

Prediction of Patients' Length of Stay after Surgery using Multi-Model-Ensembles

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INTRODUCTION

Bed management plays a crucial role in hospitals. Up to now, available bed management software mainly allows for recording occupied beds, but there is no forecast about when beds will be unoccupied. Since 2015, University of Applied Sciences Upper Austria and Oberösterreichische Gesundheitsholding (OÖG) have developed the benchmarking platform LeistungsVergleich Medizin (LeiVMed) to provide transparency concerning morbidity and mortality, processes, and cost of care in hospitals in Upper Austria. [1, 2] The data collected comprise more than 200 000 patients and include specific medical data (e.g., risk factors and complications) about patients and services provided before surgery, during their stay, and after discharge.

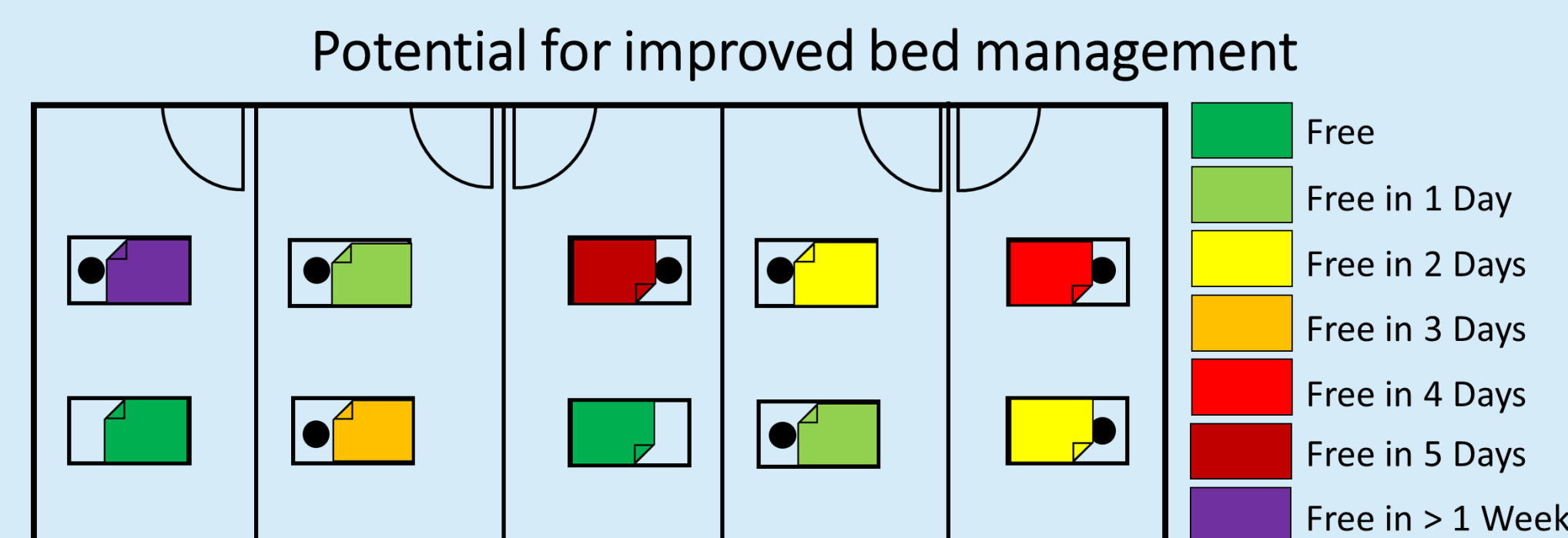


Figure 1: Schematic representation of the potential of using ML for bed management after surgery.

AIM

We investigate the feasibility of predicting the length of stay (LOS) of individual patients after surgery using a multi-model ensemble (MME) machine learning (ML) approach. Early and accurate prediction of the LOS shows great potential for improved scheduling, resource planning, and cost reduction.

METHODS

For modeling, information of more than 200 000 patients who underwent one out of 27 different surgeries was used. Models were learned that are able to predict the patients' LOS. These ML models were trained with classification and regression algorithms and were combined in a MME. Eight classes to categorize the LOS after surgery were defined: 1, 2, 3, 4, 5, 6 days, 7 to 30 days, and > 30 days. MMEs were generated using data before, on the surgery day, and up to seven days after surgery.

