HRV:

What does this mean in practice?

European Heart Journal

European Heart Journal (1996) **17**, 354–381

Guidelines

Heart rate variability

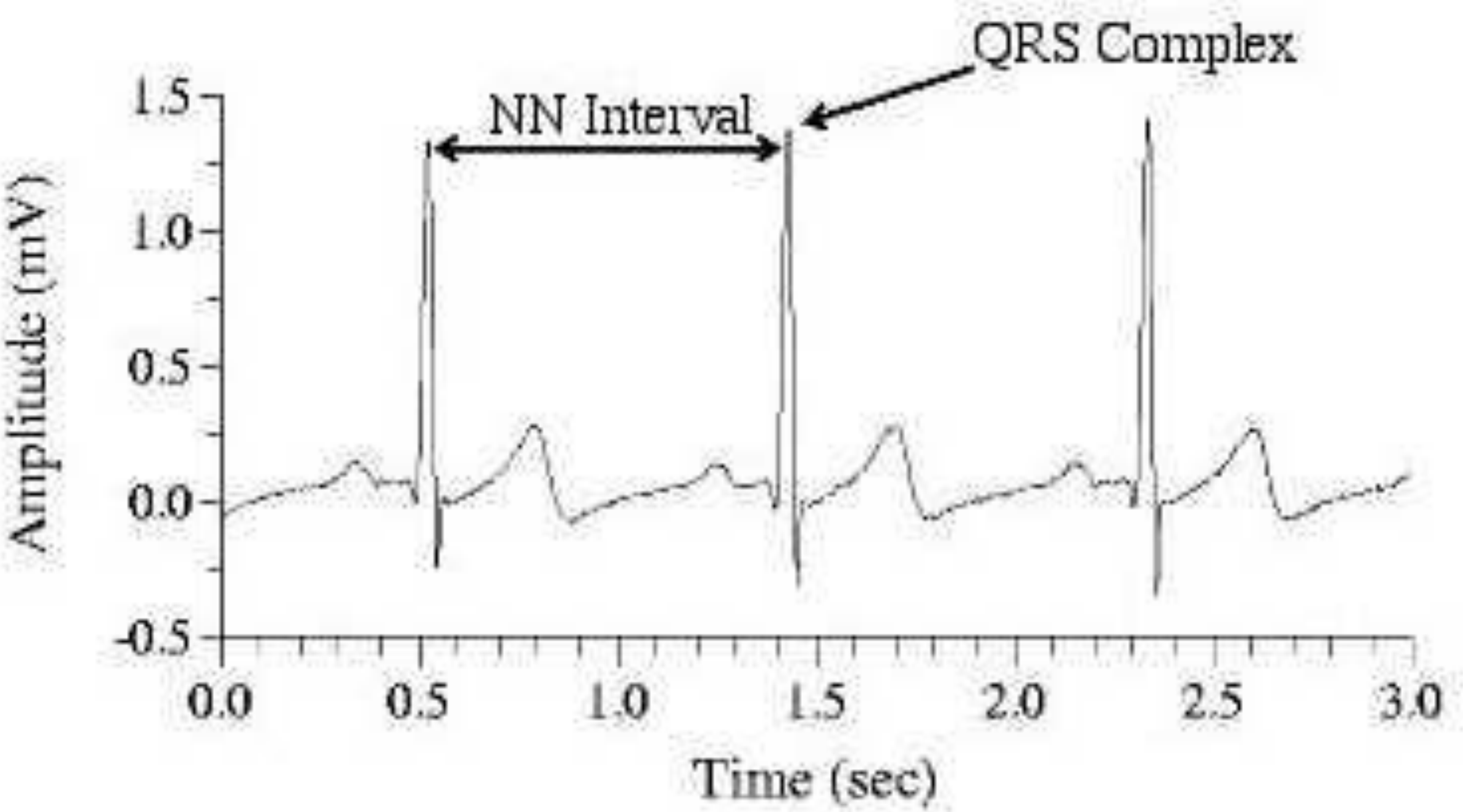
Standards of measurement, physiological interpretation, and clinical use

Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology (Membership of the Task Force listed in the Appendix)

Simplicity

<u>Time domain method:</u>

1. Do ECG
2. Measure NN Interval
3. Find the mean between successive NN intervals.



Visualization

Frequency domain method:

