ECG pre-processing and feature extraction tool for intelligent simulation systems

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1. Introduction (I)

- Increase of Cardiac Problems and Sudden Deaths in Athletes
  - International organizations demand periodic mass screening

- What is it needed?
  - Professional 12-lead ECG devices
  - An expert in the field
  - Time to analyze the results

Test performed only 1-2 times a year in professional FIFA teams

1. Introduction (II)

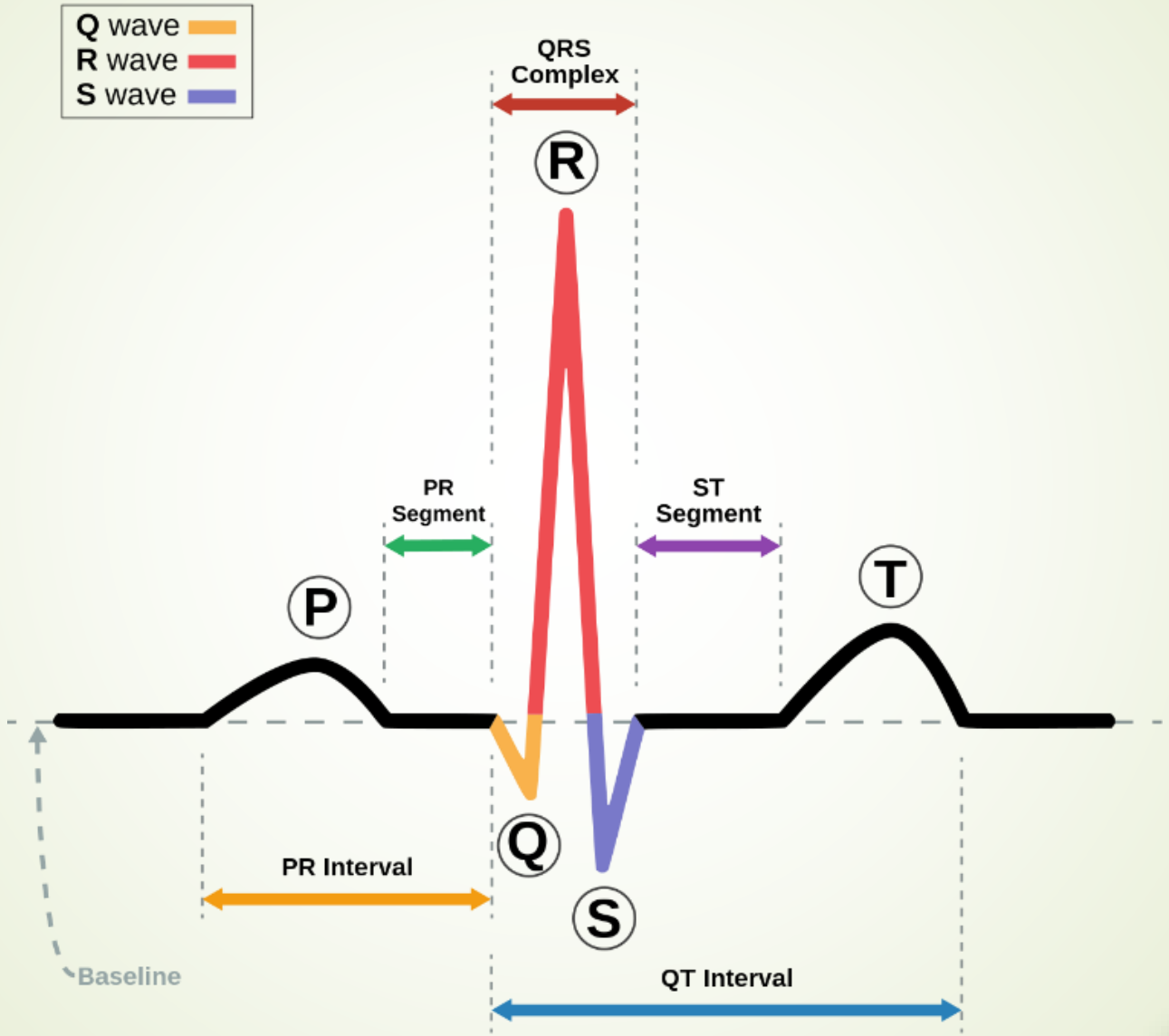
- How can technology help?
  - Simulation tools that help Cardiac Doctors to train their skills
  - Pre-processing and feature extraction tools to help in the process
- There are tools already?
  - Yes, but… ONLY FOR COMMON POPULATION!!
- Is there any problem with that? → Athletes vs Common people
  - More muscle mass
  - Bigger and stronger heart ventricles
  - More time between ECG peaks

These tools cannot be used to detect anomalies in Athletes!!

