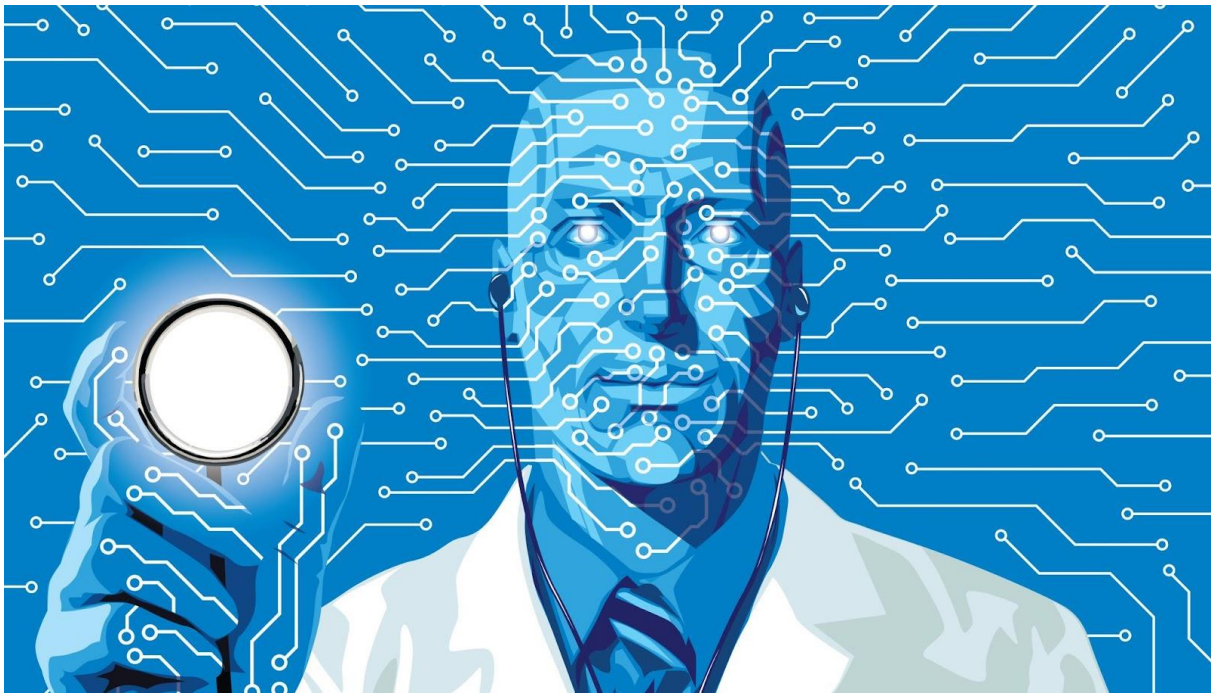
Digital Health and Connected Healthcare
Prof. Dr. Bert Arnrich
Master Thesis Proposal

In cooperation with the surgery department of the Charité Virchow clinic in Berlin

Using State-of-the-art Machine Learning for an Early Warning Complication Prediction System

Exploring new techniques with detailed heterogeneous surgery data



Imagine: you have just had your first ever open-heart surgery. You have regained conscience and look around the ward. You see someone in a white coat walk in: it's your surgeon, Dr. Arzt! He tells you that your surgery went well, and every sign seemed to indicate a quick recovery. But: suddenly he was alerted by an innovative early warning system, that a complication was likely going to happen. You were put under extra supervision, and, indeed, you had a post-surgery heart attack. Luckily, the staff rushed in and quickly managed to make it pass. Soon, all the doctors agree, you can go back home.

In this master thesis, we want to introduce the era of Machine Learning to surgery, which would provide the doctor with information to make better decisions; we can potentially save

years of life. Models like BEHRT[1] or HiTANet[2], have already shown that electronic health records provide major opportunities for disease recognition.

