Czech Technical University in Prague – Faculty of Biomedical Engineering

Modeling and Simulation – Summer Term 2014 – Michel Kana, PhD

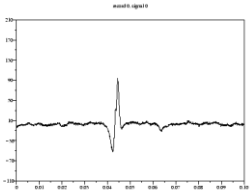
Entrance Test Solution – 18.2.2014

Name: _____

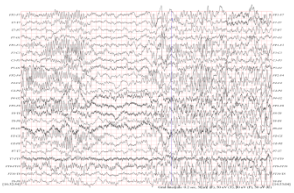
1. **Identify the following biological signals (PPG, EEG, EOG, EMG, ECG, GSR) and give their full names**

Electrocardiogram

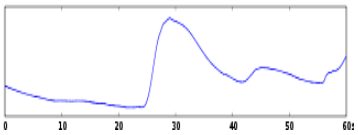
Electromyogram



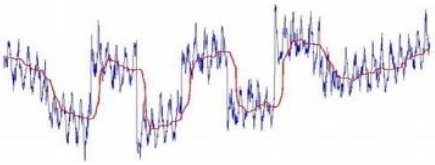
Electroencephalogram



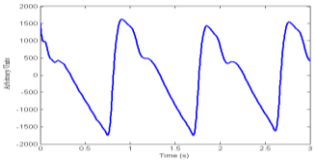
Galvanic skin response



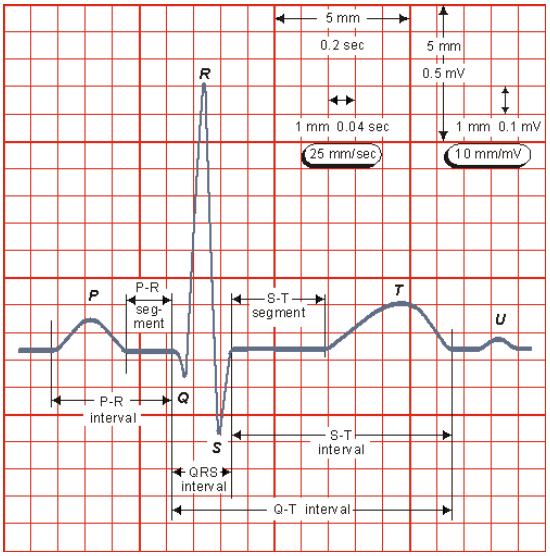
Electrooculogram



Photoplethysmogram



2. **Annotate the following ECG signal: name the waves, intervals and segments**



3. **Match the problem with possible algorithms for the solution**

ECG baseline wandering removal	Wavelet transform and singularity detection
ECG Denoising	Bayesian filtering
Event-related potentials in EEG	Derivative based algorithm
Detection of QRS complex	Over-fitting using wavelet approximation
	Adapted wavelet filtering
	Step-wise discriminant analysis
	Suitable approximation of the baseline

4. **Name the four basic groups of waves in a normal EEG and their frequency range**

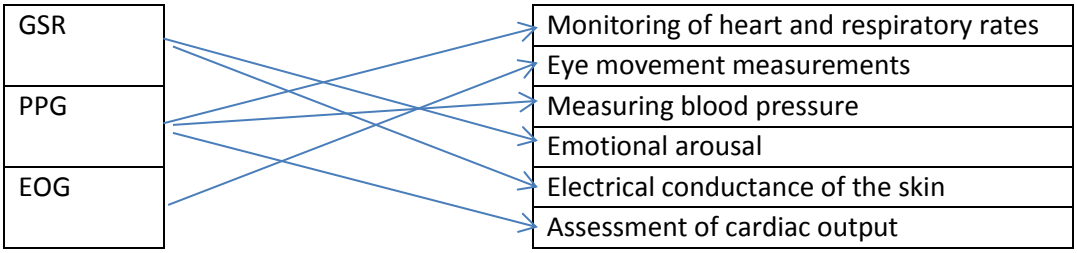
- beta (>13 Hz)
- alpha (8-13 Hz)

- theta (4-8 Hz)
- delta (0.5-4 Hz)

5. Answer True or False to the following questions

- It is valid to directly compare the EMG output (e.g., integral) of a muscle across subjects.
  False, only normalizing the measurement value against a maximal effort value makes direct comparison possible.
- An EMG signal will not necessarily reflect the total amount of force (or torque) a muscle can generate.
  True, electrodes can't pick-up all motor units that are firing.
- EMG potentials usually range between 50 µV and 30 mV.
  True.

6. Match each signal with standard applications



7. Name the four nucleotides present in human deoxyribonucleic acid

guanine, adenine, thymine, and cytosine

8. Mark the following sequences as a protein, DNA or RNA sequence

`QERLDCHGFAFFGWDWWNGPRAVKSTQIITRKWFDITNNKCDEDTNKSGYKDLVSICQTG` → Protein

`ACAAGATGCCATTGTCCCGGCCTCCTGCTGCTGCTGCTCTCCGGGGCCACGGGCTCTGAA` → DNA

`AACUUCUUCUGGAAGACCUUCUCCUCCUGCAAAUAAAACCUCACCCAUGAAUGCUCACGC` → RNA

9. Shortly define the following terms

Sampling frequency: number of samples per seconds taken from a continuous signal to make a discrete signal.

LTI system: linear time-invariant system, the output is a scaled and summed function of inputs and the output does not depend on time when the input was applied.

Heart rate variability: variation in the time interval between heartbeats.

Low-pass filter: process that passes low-frequency components of a signal and attenuates or remove components with frequencies higher than the cutoff frequency.

10. Write a simple Matlab function for removing artifacts from a biological signal, e.g. ECG

```
smoothup_hr = 1.8;
smoothdown_hr = 0.6;
hrr = hr;
t=t(1:length(hr));
baseline_hr = polyval(polyfit(t', hr, 1),0);
i=2;
while i<length(hrr)
   previous_hr = mean(hrr(max(1,i-10):i-1));
   while hrr(i) < smoothdown_hr*baseline_hr && i<length(hrr)
     hrr(max(1,i-2):min(length(hrr),i+2))=previous_hr;
     i = i+1;
   end
   i=i+1;
end;
i=2;
while i<length(hrr)
   previous_hr = mean(hrr(max(1,i-10):i-1));
   while hrr(i) > smoothup_hr*baseline_hr && i<length(hrr)
     hrr(max(1,i-2):min(length(hrr),i+2))=previous_hr;
     i = i+1;
   end
   i=i+1;
end
```