Erasmus+

Development of innovative training solutions in the field of functional evaluation aimed at updating of the curricula of health sciences schools

TEACH

MODULE BIOMECHANICS: FOUNDATIONS OF BIOMECHANICS APPLIED TO THE LOCOMOTOR SYSTEM

Didactic Unit E: Techniques for the instrumental analysis of physiological signs and anthropometric and morphometric parameters?

E.2. What are the applications of the analysis of physiological signs?

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1. Objectives

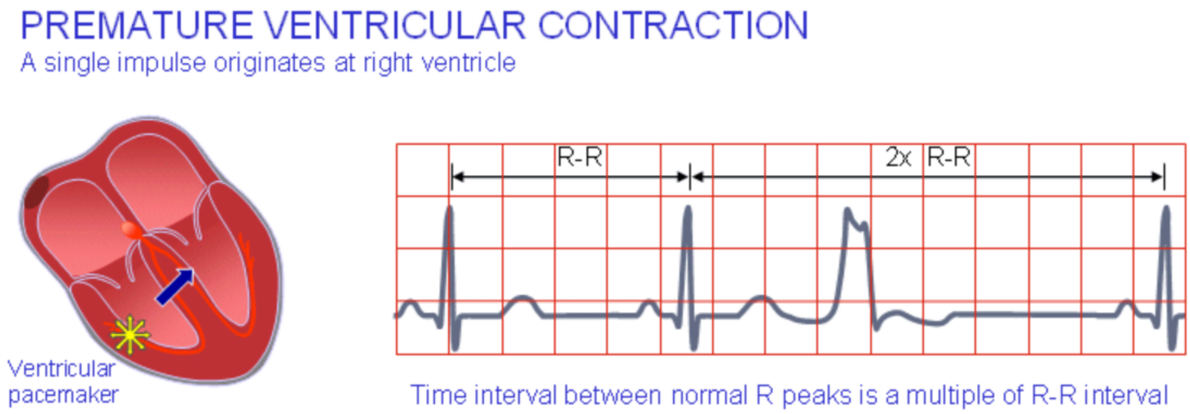
- To learn what are the chosen application fields of physiological signs measurements.
- To know and feel the idea illustrated on some examples of feature and further knowledge extraction from measured raw biosignal data.
- To be able to use gathered knowledge in selected parameter extraction from recorded physiological signals.

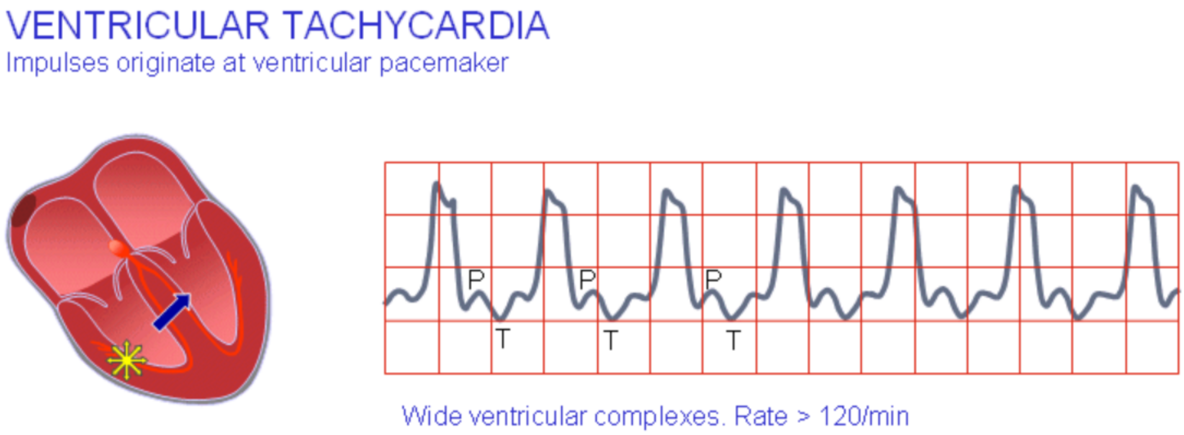
2. What are the applications of chosen, most common bio-physiological signals?

ECG signal applied to describe parameters of mechanical and electrical heart functions. ECG cycle parameters both peaks and waves reflect the state of the heart and its control system.

ECG interpretation for heart pathology detection

Shape, patterns and other features of ECG cycle reflect set of standardized pathology of cardiovascular system e.g.:





HEART RATE VARIABILITY signal as a result of ECG and PPG signal processing application.

