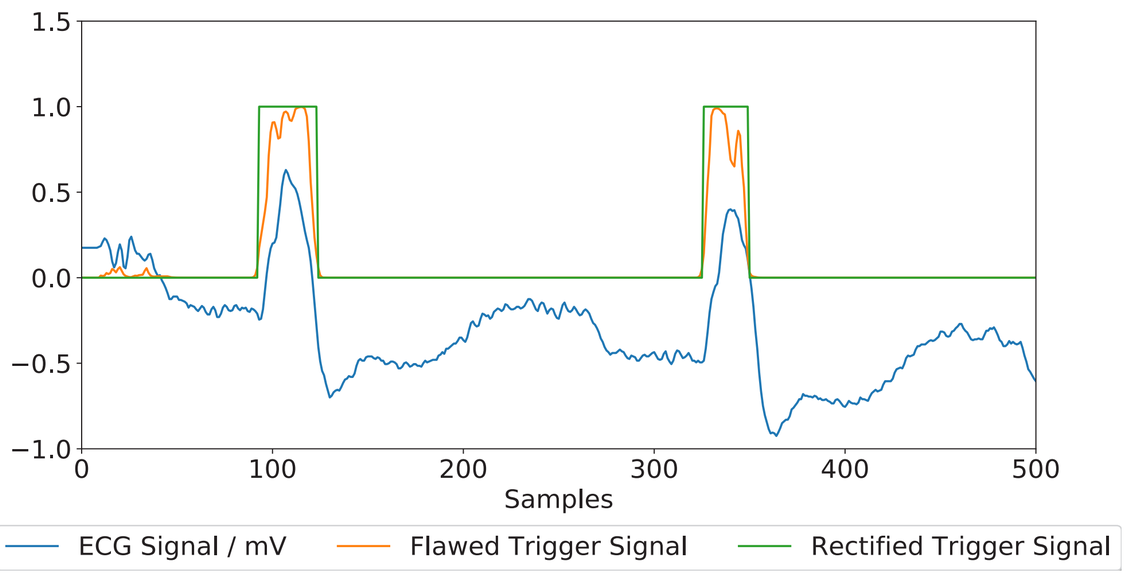
Assessing Certainty of QRS Detection
on Single-Lead Electrocardiograms Based on Artificial Neural Networks

QRS Detection with Artificial Neural Networks

The QRS complex (to be seen at samples 100 and 350 in the figure below) is the most dominant feature of the electrocardiogram (ECG). Its detection is prerequisite for a number of downstream analyses. One approach to QRS detection is based on artificial neural networks (ANNs), involving three steps:

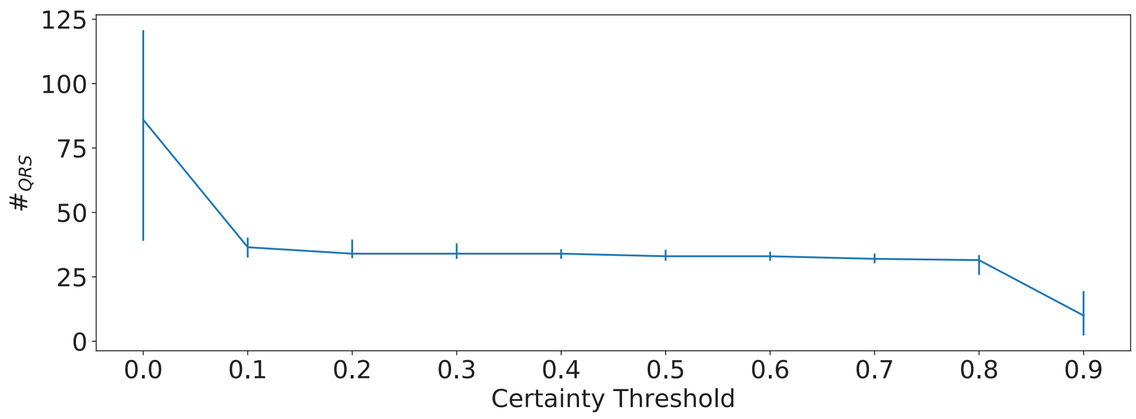
- Take for each sample of the ECG signal a neighborhood (*window*) of n samples as representative.
- Use the ANN to classify each *window* whether a QRS complex is visible in the window (class 1) or not (class 0).
- Interpret the classification as a new signal (trigger signal) ideally having a square pulse shape. Parts of the trigger signal with value 1 (*plateaus*) represent parts of the ECG signal with a QRS complex.

In the presence of noise, the trigger signal degenerates and differs from the expected square pulse shape. This is shown by the flawed trigger signal (*fts*) below. The rectified trigger signal (*rts*) is a perfect square pulse signal generated from the *fts*.

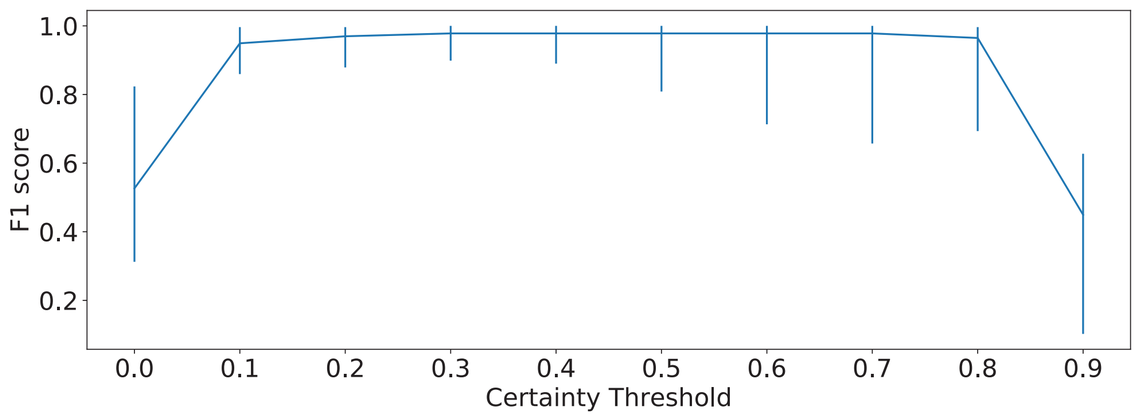


Assessing Certainty

We propose assessing certainty of a QRS detection by computing the ratio of the area under the *fts plateus* with the area under the *rts plateaus*. This can be used for detecting noise but also for improving QRS detection in the presence of noise. By choosing a reasonable certainty threshold (*ct*) below which we reject detected QRS complexes, we can remove false positives while retaining actual QRS complexes. The figure below shows the number of detected QRS complexes subject to *ct*.



Low *ct* correspond to high numbers of detected QRS complexes including false positives. High *ct* correspond to low numbers of detected QRS complexes with false negatives. For intermediate *ct* there is an area of low slope where noise is already removed but actual QRS complexes are retained. The figure below shows that this range of intermediate *ct* values corresponds to high detection performance (as measured by F1 score).



Projektpartner

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Projektbeteiligte

IT-Systems Engineering | Universität Potsdam
Jonas Chromik, Jossekin Beilharz, Lukas Pirl

Prof.-Dr.-Helmert-Str. 2–3 I D-14482 Potsdam

E-Mail: jonas.chromik@student.hpi.de
Web: hpi.de

HPI Hasso Plattner Institut
IT Systems Engineering | Universität Potsdam