1. Introduction (and III)

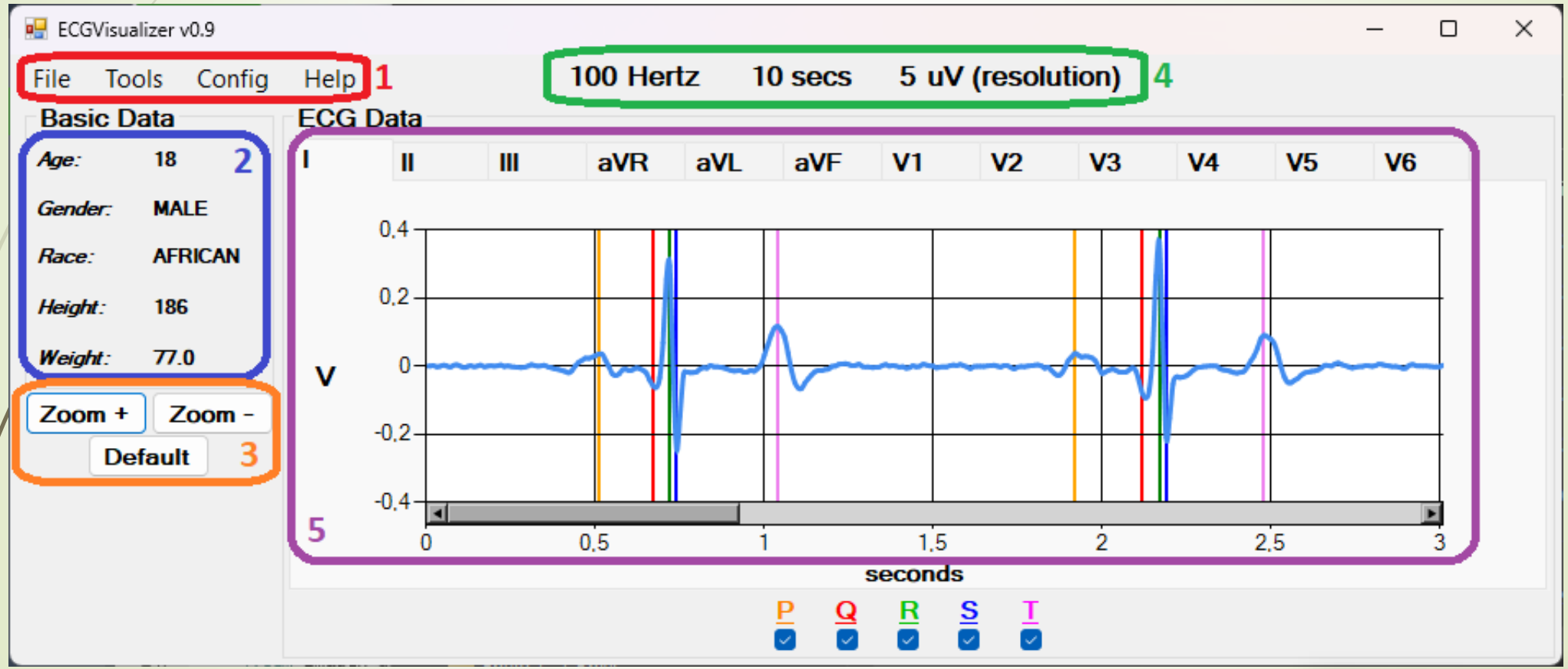
- What can we do?
  - Developing a customizable software tool
- This tool may…
  - … detect anomalies in common population and athletes.
  - … detect peaks automatically.
  - … extract a custom report from the ECG signal.
  - … and, thanks to all of them, help for Cardiac Doctors training.

2. ECG signal


Q wave
R wave
S wave
QRS Complex
R
PR Segment
ST Segment
P
T
Q
S
PR Interval
Baseline
QT Interval