Heart rate is the number of heart beats per minute [bpm].

HR [bpm] = 60/(R-R_interval [s])

Heart rate variability (HRV) is the fluctuation in the time intervals between adjacent heartbeats. HRV indexes neurocardiac function and is generated by heart-brain interactions and dynamic non-linear autonomic nervous system (ANS) processes. HRV is an emergent property of interdependent regulatory systems which operate on different time scales to help us adapt to environmental and psychological challenges. HRV reflects regulation of autonomic balance, blood pressure (BP), gas exchange, gut, heart, and vascular tone, which refers to the diameter of the blood vessels that regulate BP, and possibly facial muscles.

ECG is a base to compute the **Heart Rate Variability Signal (HRV),** which reflects the influence of autonomic nervous system (ANS) on Heart Rate modulation.

Although the heart generates its own beat, the heart rate (beats per minute or BPM) and strength of contraction of the heart are modified by the sympathetic and parasympathetic divisions of the autonomic nervous system.

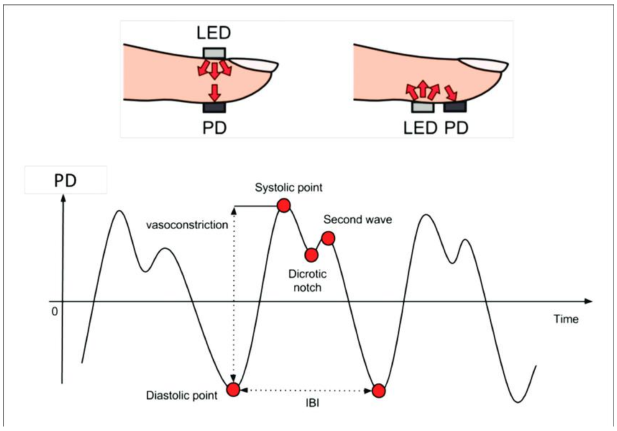
The sympathetic division increases automaticity and excitability of the sinus atria (SA) node, thereby increasing heart rate. It also increases conductivity of electrical impulses through the atrioventricular conduction system and increases the force of atrioventricular contraction.

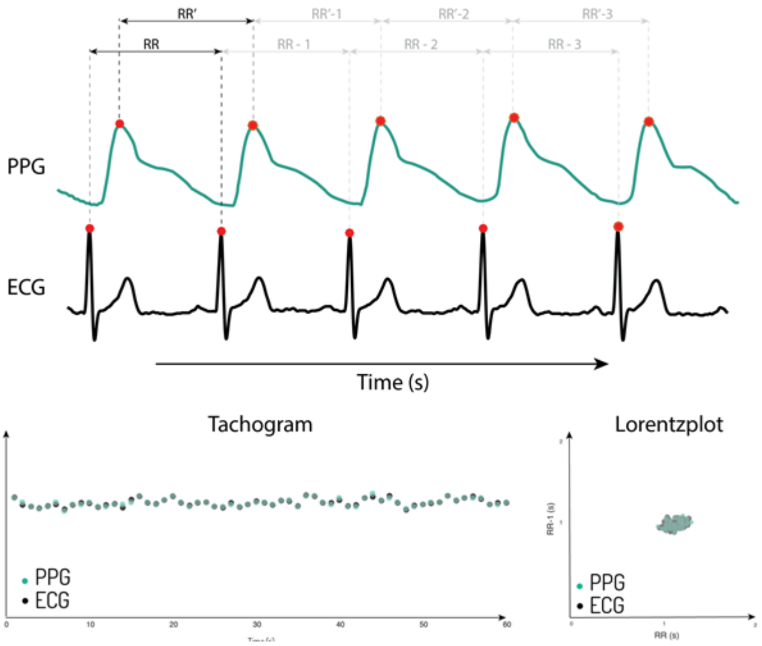
Sympathetic influence increases during inhalation.

The parasympathetic division decreases automaticity and excitability of the SA node, thereby decreasing heart rate. It also decreases conductivity of electrical impulses through the atrioventricular conduction system and decreases the force of atrioventricular contraction.

Parasympathetic influence increases during exhalation.

Heart Rate estimation from PPG pulse wave signal, recorded in nonivansive way.





Common Applications for ECG Measurement

Determining Heart Health

ECG is used in clinical applications determining heart heath by examining the various ECG components for normal and abnormal activity.

