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Automated ML Techniques for Predicting COVID-19 Mortality in the ICU

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Abstract. The COVID-19 infection is still a serious threat to public health and healthcare systems. Numerous practical machine learning applications have been investigated in this context to support clinical decision-making, forecast disease severity and admission to the intensive care unit, as well as to predict the demand for hospital beds, equipment, and staff in the future. We retrospectively analyzed demographics, and routine blood biomarkers from consecutive Covid-19 patients admitted to the intensive care unit (ICU) of a public tertiary hospital, during a 17-month period, relative to the outcome, in order to build a prognostic model. We used the Google Vertex AI platform, on the one hand, to evaluate its performance in predicting ICU mortality, and on the other hand to show the ease with which even non-experts can make prognostic models. The model's performance regarding the area under the receiver operating characteristic curve (AUC-ROC) was 0.955. The six highest-ranked predictors of mortality in the prognostic model were age, serum urea, platelets, C-reactive protein, hemoglobin, and SGOT.

Keywords. Artificial intelligence; machine learning; COVID-19; SARS-CoV-2; ICU—intensive care unit; automated machine learning.

1. Introduction and background

The COVID-19 infection is still a serious threat to public health and healthcare systems, as declared by the WHO's Emergency Committee [1]. The increase in patient numbers and the resulting scarcity of medical resources during the Covid-19 pandemic are two of the biggest problems confronting healthcare systems worldwide. Recent research suggests that the most effective way to meet these requirements would be to use machine learning (ML)-based predictive models of disease severity and outcome. This would allow for the most effective use of resources in the intensive care unit. [2-4]. However, there are currently few prognostic models in clinical use that have received sufficient validation.

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In this study, we evaluated the ability of an automated ML platform, namely the Google Vertex AI [5], to predict the mortality of critically ill COVID-19 patients in the Intensive Care Unit (ICU). A simple dataset consisting of demographic information and results of routine blood tests was used. By using an auto ML platform, we aimed to show the ease with which even non-experts can make prognostic models.

2. Methods and Materials

The records of all consecutive patients with real-time polymerase chain reaction (PCR)-confirmed COVID-19 pneumonia that were admitted to the Intensive Care Unit (ICU) of a tertiary public hospital during a 17-month period from October 2020 until February 2022, were retrospectively analyzed, after approval by the Institutional Review Board (IRB) of the hospital (no. 4333/2022). The primary end-point of the study was ICU mortality, and the secondary end-point was the recognition of the most important risk factors. From the Hospital IT system, we extrapolated patient demographics, several blood biomarkers routinely measured in Covid-19 patients, and ICU outcome. In particular, the dataset comprises seventeen attributes: age, serum levels of Urea (UREA), Creatinine (CREA), Creatine Kinase (CPK), Troponin, C-Reactive Protein (CRP), Lactate Dehydrogenase (LDH), serum glutamate-pyruvate transaminase (SGOT), serum glutamate-oxaloacetate transaminase (SGPT), total bilirubin (TBIL), D-Dimer, International Normalized Ratio (INR), hemoglobin (HGB), white blood cells count (WBC), lymphocyte count (LYM%), neutrophil count (NEUT%), platelets (PLT), and the binomial ICU outcome (survival or death).

2.1. Data preprocessing

We only use the first seven measurements of selected laboratory biomarkers from each patient during the ICU stay. In case of missing values in any of the attributes taken into consideration in this study, we replace them by calculating the average of the existing measurements that correspond to this attribute in the dataset.

2.2. Model Building

The classification problem we had to solve involved two classes of patients: those who survived and left the ICU and those who did not survive. For our experiments, we used the Google Vertex AI platform [5]. Researchers can create expansive and accurate predictive models by using AutoML, which automates the application of various ML techniques. Since it takes a lot of time and resources to build and compare the performance of numerous models, traditional ML model development is resource-intensive. Automatic scaling and normalization techniques are applied to all data by default in AutoML experiments. We kept all the default parameters and refrained from applying custom settings at any point because the goal of our research paper is to present an easy-to-apply procedure that can be explained to and even used by non-technical experts. To prevent overfitting in our analysis, we trained our models using a 10-fold cross-validation (CV) procedure.

2.3. Model Evaluation

The performance metrics that we use to evaluate the deduced model are the Precision-Recall Area under Curve (PR AUC), the Receiver Operating Characteristic Area Under Curve (ROC AUC), the F1 score, the Log loss, the Precision, and the Recall.

3. Results

Totally, 373 patients (140 female, 233 male) with COVID-19 pneumonia were included in the study. Among them, 102 (27.34%) died in the ICU. Non-survivors were older (mean [SD] age 70 yr [11.6 yr] vs 64.4 yr [13.5 yr]) and more likely to be female (28.6% vs 26.6%). The descriptive statistics for Age, Gender, and Outcome are summarized in Table 1. The performance metrics of the deduced model are shown in Table 2.

Table 1. Descriptive statistics for Age, Gender, and Outcome

Age (years)		Gender (%)		Outcome (%)	
Median	68	Male	233 (62.46)	Survived	371 (72.65)
Mean (SD)	65.9 (13.21)	Female	140 (37.53)	Died	102 (27.34)
IQR	58-75	Total	373	Total	373

Table 2. Performance metrics of the model

PR AUC	ROC AUC	Log loss	F1 score	Precision	Recall
0.956	0.955	0.272	0.906383	90.6%	90.6%

The corresponding AUC-ROC curve of the model is shown in figure 1.

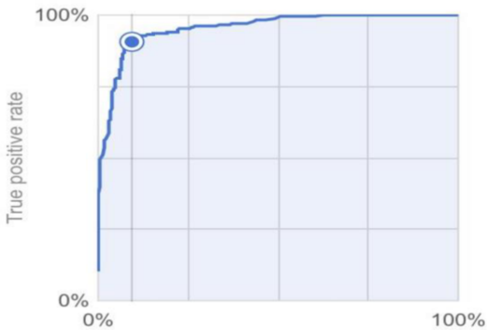

Figure 1. Receiver Operating Characteristic (ROC) Area Under Curve (AUC)

The six more important attributes of those that we are taking into consideration for the prognostic model are Age, Urea, PLT, CRP, Hgb, and SGOT.

4. Discussion

Approaches utilizing machine learning are increasingly being used to support medical diagnosis or treatment [2-4]. In this study, we used an auto ML platform to predict ICU mortality of critically ill COVID-19 patients. The deduced model presented a high performance (PR AUC 0.956). Older age, acute kidney injury, and thrombocytopenia most strongly influence the model and are principally associated with a detrimental outcome. Healthcare professionals who are unfamiliar with machine learning (ML) can benefit from using autoML platforms because they can deliver quick and accurate results [5,6]. In an ideal scenario, the involvement of data scientists could be crucial, particularly during the stages of data pre-processing, by extracting useful information from the data, choosing the right features, and ultimately assessing the outcomes. Despite lack of external validity and restricted generalizability of the model, our goal was to develop a low-cost tool using readily available data to assist clinicians in quickly discriminating patients with increased risk of mortality and directing appropriate treatment.

5. Conclusion

We assessed the performance of the Google Cloud Vertex AI platform in predicting ICU mortality of COVID-19 patients. We additionally recognized important variables associated with an unfavorable outcome. Auto ML may be a reliable prognostic tool that can be used even by non-expert healthcare professionals.

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