ELECTRONICS & COMMUNICATION ENGINEERING

TECH CONNECT

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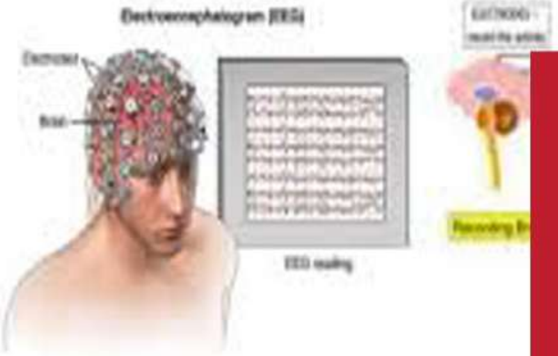
ELECTROENCEPHALOGRAM (EEG)



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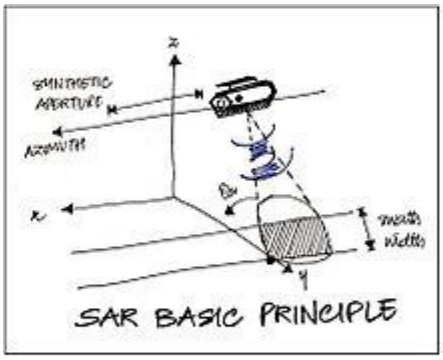
1. Synthetic aperture radar

Synthetic-aperture radar (**SAR**) is a form of radar that is used to create two-dimensional images or three-dimensional reconstructions of objects, such as landscapes.[1] SAR uses the motion of the radar antenna over a target region to provide finer spatial resolution than conventional beam-scanning radars. SAR is typically mounted on a moving platform, such as an aircraft or spacecraft, and has its origins in an advanced form of side looking airborne radar (SLAR). The distance the SAR device travels over a target in the time taken for the radar pulses to return to the antenna creates the large *synthetic* antenna aperture (the *size* of the antenna). Typically, the larger the aperture, the higher the image resolution will be, regardless of whether the aperture is physical (a large antenna) or synthetic (a moving antenna) – this allows SAR to create high-resolution images with comparatively small physical antennas.

To create a SAR image, successive pulses of radio waves are transmitted to "illuminate" a target scene, and the echo of each pulse is received and recorded. The pulses are transmitted and the echoes received using a single beam-forming antenna, with wavelengths of a meter down to several millimeters. As the SAR device on board the aircraft or spacecraft moves, the antenna location relative to the target changes with time. Signal processing of the successive recorded radar echoes allows the combining of the recordings from these multiple antenna positions. This process forms the *synthetic antenna aperture* and allows the creation of higher-resolution images than would otherwise be possible with a given physical antenna.[2]

As of 2010, airborne systems provide resolutions of about 10 cm, ultra-wideband systems provide resolutions of a few millimeters, and experimental terahertz SAR has provided sub-millimeter resolution in the laboratory.

Synthetic-aperture *radar* is an imaging radar mounted on a moving platform.[6] Electromagnetic waves are transmitted sequentially, the echoes are collected and the system electronics digitizes and stores the data for subsequent processing. As transmission and reception occur at different times, they map to different positions. The well ordered combination of the received signals builds a virtual aperture that is much longer than the physical antenna width. That is the source of the term "synthetic aperture," giving it the property of an imaging radar.[5] The range direction is parallel to the flight track and perpendicular to the azimuth direction, which is also known as the *along-track* direction because it is in line with the position of the object within the antenna's field of view.



Basic principle

The 3D processing is done in two stages. The azimuth and range direction are focused for the generation of 2D (azimuth-range) high-resolution images, after which a digital elevation model (DEM)[7][8] is used to measure the phase differences between complex images, which is determined from different look angles to recover the height information. This height information, along with the azimuth-range coordinates provided by 2-D SAR focusing, gives the third dimension, which is the elevation.[3] The first step requires only standard processing algorithms,[8] for the second step, additional pre-processing such as image co-registration and phase calibration is used.[3][9]

In addition, multiple baselines can be used to extend 3D imaging to the *time dimension*. 4D and multi-D SAR imaging allows imaging of complex scenarios, such as urban areas, and has improved performance with respect to classical inter ferometric techniques such as persistent scatterer interferometry (PSI).

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2.Electromyography

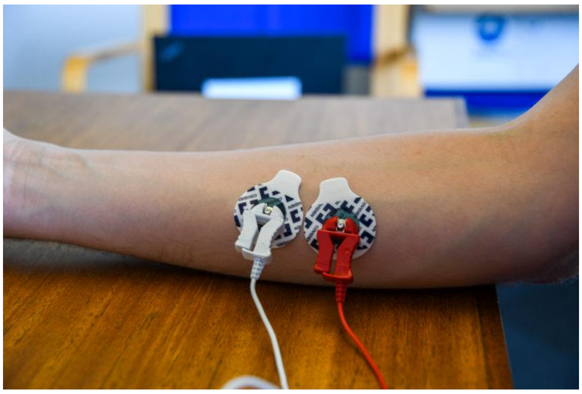
Electromyography (EMG) is a diagnostic procedure that evaluates the health condition of muscles and the nerve cells that control them. These nerve cells are known as motor neurons. They transmit electrical signals that cause muscles to contract and relax. An EMG translates these signals into graphs or numbers, helping doctors to make a diagnosis.

A doctor will usually order an EMG when someone is showing symptoms of a muscle or nerve disorder. These symptoms may include tingling, numbness, or unexplained weakness in the limbs. EMG results can help the doctor diagnose muscle disorders, nerve disorders, and disorders affecting the connection between nerves and muscles.EMG (electromyography) records the movement of our muscles. It is based on the simple fact that whenever a muscle contracts, a burst of electric activity is generated which propagates through adjacent tissue and bone and can be recorded from neighboring skin areas.