Exercise Physiology

ECG is invaluable to the study of exercise physiology (study of the body's response to physical activity), which also incorporates a wide range of physical parameters such as ventilation, oxygen uptake, carbon dioxide production, blood pressure and core/surface temperature data.

Psychophysiology

Record and analyse several physiological signals synchronously with ECG e.g. Blood Pressure, ElecroDermal Activity (EDA), Electromiography (EMG) etc.

Physiology Education

ECG is an important component in physiology education.

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Common Applications for EMG Measurement

Biomechanics

Biomechanics is the study of movement as it relates to the muscular and skeletal systems. Sport and Exercise Biomechanics encompasses the area of science concerned with analysis of the mechanics of human movement.

Gait Analysis

Gait analysis is a method used to assess the way we walk or run to highlight biomechanical abnormalities. The major focus of gait analysis is to measure the degree of pronation. Pronation is the natural inward roll of the foot as the outside part of the heel strikes the ground. This roll acts as a shock absorber for the leg and body, optimally distributing the force of the impact of the heel hitting the ground.

Facial EMG

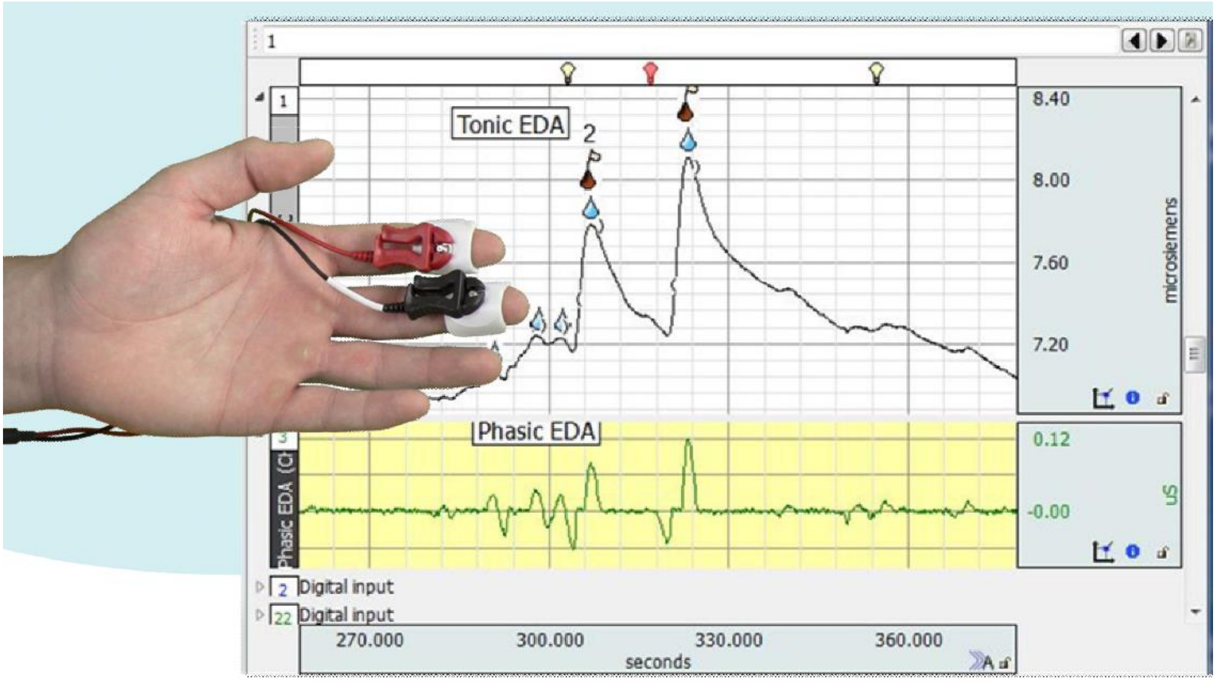
Human facial expressions are of interest to both psychologists and psychophysiologists. Facial electromyography (EMG) is one of the methods for measuring emotional expressions such as fear, surprise, happiness, disgust, sadness, and anger. There are differences in facial behavior on an individual level, based on subjective response.

Facial EMG can be distinguished based on the activity across specific facial muscles. Activities in the zygomaticus major muscle tend to correspond with positive emotions (happiness, surprise), and the corrigator supercilii muscle tends to correspond with negative emotions (anger, fear, disgust).

