

qrsdel

This project provides the implementation of a noise robust multi-lead QRS delineation algorithm on ECG signals. A full description of the algorithm is detailed in [this paper](#) presented in the [2015 Computing in Cardiology conference](#). It is recommended to be familiar with the [WFDB software package](#) in order to fully exploit this package.

Installation

This project is implemented in pure python, so no installation is required. However, there are strong dependencies with the following python packages:

1. [sortedcontainers](#)
2. [scipy](#)
3. [numpy](#)

Moreover, if you want to use qrsdel as a standalone application, it is necessary to have access to a proper installation of the WFDB software package.

Once all these dependencies are satisfied, is enough to download the project sources and execute or import the proper python scripts, as explained in the next section.

Getting Started

qrsdel as a standalone application:

qrsdel can be used directly from the command line in order to perform the delineation of a set of previously detected QRS complexes in a signal file in the [WFDB format](#). To do this, simply enter the following command from the root *qrsdel* directory:

```
python -m qrsdel.qrsdel [-h] -r RECORD -a REF -o OUTPUT
-r RECORD  Input record.
-a REF     Annotator name containing reference QRS annotations.
-o OUTPUT  Annotator name where the delineation results are stored.
```

This action loads the *RECORD* record and the QRS annotations from the annotations file with *REF* extension, and generates a new annotations file with *OUTPUT* extension with the delineation of every QRS complex.

qrsdel as a library:

It can also be possible to use *qrsdel* as a library to be included in wider projects. In that case, there are no dependencies with the WFDB software package, but the responsibility to provide the signal and the proper parameters remains in the user. The entry point of the library is the `delineate_qrs()` function in the *qrsdel/delineation.py* module, and a usage example is shown in the *qrsdel/qrsdel.py* main module.

Using *qrsdel* as a library allows you to deeply control how the algorithm works, besides obtaining additional information as per-lead delineation information or qualitative characterizations of the recognized waveforms.

Algorithm Evaluation

The project also includes some utilities to evaluate the robustness of the algorithm. The *generate_nsqtdb.py* script allows to generate a new database from the [Physionet QT database](#) by adding different amounts of electrode motion noise to each record, by following these steps:

1. Download the full QT database to a new directory, and also copy the *æm_250* record that can be found in the *records* directory.
2. Modify the *generate_nsqtdb.py* script to set `DB_DIR` variable to the path to the directory where the database has been

downloaded.

3. Run python generate_nsqtdb.py in order to generate the new records.

Once the database has been generated andqrsdel has been executed with each record, the *error_measurements.py* module can be used to generate a markdown report with the mean error and standard deviation of the QRS delineation in each record. Following we show an example of one of such reports, obtained from the original records of the QT database.

Distances table

Record	Se	QRS Onset (ms)	QRS Peak (ms)	QRS Offset (ms)
sel100	1.00	6.00 ± 15.24	-10.80 ± 2.10	-2.13 ± 6.67
sel102	0.99	44.86 ± 24.70	-41.43 ± 24.01	-48.33 ± 59.78
sel103	1.00	20.40 ± 7.96	-2.93 ± 3.71	-1.07 ± 9.23
sel104	1.00	24.36 ± 17.83	-29.19 ± 22.59	-7.27 ± 21.55
sel114	1.00	9.84 ± 15.50	-1.44 ± 1.92	-7.20 ± 14.49
sel116	1.00	9.04 ± 13.24	-11.68 ± 1.93	-0.48 ± 15.77
sel117	1.00	11.60 ± 9.54	-10.00 ± 3.39	0.80 ± 11.79
sel123	1.00	15.87 ± 16.18	-6.67 ± 2.39	8.40 ± 13.52
sel14046	1.00	6.84 ± 7.55	-10.06 ± 3.19	0.52 ± 5.63
sel14157	1.00	16.67 ± 15.73	-17.73 ± 4.58	-2.27 ± 7.98
sel14172	1.00	17.04 ± 13.45	-19.68 ± 13.76	-0.48 ± 6.82
sel15814	1.00	17.07 ± 13.10	-4.13 ± 7.41	-22.53 ± 34.06
sel16265	1.00	10.00 ± 11.21	-7.60 ± 2.39	9.73 ± 10.21
sel16272	1.00	-4.00 ± 11.78	-4.27 ± 2.52	3.87 ± 8.42
sel16273	1.00	-4.27 ± 18.12	-12.80 ± 6.65	3.07 ± 8.18
sel16420	1.00	12.93 ± 6.59	-1.73 ± 4.09	0.80 ± 7.11
sel16483	1.00	15.33 ± 9.86	-9.87 ± 2.47	7.73 ± 8.26
sel16539	1.00	8.40 ± 7.11	-6.27 ± 5.90	3.33 ± 5.37
sel16773	1.00	20.80 ± 10.45	-10.27 ± 3.04	7.07 ± 7.84
sel16786	1.00	-9.07 ± 16.65	-17.60 ± 2.44	-0.53 ± 9.45
sel16795	1.00	8.00 ± 8.82	-19.73 ± 3.57	1.20 ± 8.83
sel17152	1.00	17.73 ± 7.64	3.47 ± 3.22	-3.33 ± 12.99
sel17453	1.00	10.00 ± 8.63	-16.27 ± 3.26	6.27 ± 8.98
sel213	1.00	22.25 ± 14.55	-16.28 ± 11.98	8.73 ± 8.18
sel221	1.00	0.40 ± 16.76	-7.73 ± 4.49	5.33 ± 15.64
sel223	1.00	10.32 ± 17.62	-0.65 ± 1.79	27.87 ± 15.26
sel230	1.00	12.32 ± 12.05	-12.16 ± 3.83	8.88 ± 7.26
sel231	1.00	-11.44 ± 16.14	-13.04 ± 5.65	5.52 ± 17.71
sel232	1.00	10.53 ± 9.09	2.13 ± 2.00	-54.67 ± 39.70
sel233	1.00	10.40 ± 11.01	-5.73 ± 3.68	2.00 ± 8.69
sel30	1.00	-0.93 ± 19.51	-9.20 ± 1.83	-14.40 ± 8.62
sel301	1.00	11.33 ± 8.20	-4.40 ± 2.15	8.27 ± 7.08

