02466
Project Work
Bachelor of Artificial Intelligence and Data

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1 Motivation

When patients undergo cardiac surgery, a serious number of risk scores will follow. The most widely used tools for estimating complication rates are EuroSCORE II and STS risk score. However, these risk scores come with shortcomings, as they lack precision in estimating the risk for the individual patient, and they are mostly designed to predict mortality but not morbidity. Therefore, this project investigates the possibilities of using Artificial Intelligence (AI) to create stronger prediction models. Ultimately, if these AI models, in opposition to the existing ones, can be trained to detect complications in patients earlier, as this will help prevent mortality when undergoing surgeries. It is known that yearly, out of 1800 patients who undergo cardiac surgery at Rigshospitalet in Copenhagen. A crucial amount of these individuals will experience complications post surgery, keeping them hospitalized longer, and sometimes their health becomes fatal. The investigation done in this project is, therefore, highly important, as this new found knowledge can serve as guidance for doctors and patients deciding on the surgery.

2 State of the art

This section describes existing academic theory and previously used methods for creating the EuroSCORE II model, based on the belonging EuroSCORE II article[1]. The goal of this article was to update the European System for Cardiac Operative Risk Evaluation (EuroSCORE) risk model from the year 1995, which is mentioned as the first EuroSCORE model. Here, the newer EuroSCORE II model from 2012 was trained based on existing EuroSCORE risk factors as well as additional factors. When training this model, the data was split into a subset for training a logistic regression model and a subset for testing the model. The article concludes that EuroSCORE II was superior, as it is better calibrated while preserving powerful discrimination. From this model, it was also deduced that cardiac surgical mortality has been significantly reduced in the last 15 years despite including older and sicker patients.

However, apart from studying the EuroSCORE II model, it is mostly of interest to create stronger AI models for determining complications post surgery that covers what EuroSCORE II is unable to. Previous studies have utilized deep learning and machine learning methods to do exactly this. The article "Prediction of lactate concentrations after cardiac surgery using machine learning and deep learning approaches" [2] is an instance of this, as it highlights how researches have used the machine learning models random forest, artificial neural network and a multivariate linear regression model for predicting lactate concentration in patients after they have undergone cardiac surgery. Here, higher levels of lactate concentration is described as a possible complication post surgery. These models will, therefore, serve as basis inspiration for possible methods in this project.

[1]https://www.euroscore.org/index.php?fid=201

3 Data description

The data used in this project, is collected from 8000 patients, over five years, undergoing cardiac surgery at Rigshospitalet. The Cardiac patient data journey has a Preoperative section as; "sex, age, ECG, medical- and surgical history etc.", Perioperative as; "blood pressure, heart rate, pressure, etc.", ICU as; "blood pressure, heart rate, dialysis, etc.", Ward as; "blood pressure, heart rate, medication" from appendix 1. The above data is described in a sampling rate in the Table 1, at a surgery ($T = 0$) from appendix 2.

Variables	**Preoperative**	**Perioperative**	**Postoperative**	**High Frequency**
Medical history	√	X	X	X
Surgical history	√	X	X	X
Echocardiography	√	√	√	X
Pulmonary function	√	X	X	X
Coronary angiography	√	X	X	X
Monitors	√	√	X	√
Charts	√	√	X	√
Medication	√	√	X	√
Biochemistry	√	√	√	√
Ventilator	X	√	√	√
Extracorporal circulation	X	√	√	√
Age	√	X	X	X

Table 1: Sampling rate

Furthermore, a logistic regression (EuroSCORE II) on the data has already been made, which would be used to compare the more complex machine model that will be created during this project.

There will be a restriction when working with the data, for the reason that the data used is under the GPR-rules, thus, the data can only be used on one computer when training and creating the machine learning models.

4 Research questions

The main focus is to assess the risk of organ failure following cardiac surgery, which is especially to investigate the risk of mortality after 30 to 90 days post-surgery. To research that there are three following questions:

- To what extent is a Machine Learning (ML) model able to outperform the EuroSCORE II, in predicting the mortality of a cardiac surgery patient, and is it more practical?
  - This will be operationalized by first choosing and designing a suitable ML model, that can predict the probability of mortality, like the EuroSCORE. It is important to create a common ground for comparison, for a valid result.
- Is there a correlation between different groups and the outcome of the surgery, so the complex ML model can decide if a patient should undergo cardiac surgery?
  - This will be investigated by using either a regression or classification model, depending on which model makes the most sense. Certain groups will be chosen with either logical reasoning or, methods like a MARS model.
- How well can ML models predict post-operative complications, like organ failure, so the patient would not stay in the ICU?
  - This question will be operationalized, by firstly creating some relevant metrics to predict. Afterward, a Deep Learning Network will be fitted to the data to find linear or nonlinear correlations, between measurements and the chosen post-operative metrics.

