two Applications of Deep Learning in the Physical Layer of Communication Systems

Emil Björnson and Pontus Giselsson

Deep learning has proved itself to be a powerful tool to develop data-driven signal processing algorithms for challenging engineering problems. By learning the key features and characteristics of the input signals, instead of requiring a human to first identify and model them, learned algorithms can beat many man-made algorithms. In particular, deep neural networks are capable of learning the complicated features in nature-made signals, such as photos and audio recordings, and use them for classification and decision making.

The situation is rather different in communication systems, where the information signals are man-made, the propagation channels are relatively easy to model, and we know how to operate close to the Shannon capacity limits. Does this mean that there is no role for deep learning in the development of future communication systems?

I. Relevance

The answer to the question above is "no" but for the aforementioned reasons, we need to be careful not to reinvent the wheel. We must identify the right problems to tackle with deep learning and, even then, not start from a blank sheet of paper. There are many signal processing problems in the physical layer of communication systems that we already know how to solve optimally, for example, using well-established estimation, detection, and optimization theory. Nonetheless, there are also important practical problems where we lack acceptable solutions, for example, due to a lack of appropriate models or algorithms. In this lecture note, we first introduce the key properties of artificial neural networks and deep learning. The focus is not on technicalities around the training process or choice of network structure, but on what we can practically achieve, assuming the training is carried out successfully. We will then describe three engineering, whereof one exposes some fundamental weaknesses tant advances that can be made by utilizing deep learning.

Potential benefits
No need to approximate the function
Capture real characteristics

Publications

1. Özlem Tugfe Demir, Emil Björnson, "**Channel Estimation in Massive MIMO under Hardware Non-Linearities: Bayesian Methods versus Deep Learning**," IEEE Open Journal of the Communications Society, To appear.
2. Emil Björnson, Luca Sanguinetti, "**Making Cell-Free Massive MIMO Competitive With MMSE Processing and Centralized Implementation**," IEEE Transactions on Wireless Communications, vol. 19, no. 1, pp. 77-90, January 2020.

Simulation code On GitHub

3. Sucharita Chakraborty, Emil Björnson, Luca Sanguinetti, "**Deep Learning for Dynamic Clustering in Cell-Free Massive MIMO**," Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, USA, November 2019.
4. Özlem Tugfe Demir, Emil Björnson, "**Channel Estimation under Hardware Impairments: Bayesian Methods versus Deep Learning**," Proceedings of International Symposium on Wireless Communication Systems (ISWCS), Oulu, Finland, August 2019.
5. Emil Björnson, Luca Sanguinetti, "**A New Look at Cell-Free Massive MIMO: Making It Practical with Dynamic Cooperation**," Proceedings of IEEE Symposium on Personal, Indoor, Mobile and Radio Communications (PIMRC), Istanbul, Turkey, September 2019.
6. Emil Björnson, Luca Sanguinetti, "**Cell-Free versus Cellular Massive MIMO: What Processing is Needed for Cell-Free to Win?**," Proceedings of IEEE International Workshop on Signal Processing Advances in Wireless Communications (SPAWC), Cannes, France, July 2019.

Media Coverage

ÖST

Emil Björnson förvandlar stora basstationer till en tejpremsa Foto: Lena Liljeborg/SVT

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