Record	Se	QRS Onset (ms)	QRS Peak (ms)	QRS Offset (ms)
sel302	1.00	17.73 ± 5.23	-6.13 ± 2.47	-1.07 ± 7.79
sel306	1.00	2.56 ± 14.55	-11.78 ± 3.99	3.11 ± 7.61
sel307	1.00	14.67 ± 6.23	-6.00 ± 2.00	6.27 ± 6.51
sel308	1.00	13.52 ± 15.39	-48.24 ± 8.67	3.12 ± 10.25
sel31	1.00	16.40 ± 21.00	-12.00 ± 2.31	-9.60 ± 6.08
sel310	1.00	19.87 ± 5.11	-9.60 ± 1.96	0.67 ± 7.24
sel32	1.00	8.53 ± 13.77	-11.60 ± 4.54	-3.60 ± 10.03
sel33	1.00	24.67 ± 3.11	-10.80 ± 3.60	-16.53 ± 14.23
sel34	1.00	19.73 ± 4.95	-10.00 ± 2.00	-40.40 ± 6.88
sel35	1.00	12.90 ± 13.51	-10.71 ± 2.36	-7.48 ± 7.09
sel36	1.00	15.74 ± 10.56	-9.42 ± 2.39	-61.29 ± 38.51
sel37	1.00	18.08 ± 16.86	-7.68 ± 8.68	-7.12 ± 12.83
sel38	1.00	32.27 ± 11.77	24.00 ± 6.20	-16.27 ± 9.74
sel39	1.00	4.93 ± 6.42	-17.20 ± 4.75	-25.73 ± 28.16
sel40	1.00	20.80 ± 11.61	-12.13 ± 2.19	-6.13 ± 8.56
sel41	1.00	17.47 ± 6.81	-7.60 ± 1.58	-2.53 ± 9.77
sel42	1.00	43.47 ± 5.91	-12.40 ± 10.75	-6.40 ± 5.23
sel43	1.00	57.20 ± 13.15	-3.73 ± 5.56	-0.27 ± 5.26
sel44	1.00	33.47 ± 29.64	-10.13 ± 2.00	-28.67 ± 23.03
sel45	1.00	22.67 ± 5.78	-11.60 ± 1.89	-6.27 ± 8.93
sel46	1.00	5.07 ± 17.34	-18.53 ± 8.67	-2.80 ± 5.38
sel47	1.00	24.67 ± 16.75	-12.00 ± 3.10	-13.87 ± 16.58
sel48	1.00	17.73 ± 12.51	-13.33 ± 1.89	-22.13 ± 15.86
sel49	1.00	15.47 ± 5.03	-5.73 ± 1.98	-11.60 ± 10.65
sel50	1.00	15.62 ± 16.62	-8.88 ± 3.57	-4.25 ± 14.03
sel51	1.00	10.93 ± 5.05	-1.20 ± 1.83	-20.00 ± 7.45
sel52	1.00	-1.87 ± 21.48	-8.00 ± 2.53	-8.67 ± 12.61
sel803	1.00	12.00 ± 7.93	-3.73 ± 2.29	8.67 ± 13.15
sel808	1.00	3.87 ± 8.67	-27.73 ± 3.99	1.20 ± 7.88
sel811	1.00	13.47 ± 14.22	-4.80 ± 2.40	6.67 ± 18.48
sel820	1.00	-0.27 ± 13.14	-10.00 ± 2.25	10.40 ± 9.44
sel821	1.00	6.13 ± 7.28	-8.93 ± 3.38	4.93 ± 4.09
sel840	1.00	9.26 ± 4.56	-12.06 ± 5.72	8.00 ± 6.34
sel847	1.00	4.36 ± 13.41	-8.97 ± 3.94	2.91 ± 6.70
sel853	1.00	-0.67 ± 16.82	-17.47 ± 2.63	7.20 ± 5.69
sel871	1.00	32.69 ± 9.27	-29.60 ± 9.06	3.60 ± 5.82
sel872	1.00	15.20 ± 7.19	-4.53 ± 2.25	10.93 ± 6.10