1. Do ECG
2. Power Spectral Density (PSD) analysis

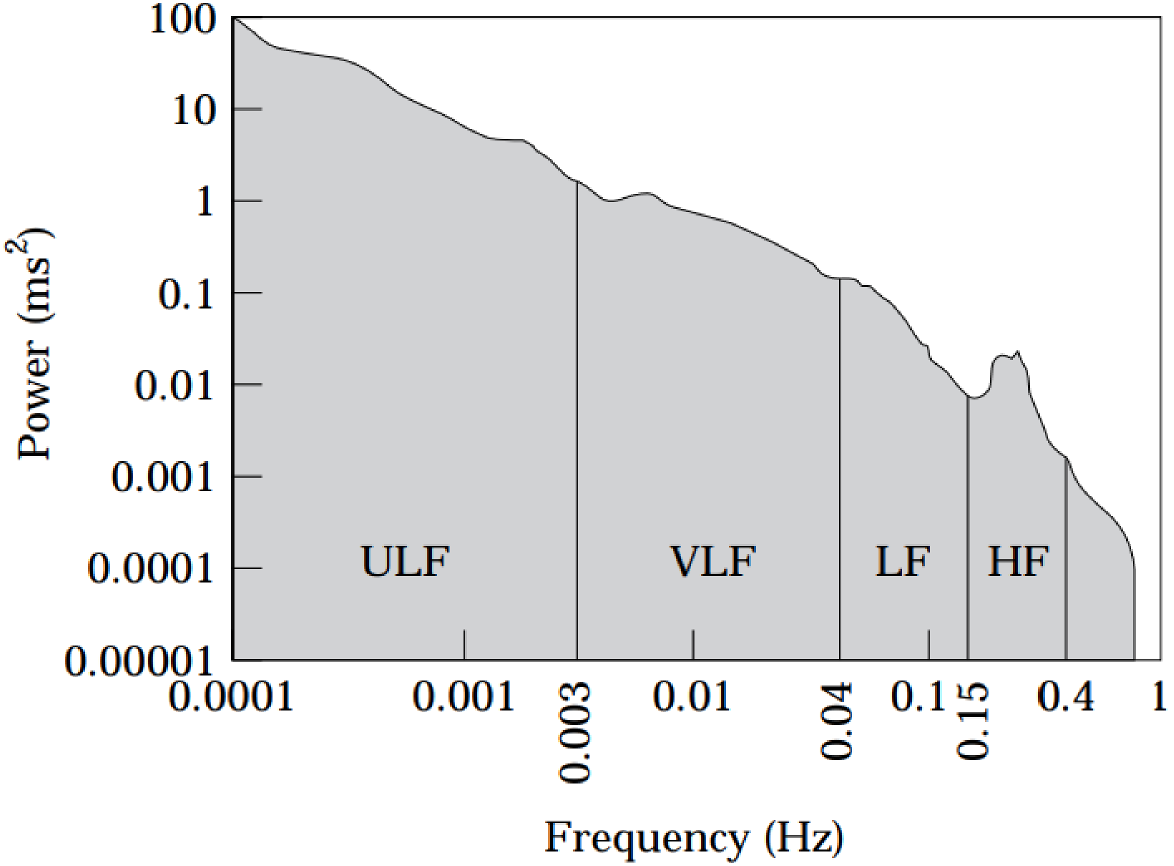


Figure 4 **Example of an estimate of power spectral density obtained from the entire 24-h interval of a long-term Holter recording. Only the LF and HF components correspond to peaks of the spectrum while the VLF and ULF can be approximated by a line in this plot with logarithmic scales on both axes. The slope of such a line is the α measure of HRV.**