3. Software Tool (I)

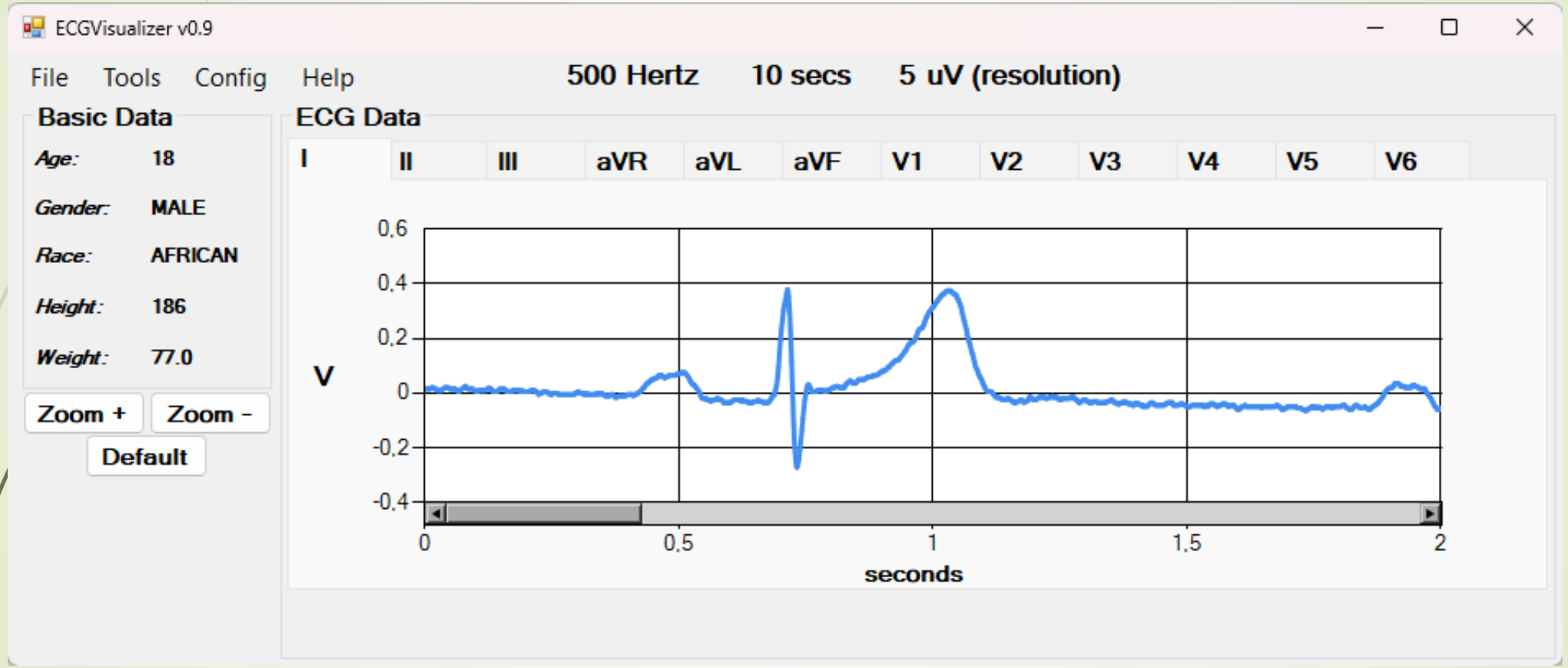
- So far… XML files from ***General Electric CardioSoft 12SL ECG***
  - Soon… *Contec 1200G device*



3. Software Tool (II)

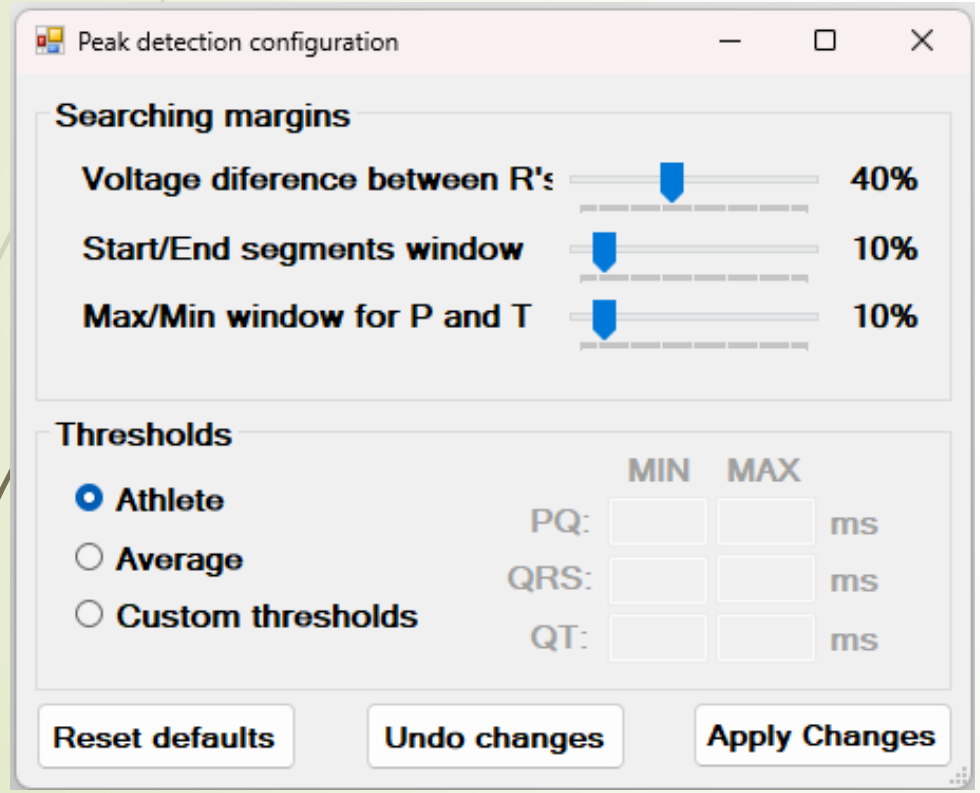
- Characteristics:

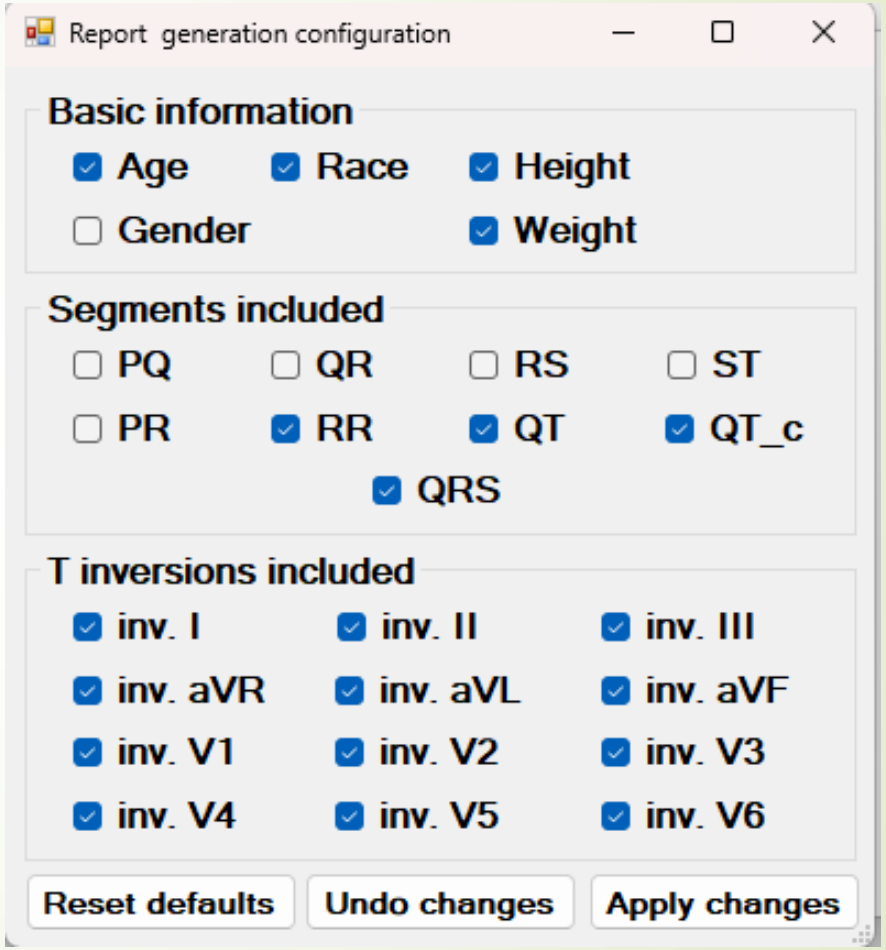
[1] Loading and navigating



3. Software Tool (III)