Record	Se	QRS Onset (ms)	QRS Peak (ms)	QRS Offset (ms)
sel873	1.00	12.97 ± 5.83	-7.27 ± 5.95	4.36 ± 6.56
sel883	1.00	10.13 ± 14.92	-6.40 ± 3.20	6.27 ± 15.75
sel891	1.00	5.75 ± 15.13	-19.32 ± 2.51	-3.61 ± 18.79
sele0104	1.00	16.40 ± 4.77	-11.73 ± 2.29	9.73 ± 7.84
sele0106	1.00	20.53 ± 4.47	-5.07 ± 9.85	11.73 ± 4.73
sele0107	1.00	17.06 ± 11.24	-6.59 ± 3.20	2.47 ± 5.74
sele0110	1.00	8.93 ± 4.70	-13.47 ± 7.12	3.20 ± 4.78
sele0111	1.00	7.60 ± 7.11	-10.53 ± 3.50	7.20 ± 17.26
sele0112	1.00	16.40 ± 10.62	-10.24 ± 3.68	19.36 ± 8.37
sele0114	1.00	13.87 ± 10.11	-6.53 ± 2.42	10.13 ± 9.45
sele0116	1.00	2.13 ± 16.77	-6.00 ± 3.39	-18.13 ± 25.77
sele0121	1.00	7.07 ± 5.03	-3.87 ± 1.63	14.93 ± 8.06
sele0122	1.00	11.33 ± 4.51	-9.73 ± 1.98	16.27 ± 7.72
sele0124	1.00	7.04 ± 8.96	-5.76 ± 4.74	3.28 ± 11.99
sele0126	1.00	11.73 ± 7.65	-1.60 ± 4.80	8.80 ± 10.65
sele0129	1.00	-10.27 ± 19.67	-22.80 ± 3.12	14.27 ± 7.84
sele0133	1.00	4.00 ± 20.16	-24.67 ± 3.11	13.33 ± 7.96
sele0136	1.00	18.93 ± 5.46	-6.00 ± 2.68	9.47 ± 7.04
sele0166	1.00	-29.78 ± 13.15	-11.67 ± 7.20	-0.44 ± 16.43
sele0170	1.00	9.87 ± 5.91	-3.87 ± 0.72	6.93 ± 3.26
sele0203	1.00	11.33 ± 7.87	-5.33 ± 2.15	2.67 ± 8.78
sele0210	1.00	17.73 ± 7.64	-6.00 ± 2.00	2.93 ± 12.00
sele0211	1.00	9.60 ± 18.11	-5.07 ± 2.05	8.53 ± 8.87
sele0303	1.00	14.27 ± 4.70	-2.13 ± 2.68	12.40 ± 8.54
sele0405	1.00	-2.13 ± 10.26	-12.80 ± 2.17	2.67 ± 10.03
sele0406	1.00	5.29 ± 13.95	-5.68 ± 3.01	4.26 ± 3.79
sele0409	1.00	12.00 ± 6.28	-3.73 ± 1.44	0.40 ± 5.69
sele0411	1.00	7.20 ± 6.23	-6.53 ± 2.19	3.60 ± 12.58
sele0509	1.00	6.27 ± 4.58	-6.13 ± 2.00	-34.13 ± 5.34
sele0603	1.00	6.53 ± 13.72	-10.80 ± 2.95	1.20 ± 15.18
sele0604	1.00	8.53 ± 6.09	-15.33 ± 7.24	7.87 ± 10.46
sele0606	1.00	16.93 ± 6.59	-6.13 ± 2.00	-26.80 ± 4.64
sele0607	1.00	22.40 ± 14.03	-23.07 ± 1.69	4.80 ± 6.88
sele0609	1.00	21.87 ± 11.40	1.60 ± 1.96	11.07 ± 12.12
sele0612	1.00	13.47 ± 14.51	-6.00 ± 2.25	-0.93 ± 11.99
sele0704	1.00	11.60 ± 9.08	-20.27 ± 4.84	-84.53 ± 12.76
Total:	1.00	13.09 ± 17.48	-11.47 ± 12.01	-2.41 ± 22.34

INFORMACIÓN

Investigadores
Paulo Félix Lamas
Jesús María Rodríguez Presedo
Tomás Teijeiro Campo

Licenza

DESCARGAR

-  Repositorio Gitlab
-  Descargar de Gitlab
-  Repositorio Github

PUBLICACIONES

A Noise Robust QRS Delineation Method Based on Path Simplification
Computing in Cardiology, 2015