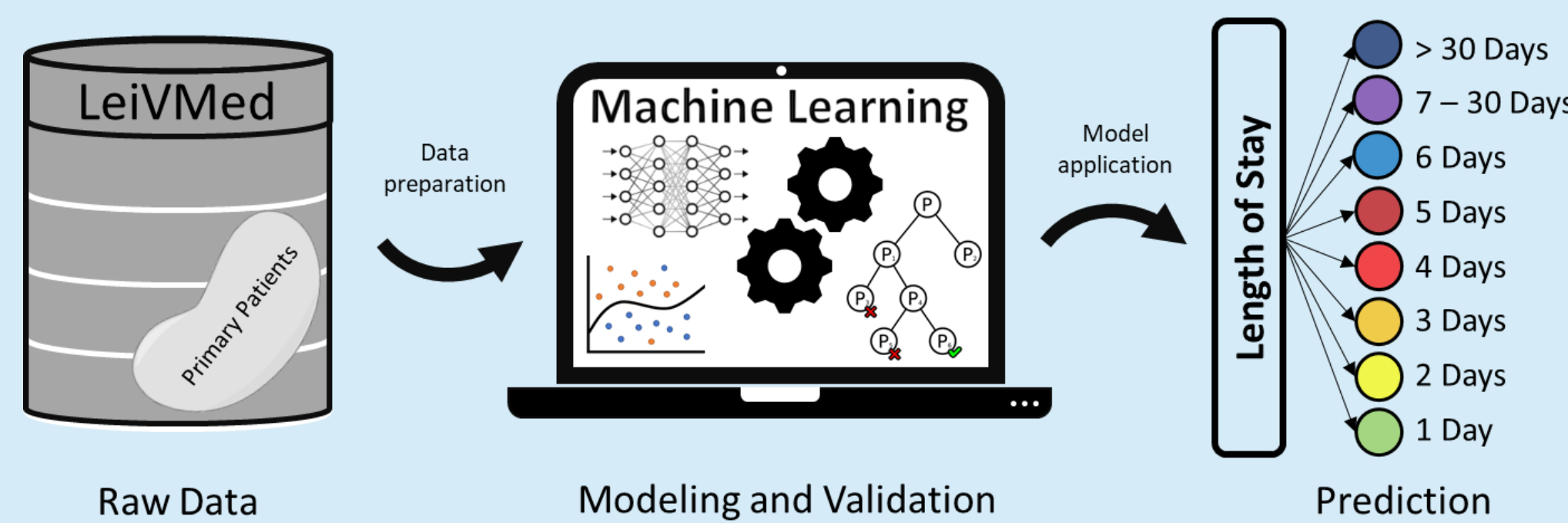


Figure 2: LOS prediction workflow.

RESULTS

Results show that 68.97% of all cases are correctly categorized into one of the eight different classes using data from the admission day until surgery (Figure 3). When including classifications one day before and after the target class (light blue bars in Figure 3), the accuracy is 91.97%. Investigating the results of the 27 surgeries, we see that in some surgeries the classification process is more complex than in others, such as appendectomy and cesarean section. However, these surgeries show higher variance in LOS and an increased number of emergency cases compared to scheduled cases (95.01% acute cases of appendectomy and 57.17% of cesarean section). Better classification performances are obtained for extracapsular cataract extraction (1.77% acute cases; 97.34% accuracy) and adenotomy (4.39% emergency cases; 93.19% accuracy). Using the MME approach, we further see, as shown in Figure 4, that hospital discharges within the first four days after surgery show higher accuracies (e.g., day one after surgery: 85.41%) compared to day five and more after surgery (five days: 70.66%).