Muscular Biofeedback

Biofeedback is a form of self-regulation in which an individual is provided information in the form of sensory feedback about a biological condition or function in order to gain control over that biological function. Biofeedback is often used as a therapeutic tool by which therapists, sports medicine/rehabilitation professionals, neurophysiologists, and psychophysiologists can use electrophysiological instrumentation to measure, process, and “feedback” the recorded information to the subject (client, patient, athlete)..

Common Applications for EDA Measurement.



Psychological Research

Psychological research studies utilize EDA (electro-dermal activity or galvanic skin response GSR) to identify how humans respond emotionally towards various stimuli. Sensory stimuli (vision, hearing, equilibrium, taste, smell) also exerts an effect on a participant's emotional state. Interestingly (although highly subjective), the perception of colour may also elicit changes in autonomic tone, which in turn, affect a participant's mood and behaviour. Warm colours such as red, orange, and yellow evoke emotions of warmth and comfort in some persons, feelings of anger and hostility in others. The phrase "seeing red" refers to an angry person. Cool colours such as green, pink, and blue evoke feelings ranging from enviousness ("green with envy"), tranquillity, and sadness or indifference ("feeling blue").

Psychotherapy

EDA is often used in the treatment and assessment of patients suffering from various phobias, posttraumatic stress disorder (PTSD) and other emotional conditions. By monitoring EDA, the physiological arousal of the patient can be a helpful barometer for assessing severity of the condition as well as the success of subsequent therapeutic measures.

Physiology Education

EDA is an important component in physiology education and one of the many physiological signals including Polygraph and Biofeedback studies.

Neuromarketing and Media Research

EDA can be used to track emotional arousal resulting from exposure to products, commercials, trailers and TV shows during consumer research studies. Many shopping and viewing preferences are based upon sub-conscious processes. EDA data can be helpful in assessing customer preferences on a subliminal level and providing researchers with objective subject feedback.

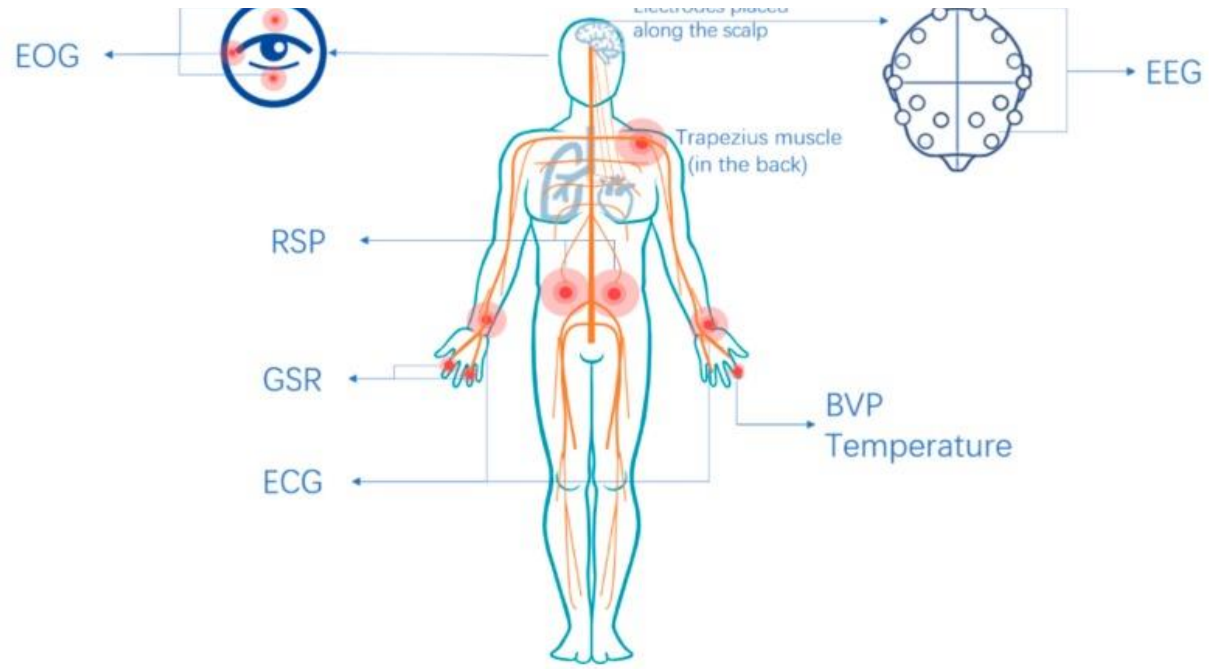
Software Usability and User Experience Testing

EDA is often used as a barometer when testing ease-of-use for software and other interactive applications. These applications can include stimulus presentation, video, and virtual reality. If a participant becomes silently confused or frustrated, EDA data is a good indicator of these types of emotional responses and at which point during the experience the responses occur.