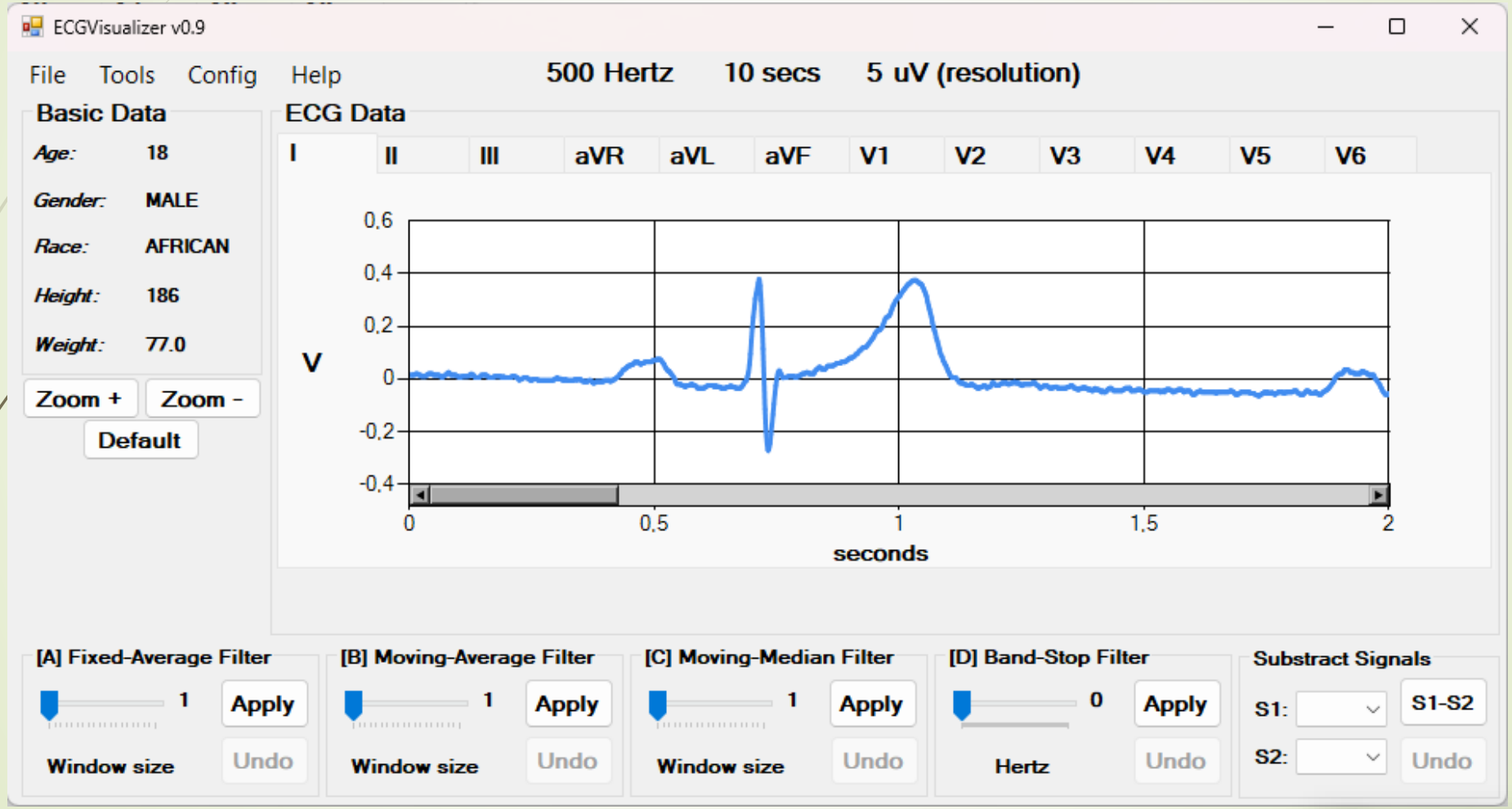
[2] Configuration





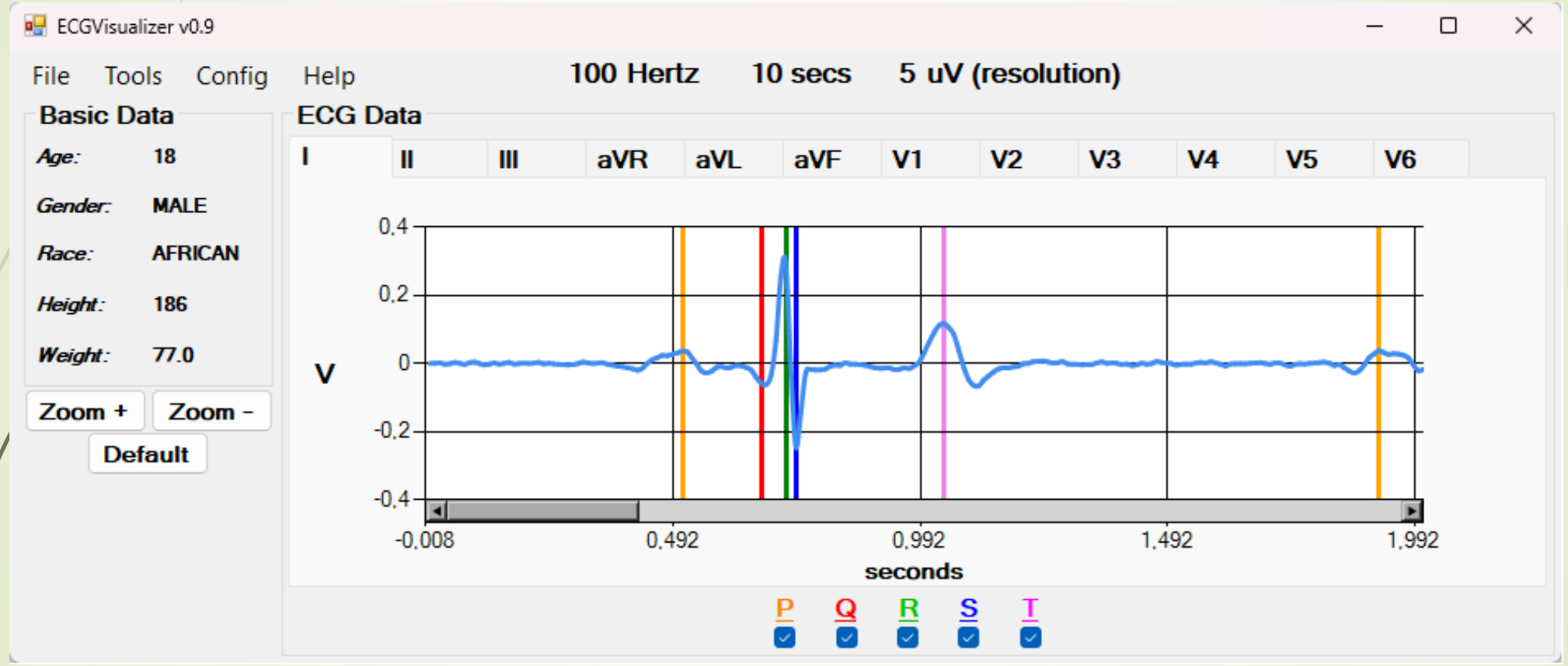
3. Software Tool (IV)