Accuracy

- Statistical Methods

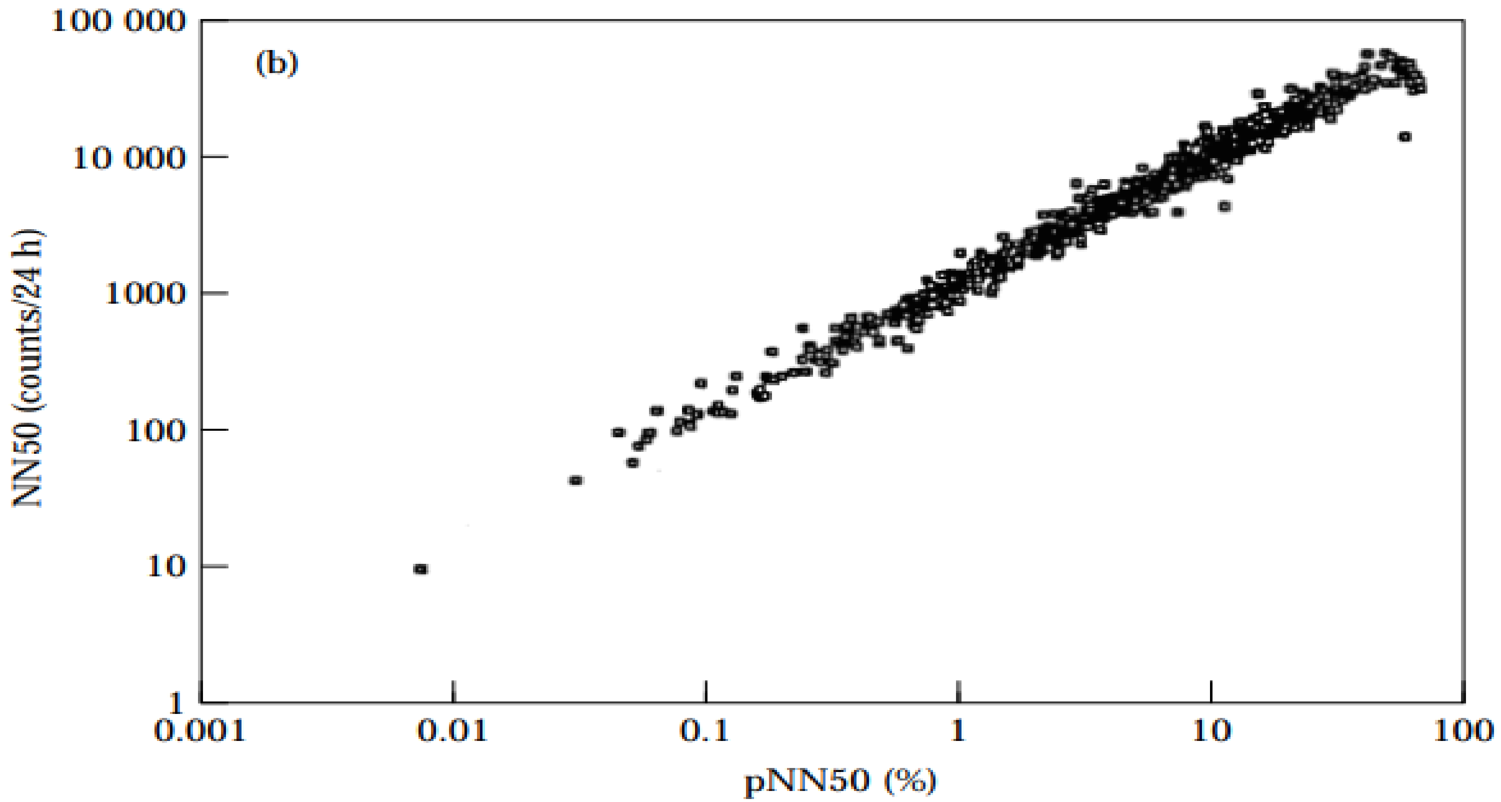


Figure 1 **Relationship between the RMSSD and pNN50 (a), and pNN50 and NN50 (b) measures of HRV assessed from 857 nominal 24-h Holter tapes recorded in survivors of acute myocardial infarction prior to hospital discharge. The NN50 measure used in panel (b) was normalized in respect to the length of the recording (Data of St. George's Post-infarction Research Survey Programme.)**

