Mortality prediction after PCI/CABG using ECG and comorbidities

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Background

The treatment of myocardial infarction (MI) using percutaneous coronary intervention (PCI) or coronary artery bypass graft (CABG) is often directed by guidelines and population-level studies[1,2,3,4]. These studies, with often unclear or limited effect sizes, are based on large, heterogeneous study populations. Personalization of treatment plans is mainly based on physician expertise. Patient-specific risk scoring and outcome prediction are hardly used due to their low predictive power[5,6]. These scoring systems use very limited sets of structured, patient-level data. Mahayni et al. recently showed promising results, predicting mortality after cardiac surgery using an electrocardiography-based AI model[7]. We propose a data fusion approach to predicting treatment outcome, through merging ECG recordings around the MI event with comorbidities and laboratory measurements. Current results show our system in action in an age-predicting task; results on our main clinical question are expected in the near future.

Methods

Our dataset is retrospective data from a regional hospital, AZ Delta, in Belgium. The complete dataset contains over 100.000 patients, for whom structured data has been mapped to an OMOP-dataset in Google BigQuery. The mapped data include diagnoses, procedures, laboratory measurements, clinical measurements, medication prescriptions, questionnaires, demographic data… From this dataset, binary features are derived, annotating the presence or absence of comorbidities. Comorbidities contained in the Charlson comorbidity index (CCI)[8] are extracted, using concept codes selected by a physician using our in-house concept set builder, *Rabid*. Over 600.000 electrocardiograms (ECG's) are extracted from our MUSE-database and stored as a separate Parquet-dataset.

We developed a new neural network architecture (fig. 1), using a convolutional network, similar to Ribeiro et al[9], to reduce the ECG's to a limited number of features. These features are combined with the binary comorbidity-features and fed into two dense layers followed by a task-specific output layer. To predict survival after a specific time interval (90 days, 1 year and 3 years), a sigmoid output layer is used. The correct output labels are extracted from our OMOP-dataset. Predictive power will be assessed using the AUC-value, and compared with current state-of-art results from literature and with simplified systems using only ECG or only comorbidity data.

As an initial task, we predicted age, extracted from OMOP, using only ECG signals and evaluated the correlation between the error in predicted age and the CCI at time of ECG measurement. For this regression task, the output layer was changed to a linear layer. The data was split in a training, validation and test set following an 80/10/10 split.

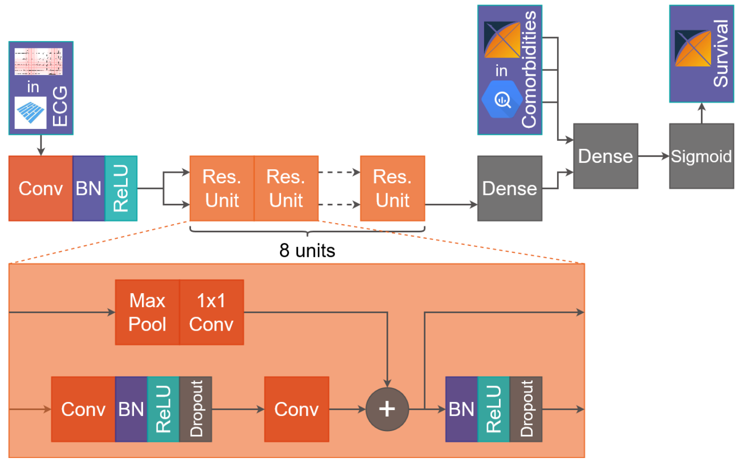

Figure 1. Network architecture, fusing ECG (in Parquet dataset) and (OMOP-derived) comorbidities (in Google BigQuery dataset) to predict survival after PCI/CABG.

Results

For now, we only present preliminary results for the age-predicting task. Our model can predict age upto a mean absolute error of 6.9 years, just like the model from Attia et al.[10] (fig. 2). Similar to their results, we show a slight skew to overestimation of the age. Furthermore, using our OMOP-dataset, we are able to show the random nature of the error, showing no relationship with the CCI at time of ECG measurement.

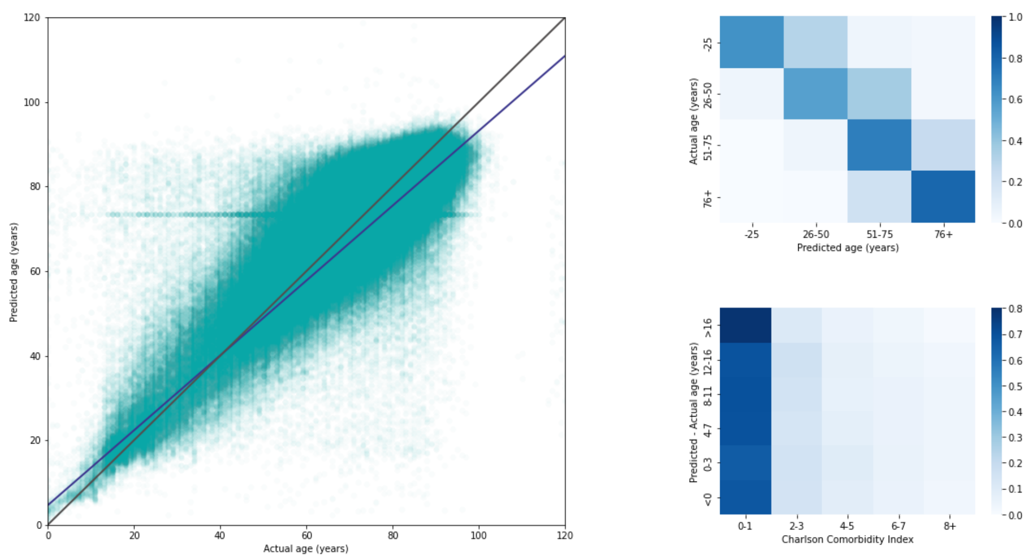

Figure 2. Clear linear relation between predicted and actual age, with robust linear regressor close to identity relation (left). Bucketing shows bias to older age (top-right). No relationship between Charlson Comorbidity Index and the overestimation of age (bottom-right).

Conclusion

We can show a working set-up, linking ECG-signals with data derived from an OMOP dataset to make patient-specific predictions. Age-prediction was used as an initial task to identify and optimize a neural network architecture capable of extracting subtle but meaningful features from an ECG signal. Results on predicting mortality after PCI or CABG for myocardial infarction are coming soon.

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