[3] Custom Filtering



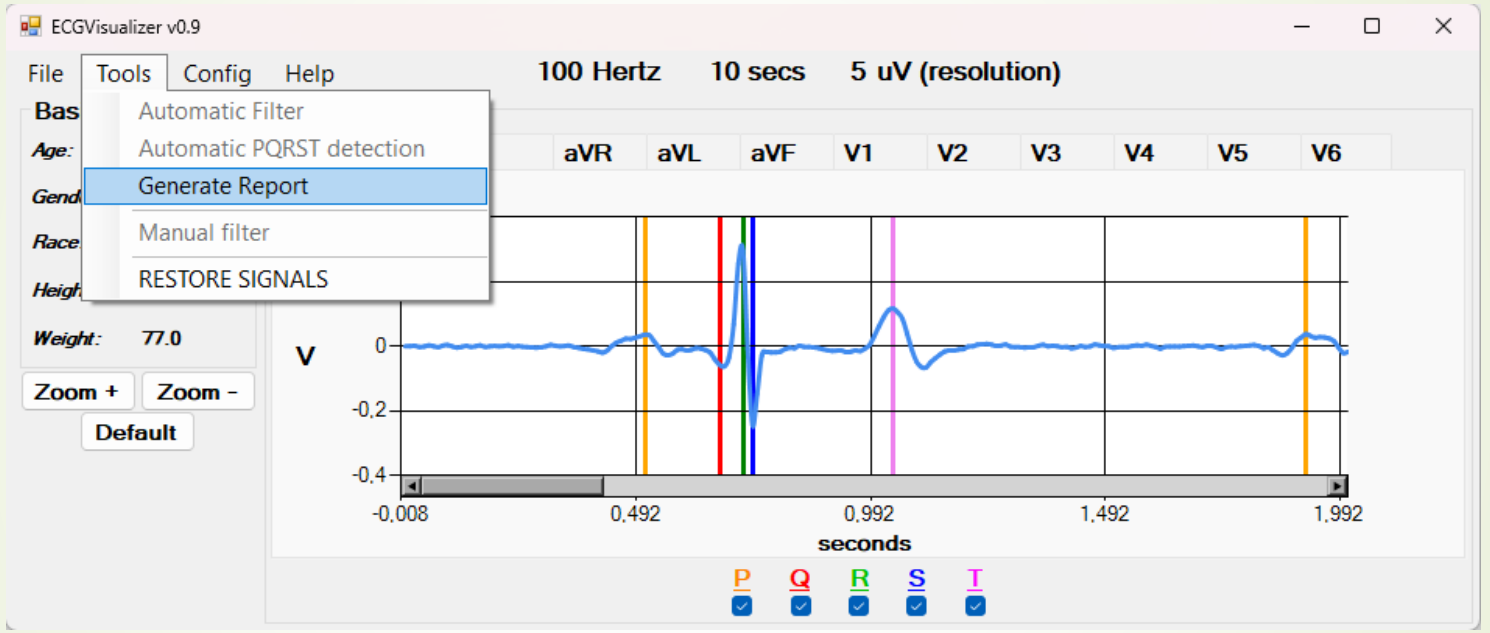
3. Software Tool (V)