Practicality

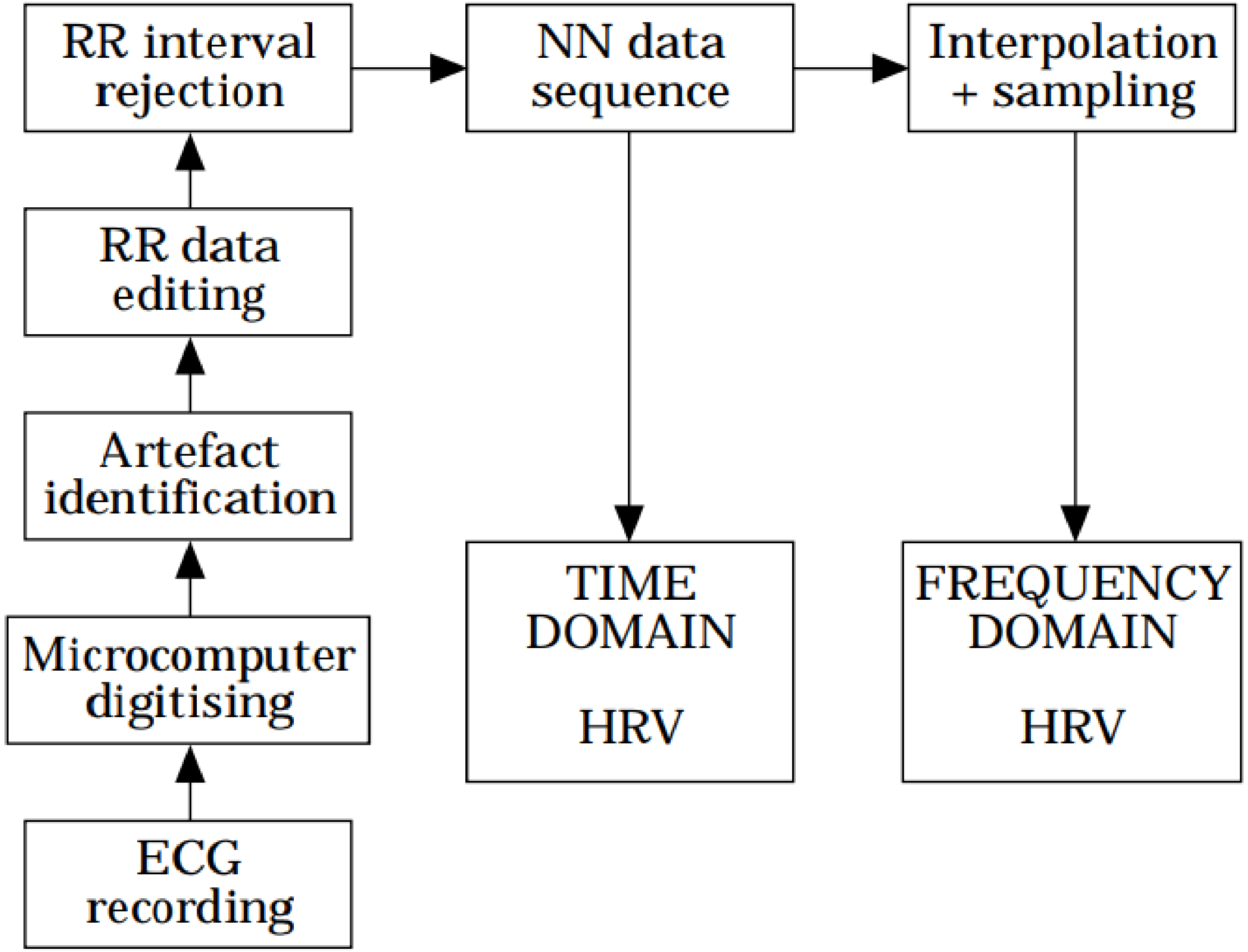


Figure 7 **Flow chart summarizing individual steps used when recording and processing the ECG signal in order to obtain data for HRV analysis.**

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Clinical Applications of Heart Rate Variability in the Triage and Assessment of Traumatically Injured Patients

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Extensive Uses

Heart rate variability analysis techniques and their uses in trauma.

Technique	Description	Metrics	Evidence of changes in trauma	Population
Time domain	Estimation of variability using statistics and measures of central tendency [3]	HRVi	↓ predicts mortality, ICH, adrenal insufficiency [11, 15, 19–22, 36]	ICU
		Uncoupling	↑ reflects acidosis, coagulopathy, MOSF, AI, severe TBI, ↑ ICP, predicts mortality [6, 9, 12, 22]	ICU
		SDNN	↓ predicts TBI, mortality, acidosis, LSI [16, 23]	Prehospital ER ICU
		RMSSD	↓ reflects TBI, hemorrhage, mortality [23, 28, 47]	ER ICU
Frequency domain	Calculation of power (amplitude) of contributing frequencies to an underlying signal [18]	TP	↓ reflects ↑ICP, TBI, prolonged neurologic recovery, need for LSI, mortality, brain death [10, 28, 43]	ICU Outpatient
		LF	↓ reflects ↑ICP, TBI, hemorrhage, need for LSI, mortality, brain; ↑ reflects ↑CI, HR, MAP death [4, 10, 27, 28, 37, 43, 48, 49].	ER ICU
		HF	↓ reflects trauma, ↑ICP, need for LSI, hemorrhage, brain death, and mortality [10, 37, 43, 47, 50, 51]	Prehospital
		LF/HF	↑ reflects ↑ICP, ↓CPP; ↓ reflects brain death, mortality, hemorrhage, ↓GCS, poor neurologic outcome [5, 7, 10, 27, 48, 51]	Prehospital ICU

