

# Prediction of Ambulance Demand and KPIs in cooperation with IABG mbH

IABG mbH is an European technology company with the core competencies of analysis, simulation & testing as well as plant and system operation. Its clientele is essentially composed of renowned industrial players (manufacturers of aeronautics and space systems, of automobiles and their suppliers), Federal Ministries and various State Ministries. In this context, IABG has been active in the field of control & situation centers for many years and supports customers in further development and optimization.

For emergency medical service (EMS) systems, fast response times are paramount to provide first aid in a timely manner. To improve response times, models exist to predict the demand for ambulances in the future. Many models build upon a given demand distribution to calculate the expected performance measures such as the average response times. These performance measures are used to optimize facility or ambulance locations as well as the dispatching process of ambulances. For small systems, models, such as the hypercube queueing model, can exactly calculate the expected performance measures. However, for large systems, this remains a challenge in literature and practice.

## Aims and scope of the thesis

The aim of this master thesis is to evaluate different architectures of machine learning models to predict the response times of ambulances for different regions focusing on large EMS systems. In the following, two example architectures are given. First, the performance measures of the EMS should be predicted in two steps. Here, the performance measure prediction should be based on the outputs of a demand prediction. Second, the demand and performance measures should be predicted in one integrated model. For the different architectures, the implementation and combination of different machine learning models should be considered. As a basis, historical ambulance demand and the observed EMS performance measures must be pre-processed. In the following, suitable model architectures should be identified, implemented and evaluated.

To summarize, the work consist of the following research tasks:

- Literature review on predicting ambulance demand and response times applying machine learning
- Identification of suitable machine learning model architectures
- Formulation of theoretical models and architectures
- Implementation and optimization of the model architectures
- Evaluation and comparison of the developed architectures based on suitable key performance indicators

## Requirements

This thesis targets students of the TUM-BWL (with a major in Supply Chain Management), Data Science, Informatics, Engineering or similar study programs. Knowledge of mathematical programming, optimization, and a general-purpose programming language (e.g. C++, Java, Python) is required. Prior participation in one of the seminars offered by the chair (i.e. Modeling Future Mobility Systems, Advanced Seminar) is recommended. The thesis should be written in English.

## Related Research

- Setzler H, Saydam C Park S (2009) EMS call volume predictions: A comparative study. *Computers & Operations Research* 36(6):1843-1851.
- Lin AX, Ho AFW, Cheong KH, Li Z, Cai W, Chee ML, Ng YY, Xiao X, Ong MEH. Leveraging Machine Learning Techniques and Engineering of Multi-Nature Features for National Daily Regional Ambulance Demand Prediction. *International Journal of Environmental Research and Public Health*. 2020; 17(11):4179.
- Russell, S., Norvig, P. (2002). *Artificial intelligence: a modern approach*.

**Begin:** as soon as possible

**Advisor:** Maximiliane Rautenstraub

**Application:** See <https://www.osm.wi.tum.de/education/masters-thesis/>