[4] Peaks detection



3. Software Tool (VI)

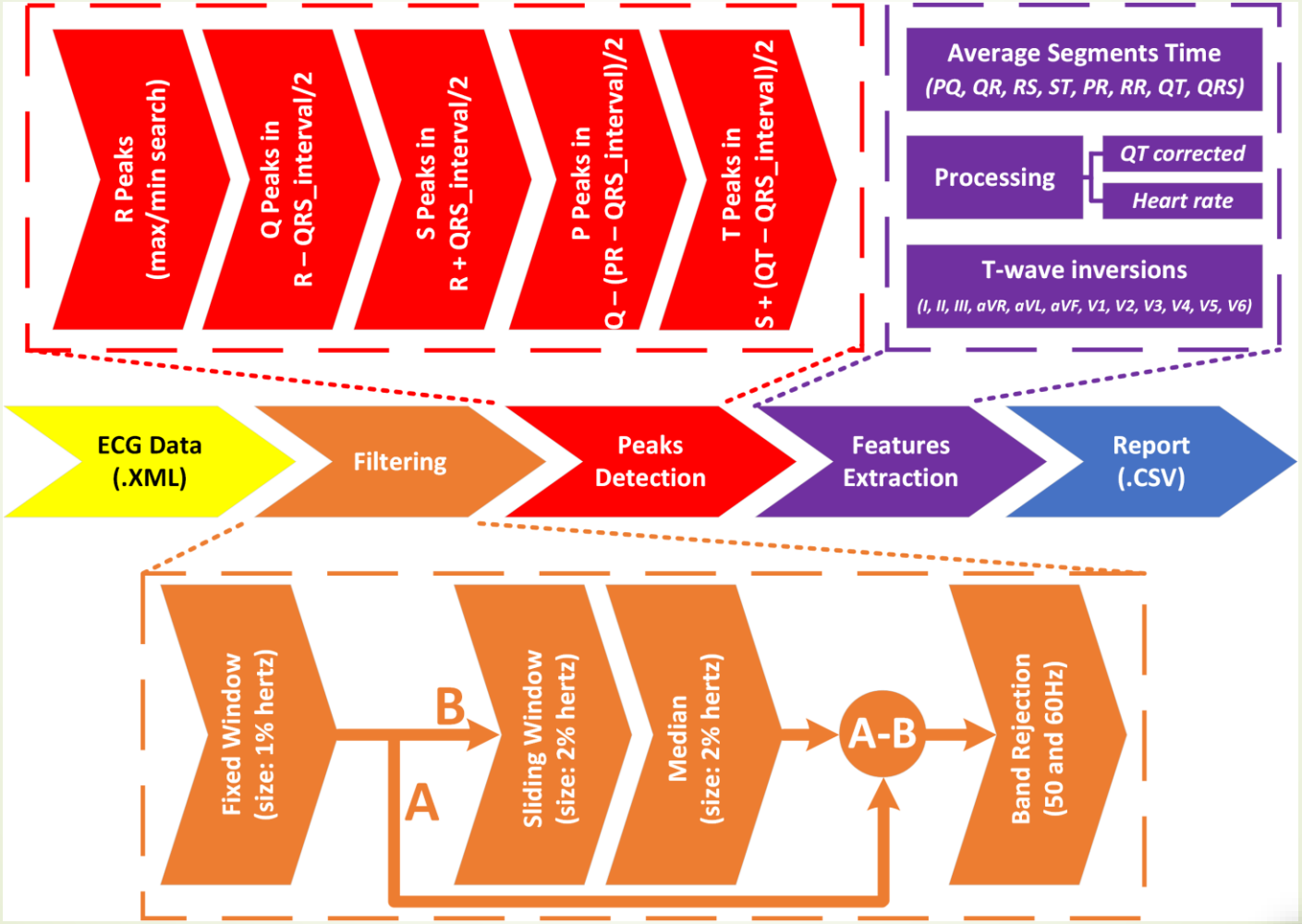
[5] Report Generation



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
1	ID	Age	Race	Height	Weight	RR interval	QRS interval	QT interval	QT_c interva	T inv I	T inv II	T inv III	T inv aVR	T inv aVL	T inv aVF	T inv V1	T inv V2	T inv V3	T inv V4	T inv V5	T inv V6
2	example1	18	AFRICAN	186	77	1234,28571	82,8571429	360	300,782903	0	0	0	0	1	0	0	0	0	0	0	0