6. Summary

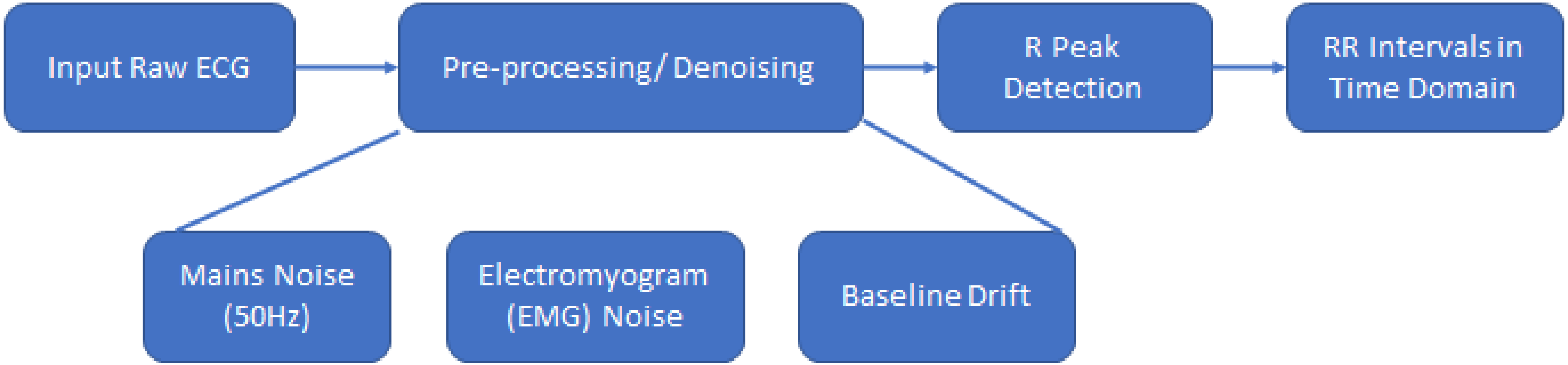
There are at least 23 different variables using the 3 different methods of analysis that reflect HRV (Table 4), each with strengths and weaknesses. Decreases in HRV in trauma patients indicate significant injury or pathology and accurately predict morbidity and mortality. However, there are multiple challenges which must be overcome before HRV can become a routine monitoring and triage tool in trauma. The key issues for future investigations are

(1) how to implement HRV in the triage of civilian and military trauma,
(2) guidelines for the monitoring and assessment of trauma patients using HRV,
(3) development of normal values and thresholds for treatment,
(4) target values for resuscitation.

Back to our clinician…

- **Responsibility** – analyzing HRV and linking it to pathology vs. calculating HRV.
- Important **diagnostic** tool – e.g. risk assessment for pts. suffering MIs.
- **SDNN** – combined with ejection fraction and baroreflex sensitivity.

Coding Plan


Input Raw ECG
Pre-processing/ Denoising
R Peak Detection
RR Intervals in Time Domain
Mains Noise (50Hz)
Electromyogram (EMG) Noise
Baseline Drift

Type of Noise	Removal Method	Comments
Mains Noise	IIR Notch Filter	Eliminates the interference with a bandwidth range e.g. 49-51Hz which is eliminated. Uses past inputs and outputs and present inputs to do this. Can result in filter ringing which distorts the QRS segment.
	FIR Filter	Similar to above but doesn't use the previous outputs, only inputs.
	Adaptive Filter	Automatically changes its characteristics based on which algorithm is used to filter the signal. Methods used may be least mean square (LMS), recursive least squares (RLS), stochastic gradient (SG) and others. These algorithms are applied to change the elimination region of filters such as IIR and FIR. This is an added layer of complexity on top of the filters mentioned above.
EMG Noise	Low Pass Filter	The frequency of QRS complex overlaps that of EMG noise, so noise removal is extremely difficult without losing ECG morphology
Baseline Drift	High Pass Filter	Baseline Drift has low frequency of generally below 0.5Hz, so a high pass filter with a cut-off point of 0.5Hz should remove it. Must be aware though that ECG signals have frequencies starting at around this value.

On to this week’s code…