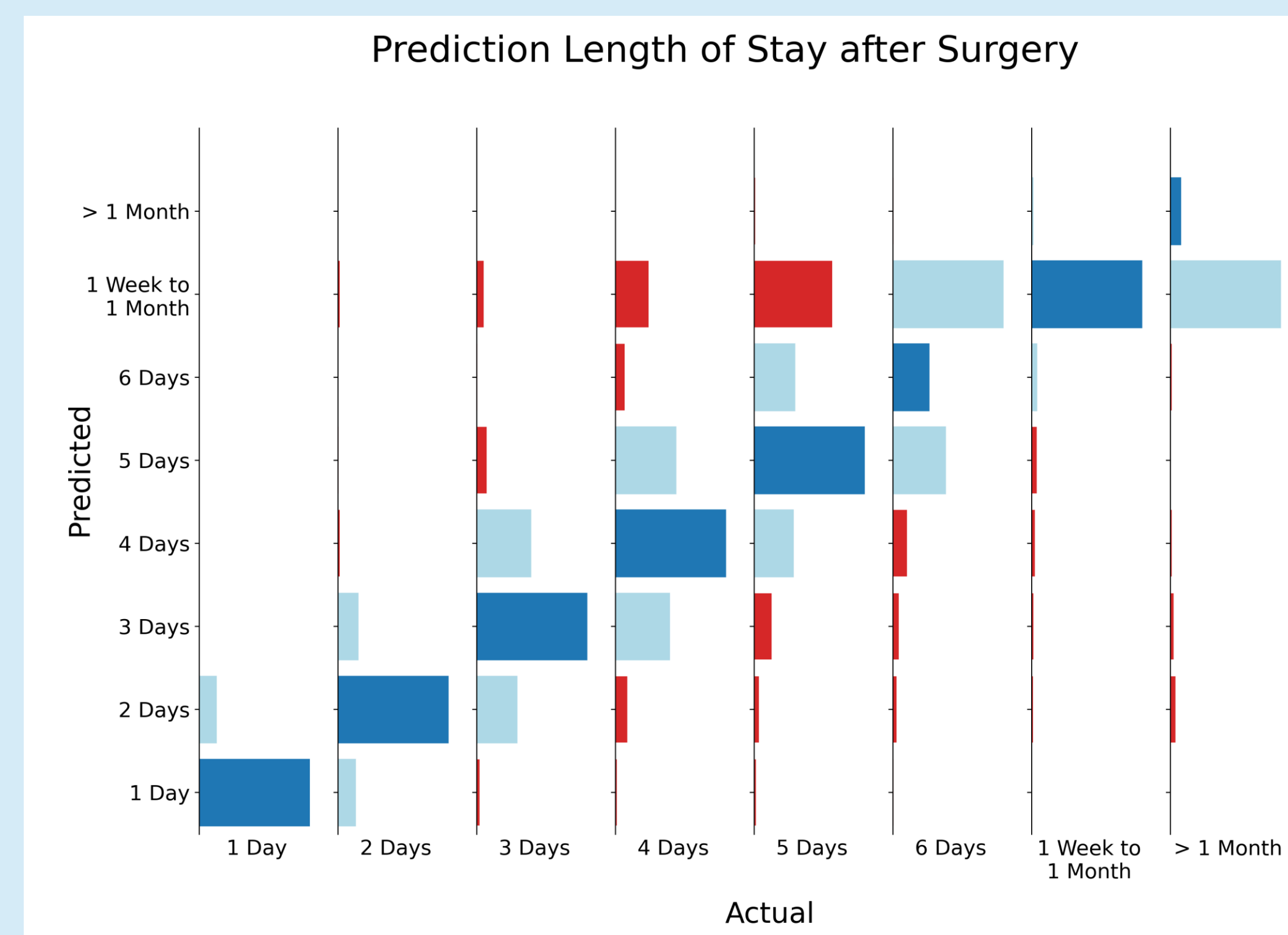


Figure 3: Confusion matrix in bar chart format showing the percentage of correctly predicted (blue) cases. In light blue, cases with +/- one day classification are shown.