3. Software Tool (and VII)

[6] Automatic alternative*

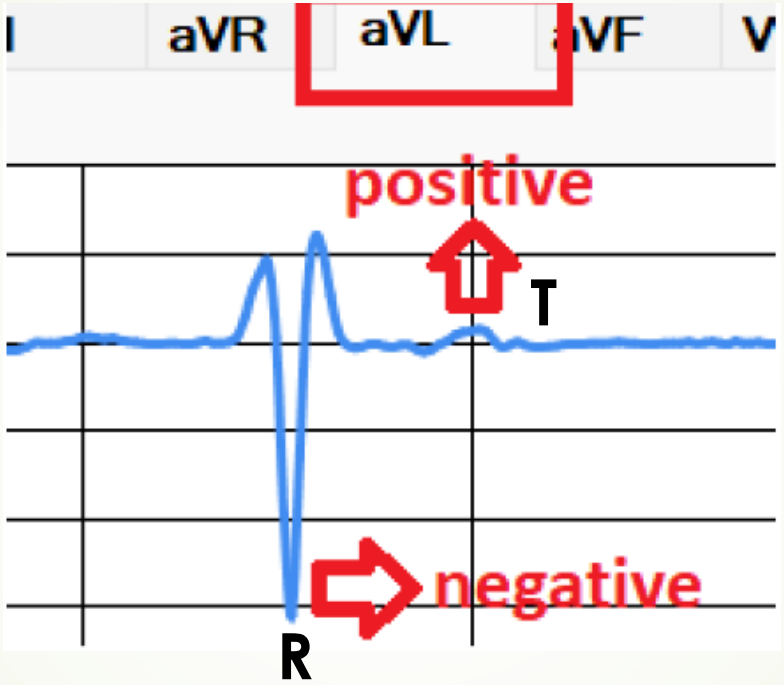


4. Testing (I)

- Dataset collected previously:
  - PF12RED (https://github.com/dradolfomunoz/PF12RED)
    - Collected from professional UEFA football players from LaLiga EA SPORTS
    - ClinicalTrials No. NCT05872945.
  - Contains:
    - 163 raw ECG data in XML format from 54 football players (and the waveforms scanned).
    - Labels: common features and some clinical appearances like *sinus bradycardia* or *incomplete right bundle branch block*.
- Tests → Peaks detection and feature extraction
  - Evaluated one by one by a Cardiac Doctor.
  - Comparison between automatic processing report and doctor diagnosis

4. Testing (II)

- Comparison example

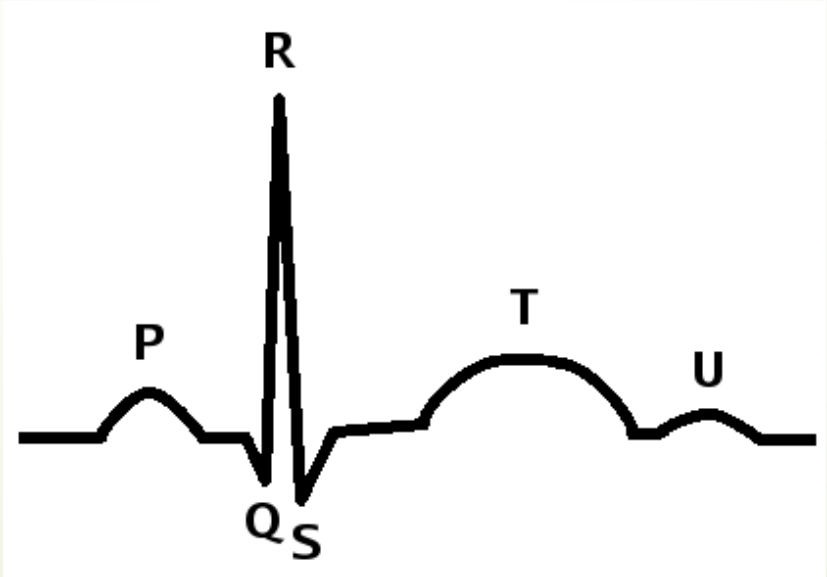


ID	Age	Race	Height	Weight	RR interval	QRS interval	QT interval	QT_c interval	T inv I	T inv II	T inv III	T inv aVR	T inv aVL	T inv aVF	T inv V1	T inv V2	T inv V3	T inv V4	T inv V5	T inv V6
example1	18	AFRICAN	186	77	1234,285714	82,85714286	360	300,7829033	0	0	0	0	1	0	0	0	0	0	0	0

4. Testing (and III)

- Results summary:
  - Accuracy over 98% taking into account the most common markers: ***segments***, ***intervals*** and ***T-wave inversions***
  - Discrepancies obtained → confusion between **peak T** and **peak U**.

- ¿Peak U? → Unusual wave, produced by a bounce of the signal T.



5. Comparison

Software Tool	Input	Leads	Filtering		Peaks		Features		Free
			Auto	Manual	Auto	Manual	Auto	Manual	
Edelmann et al. (2019) [6]	.mat	1	Yes	No	Yes	No	Yes	No	Yes
Encord ECG (2023) [2]	DICOM	12	No	No	Yes	No	No	No	No
OHIF ECG Viewer (2023) [3]	DICOM	12	No	No	Yes	No	No	No	Yes
Waveform ECG (2008) [4]	.xml	12	No	No	Yes	No	No	No	Yes
ECG-Viewer (2022) [1]	.dat, .txt, .csv	12	Yes	Yes	Yes	No	No	No	Yes
ECGVisualizer (2023) [this work]	.xml	12	Yes	Yes	Yes	Yes	Yes	Yes	Yes

6. Conclusions

- Medical professionals need simulation tools to help them in their learning process.
  - This applies to all areas, including the detection of cardiac problems.
- When working with ECG data, it is necessary to pay attention to the PQRST peaks of each of the twelve leads.
  - The intervals between peaks and the features vary in professional athletes.
- This work presents a free software tool that, thanks to its filtering and peak detection capability, serves as a simulation tool to evaluate the expertise of the future cardiac doctors.
  - Includes XMLs loading from a 12-lead ECG, visualization, filtering, feature extraction and fully customized report generation.
- The two main contributions of this tool are the total customization of the whole process; and, secondly, the possibility of adapting the analysis to the type of person.
- Results demonstrate the correct feature detection and the future usefulness of this tool.

THANK YOU!

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