We want to take the next steps by creating a system for high-resolution gastrointestinal surgery data. Whereas earlier works and models have focused on long-term electronic health records, we want to use much more fine-grained, multimodal, data which surrounds the surgery processes. Specifically, we want to use newly collected datasets, provided by our project partners at the Charité, that is collected in the following time periods. This data is high-resolution and covers important vital signs which can have great potential for engineering a novel model for to predict complications. The dataset can be categorized in the following time periods:

Pre-operative anamnesis

Before the operation, for example: patient characteristics

Intra-operative

Measured during the operation, for example: time series and clinical scores

Post operative ICU

Measured immediately after the operation, for example: vital signs

Normal ward sensors

Measured in the days after the operation after moving the patient to the normal ward, for example: vital signs measured by wearables.

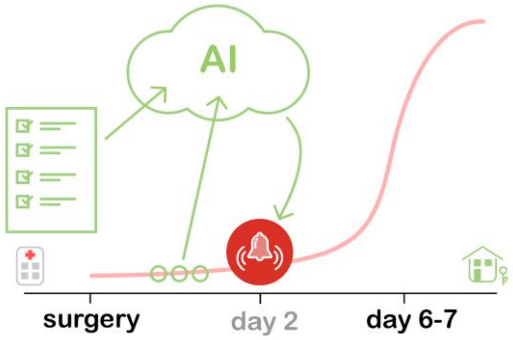


Figure 1: A System that alerts doctors of complications before they are likely to happen

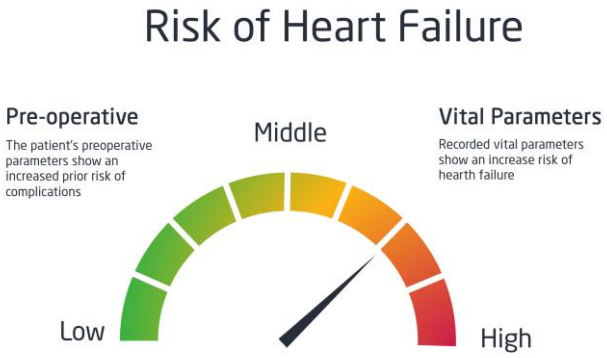


Figure 2: Calculating the risk of complication before an operation

In your master thesis, we want to you to discover the current best practices and using to develop a model which is able to accurately predict the probability of a complication. In order for the prediction system to be used in practice, we will also need a high degree of so-called

[1] Y. Li et al., "BEHRT: Transformer for Electronic Health Records," Sci Rep, vol. 10, no. 1, p. 7155, Dec. 2020, doi: 10.1038/s41598-020-62922-y.
[2] Luo, M. Ye, C. Xiao, and F. Ma, "HiTANet: Hierarchical Time-Aware Attention Networks for Risk Prediction on Electronic Health Records," in Proceedings of the 26th ACM SIGKDD International Conference on Knowledge Discovery & Data Mining, Virtual Event CA USA, Aug. 2020, pp. 647–656. doi: 10.1145/3394486.3403107.

explainability (see, for example, Lauritsen et al.[3]) to enable the doctor to extract new insights to apply in practice. You will be discovering the ideal model characteristics and testing them on the data from the Charité to make your predictions as accurate as possible.

We explicitly offer the possibility to contribute to computer science research and current medical practice by publishing your results.

Requirements and Expectations

This master thesis offers an opportunity to contribute to the practical application of state-of-the-art computer science to improve daily medical practice. To participate, you have a data science or computer science background and are excited to learn about applying this to the health domain. The following topics will be relevant for this project, and we expect prior knowledge of at least one of the following:

- Machine learning and deep learning
- Processing static, textual, and time-series data
- Doing an extensive review on existing prediction systems
- Creating a reliable, extensible, and explainable AI system

Contact

If you have any questions about the project, do not hesitate to contact us.

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[3] S. M. Lauritsen et al., "Explainable artificial intelligence model to predict acute critical illness from electronic health records," Nat Commun, vol. 11, no. 1, p. 3852, Dec. 2020, doi: 10.1038/s41467-020-17431-x.