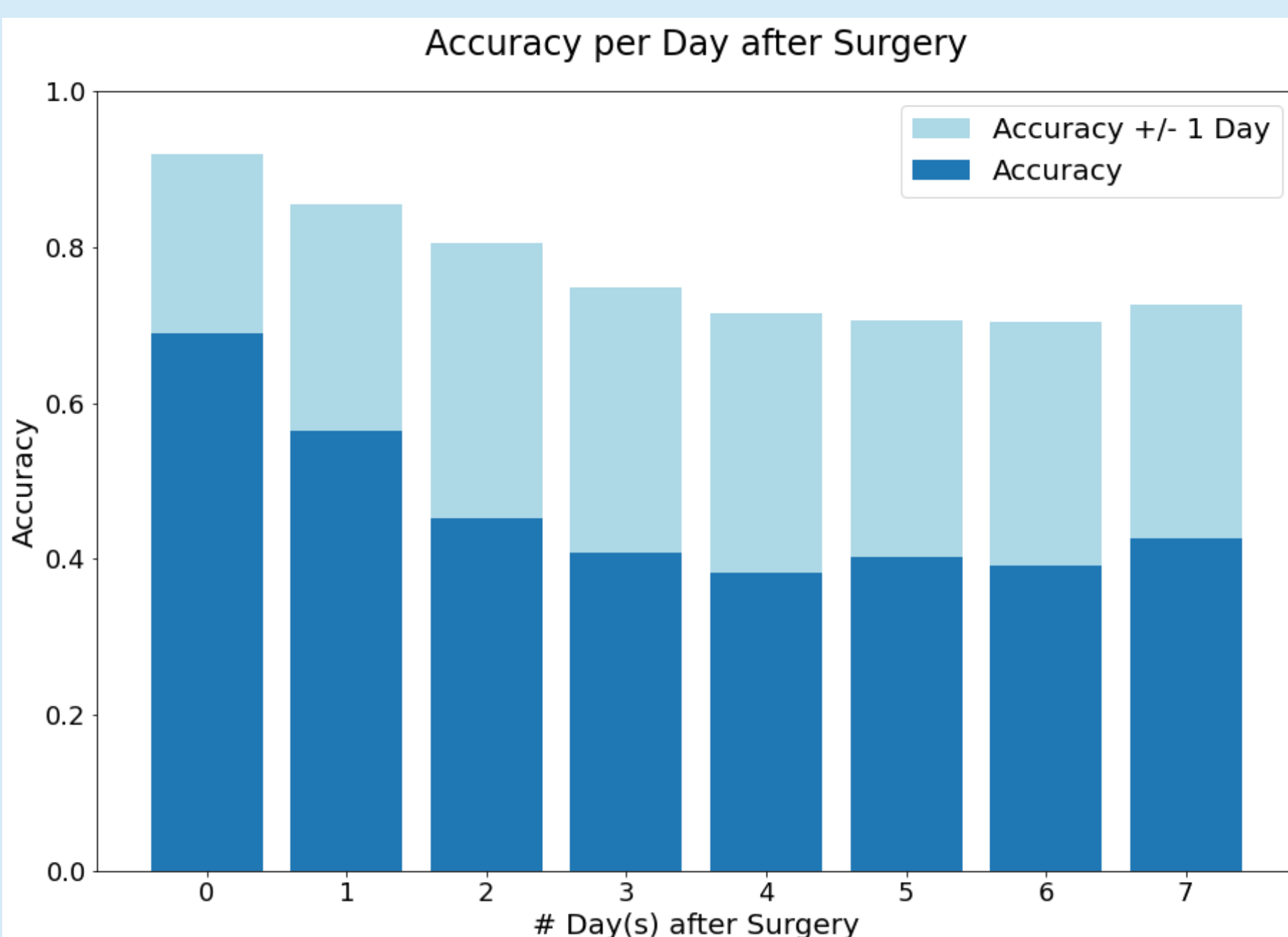


Figure 4: Accuracies of the MMEs from the day of the surgery and up to seven days after surgery. Light blue shows the percent of correctly predicted cases allowing +/- one day.