References

[1] PhD studerende Theis Itenov MD PhD Lars Grønlykke MD PhD Chaoqun Zheng, MD. *Cardiac surgery prediction modelling*, pages 3, 4. 2024.

[2] Evan Yu Brian Bush Youn-Hoa Jung Zachary Murphy Lee Goeddel Glenn Whitman Archana Venkataraman Charles H. Brown Yuta Kobayashi, Yu-Chung Peng. Prediction of lactate concentrations after cardiac surgery using machine learning and deep learning approaches. 2023.

5 Appendix

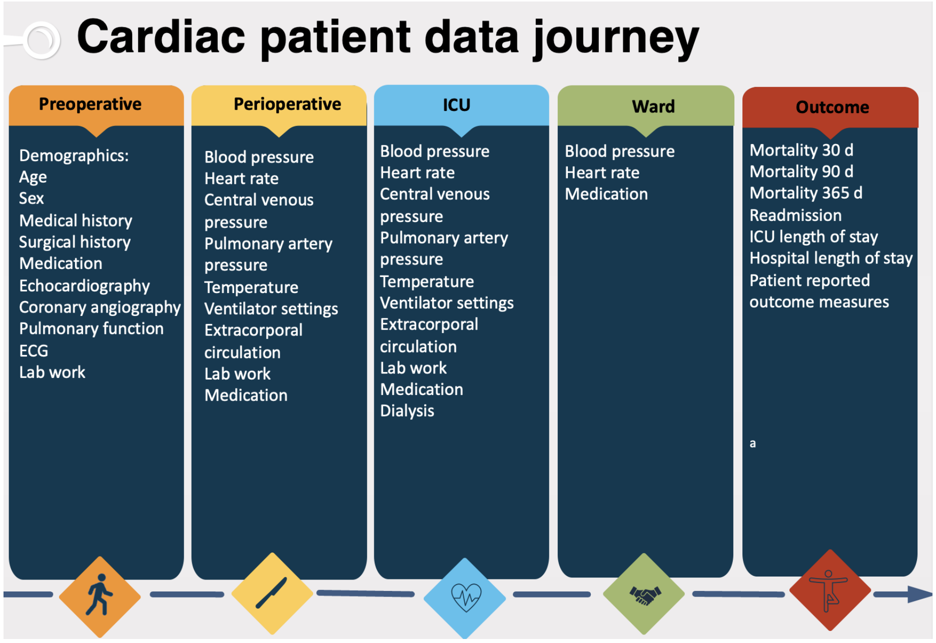

Figure 1: Cardiac patient data journey [1]

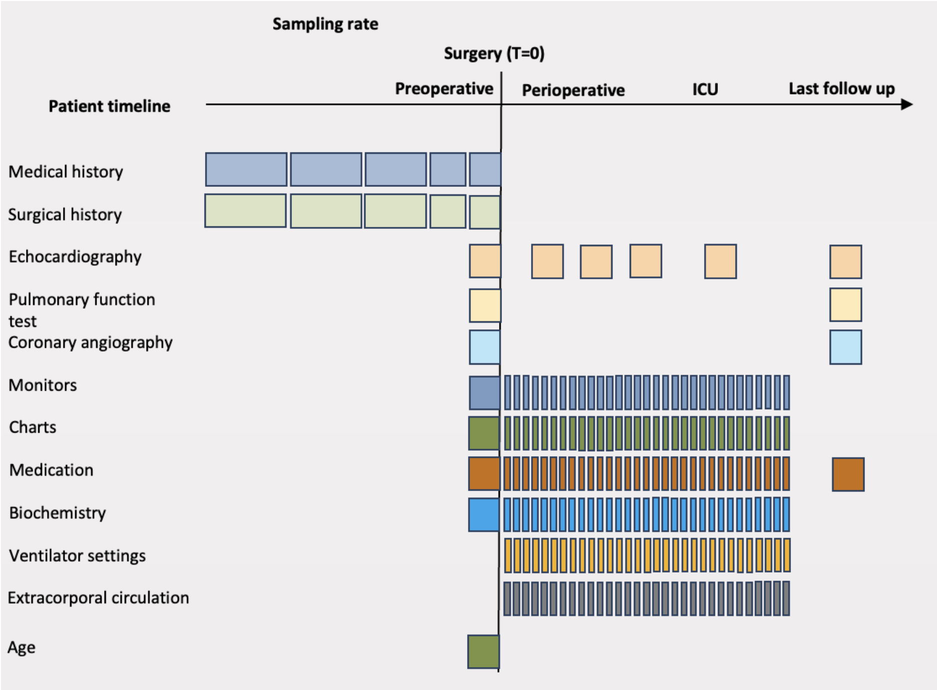

Figure 2: Sampling rate [1]