3. Body Sensor Networks application field of multichannel and multimodal connected biosensors. How can they deliver patient's physiological data to global system for remote analysis and reasoning?

With the development of physiological sensors, low-power integrated circuits, and wireless communication technologies, body sensor networks (BSNs) have become an indispensable part of smart medical services by monitoring the real-time state of users. These systems are also referred as body area network (BAN), a wireless body area network (WBAN) or a medical body area network (MBAN).

The body area network field is an interdisciplinary area which could allow inexpensive and continuous health monitoring with real-time updates of medical records through the Internet. A number of intelligent physiological sensors can be integrated into a wearable wireless body area network, which can be used for computer-assisted rehabilitation or early detection of medical conditions. This area relies on the feasibility of implanting very small biosensors inside the human body that are comfortable and that don't impair normal activities. The implanted sensors in the human body will collect various physiological changes in order to monitor the patient's health status no matter their location. The information will be transmitted wirelessly to an external processing unit. This device will instantly transmit all information in real time to the doctors throughout the world. If an emergency is detected, the physicians will immediately inform the patient through the computer system by sending appropriate messages or alarms.



Assessment of Mental Workload with Psychophysiological measures

A relevant study of Bailey et al. [17] who develop psychophysiological measures to assess the effect of interruptions on the performance of a person executing a task. They establish that interruption involves considerable negative effects, such as increased time to complete the task, a wider range of errors, additional efforts in decision-making and mood changes such as increased frustration and anxiety.

The mental workloads of basic tasks such as the resolution of problems on a monitor, visual perception, and cognitive speed can be measured by Body Sensor Networks components e.g. eye-tracking device, EEG, ECG, EDA, heat flow, and Heart Rate measurements. As a result, they find that ECG and heat flow together distinguish between tasks of high and low cognitive demand with 80% precision.

Stress detection by means of complex body sensor networks applications.

Stress is a major factor in several diseases, and everyone may experience stress at some time or once in a lifetime, due to the enormous psycho-physiological demands while performing their day-to-day activities. Human stress is a kind of controllable unsteady state which can be countered by using suitable relaxation and management techniques at the appropriate time. Several studies indicate that stress is a common factor both pathogenesis, besides exacerbating the impact of many diseases, from the common cold to severe cardiovascular disease. Physiological signals and biochemical samples are advanced methods for measuring the stress levels. Urine, saliva, and blood samples are the primary measures in biochemical samples to identify the effects of stress in the human body. However, these biochemical samples are usually taken at various intervals of time compared with the continuous sampling of physiological signals. It is invasive and inconvenient which severely constrains its efficacy in real-time stress assessment. Conversely, physiological signals (ECG, galvanic skin response (GSR), electromyogram (EMG), electroencephalogram (EEG), blood pressure (BP), skin temperature (ST), respiration rate (RR), and blood volume pulse (BVP)) have attracted major research interest with a view to developing newer and more efficacious methodologies for measuring stress.

Among the several types of physiological signals, ECG in specific heart rate variability (HRV) signals plays a vital role in stress assessment research. Even though this signal is a major consideration, there are obstructions, such as validity of short-term HRV signals, optimization of stress relevant features, frequency band selection and improving stress detection rate in subject-independent analysis using large population. Most experiments on affective state assessment, such as emotion and stress, as found in the literature, have been measured through physiological signals over shorter time intervals (less than 60 s). The European Society of Cardiology has suggested that a minimum of 5 min duration is essential for measuring the heart rate (HR) from ECG signals, and that anything less than 5 min duration is of dubious value.

4. Key ideas

- For every recorded physiological signals the key is: how to change measured raw data into knowledge based on feature extraction algorithms.

- An excellent example of application of physiological signals analysis is the Heart Rate signal (HRV), which is the result of non-invasive recorded ECG or blood pulse wave processing. HRV measured in such a comfortable allow to get some information about Autonomic Nervous System state and action.

- Body Sensor Networks, currently developing so dynamically thanks to the combination of sensory and IT technologies are the final, most extensive example of physiological measurements applications.

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