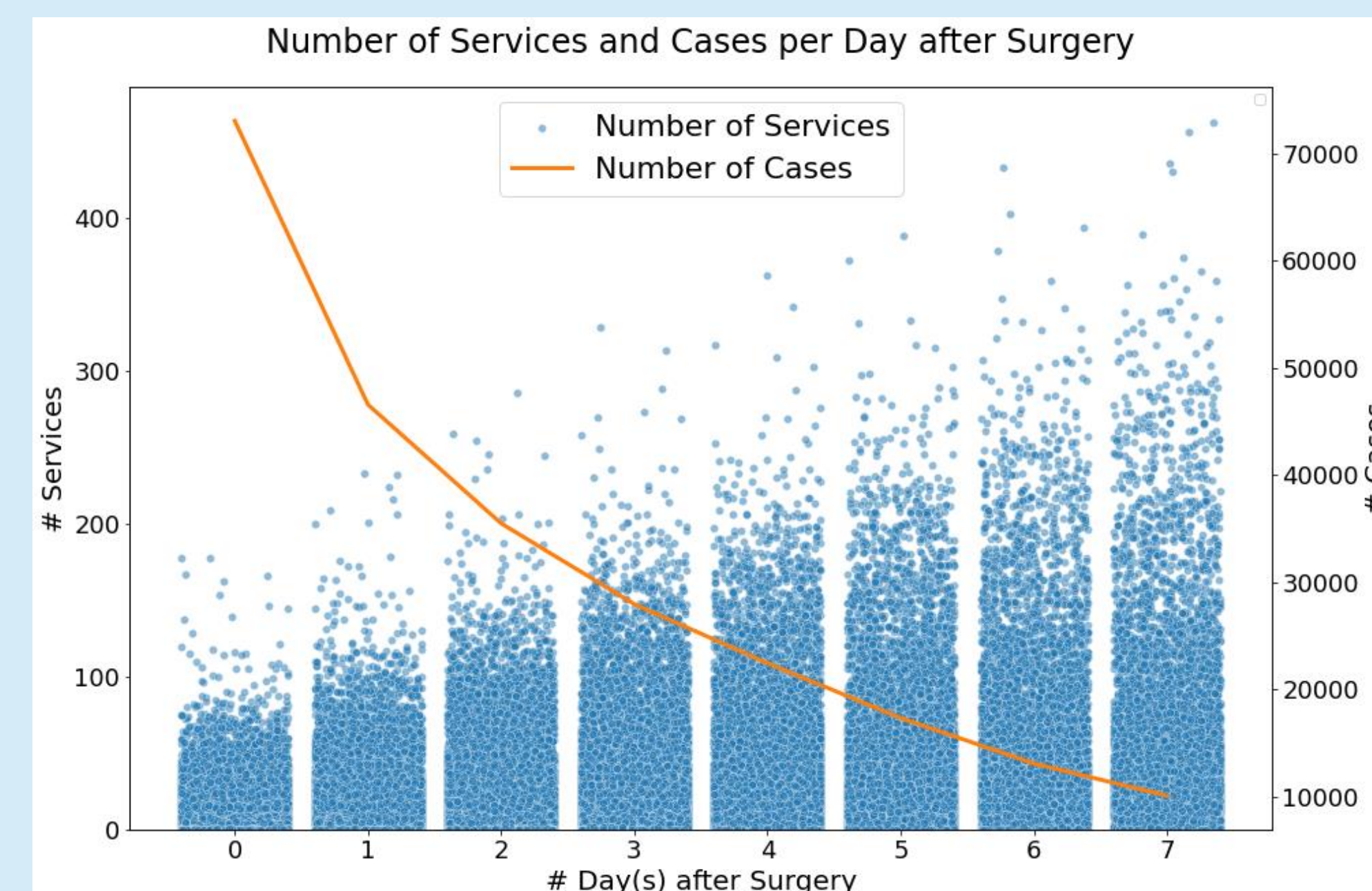


Figure 5: Number of services increasing for each patient from the day of surgery until one week after (blue) as well as the number of patients (orange) used for LOS prediction.

CONCLUSIONS

Our results show that careful algorithm and feature selection, algorithm parameter finetuning, and the MME approach promise potential for patients' LOS prediction. Especially, predictions on the day of surgery show high potential for an AI-assisted system for bed occupancy planning in hospitals. Calculating the total estimated days of occupancy for one to six days after surgery, the predicted LOS deviates by 7.64% from the actual value. Due to the rather high dropout rate after each inpatient day and the increasing variance in the number of services (see Figure 5), LOS prediction seems more difficult using data after surgery. However, we see the feasibility of LOS prediction after surgery and the potential to improve scheduling and resource planning in hospitals.

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