Movement of Muscles:

The process of course begins in the brain. Triggering muscle movements begins in the motor cortex, where neural activity (a series of action potentials) signals to the spinal cord, and the information about the movement is conveyed to the relevant muscle via motor neurons

This begins with upper motor neurons, that carry the signal to lower motor neurons. The lower motor neurons are the actual instigators of muscle movement, as they innervate the muscle directly at the neuromuscular junction. This innervation causes the release of Calcium ions within the muscle, ultimately creating a mechanical change in the tension of the muscle [1, 2]. As this process involves depolarization (a change in the electrochemical gradient), the difference in current can be detected by EMG.



Information provided by EMG:

As EMG activity (measured in microvolts) is linearly related to the amount of muscle contraction as well as the number of contracted muscles – or in other words, the stronger the muscle contraction and the higher the number of activated muscles, the higher the recorded voltage amplitude will be.

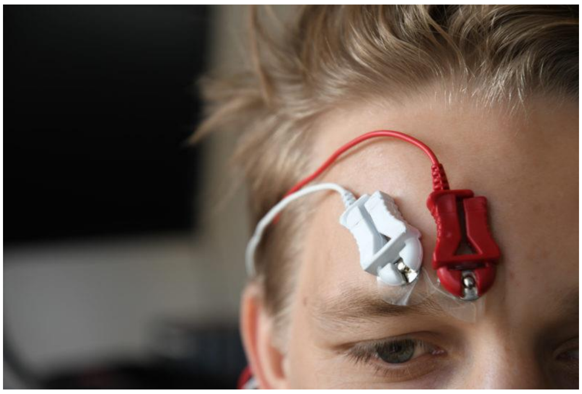
As EMG activity is even measurable when we do not display obvious actions or even inhibit certain behaviors, EMG recordings represent an additional source of information into cognitive-behavioral processing which would be hidden based on pure observation.

Previous research indicates a close coupling between muscular EMG and motor cortex EEG as reflected by significant correlations in signal features such as frequency power and phase in the (12 – 25 Hz) beta band. This emphasizes the power of EMG recordings for monitoring the interaction of cortical and motor systems.While EMG is clearly helpful in understanding how people move, the use of fEMG (facial electromyography, in which EMG signals are recorded from the muscles of the face), can also provide information about facial expressions.

Facial electromyography

The particular strength of fEMG as compared to automated or manual facial expression analysis (that is based on the analysis of video recordings), is the sensitivity it has in detecting signals. While more difficult to set up than video recordings, the data it provides is more robust. It can even detect the non-visible muscular activity of the face, providing information about suppressed expressions, or those that otherwise do not pass the threshold for visible activity. This sensitivity is instrumental in understanding the hidden (intentionally or not) facial expressions that can be linked to an internal emotional state, allowing a window to see how someone is implicitly feeling.

This process can be made even more powerful if complemented with other measures of human behavior, such as eye tracking or GSR (galvanic skin response), allowing you to see where someone looks, and their level of emotional arousal, as well as the direction of those emotions.



Usage of EMG

- Use surface electrodes
  - Surface EMG is a completely non-invasive technology that allows you to easily place EMG electrodes with stickers to the skin.
  - As these electrodes are non-invasive, EMG is an ideal method for monitoring physiological processes without interfering established routines and movement patterns.
  - In order to obtain high-quality data, keep in mind to always clean the recording sites and remove makeup using alcohol rubs.

- Place EMG electrodes over muscle groups of interest
  - Admittedly, this requires a certain level of anatomic knowledge. Only if you know the muscle regimes involved in a specific action you will be able to get valid and reliable signals.
  - Facial EMG recordings, for example, are complicated by the fact that there are 43 muscles in the face. Most of these are controlled by the seventh cranial nerve (the “facial nerve”), which routes from the cerebral cortex to five primary branches (temporal, zygomatic, buccal, mandibular and cervical).
  - Each branch innervates muscles in different face areas, allowing for intricate facial twists and contortions.

- Select an appropriate reference site
  - EMG data is collected as the voltage difference between recording site and reference site, therefore selecting an appropriate reference site is as important as the actual recording site.

  - We recommend placing EMG reference channels at bony body parts such as an elbow, hip or collar bones.
- Use short electrode cables/leads
  - In order to minimize the amount of electrical noise picked up from surrounding power sources, keep the length of the cables that connect the recording electrodes with the amplifier/recording device as short as possible.

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3.Intensity Inhomogeneity Correction

MRI is a medical imaging technique used in radiology that produces images of internal physical and chemical characteristics of an object from externally measured nuclear magnetic resonance (NMR) signals. MRI scanners use magnetic fields and radio waves to form images of the body. The technique is widely used in hospitals for medical diagnosis, theatrical production of disease and follow-up without exposure to ionizing radiation. MRI has a wide range of applications in medical diagnosis and over 25,000 scanners are estimated to be in use worldwide.MR imaging is a popular medical imaging technique used in radiology to visualize detailed internal structures. It provides good contrast between different soft tissues of the body, which makes it especially useful in imaging the brain, muscles, the heart and cancers. Magnetic resonance imaging segmentation provides important information for clinical diagnosis where different kinds of tissue and body fluids are associated to the clusters of similar image intensity values [8]. MRI plays a major role to decide treatment strategy especially for brain injuries. Brain injuries lead several Neurological disorders, which can be deflected by early diagnosis and treatments.

A. Why MRI Segmentation?

It is essential to several important applications in diagnosis, therapy evaluation and human brain mapping is a challenging task due to frequent image artifacts and poor contrast between the structures to segment. Magnetic resonance imaging (MRI) segmentation provides important information for clinical diagnosis where different kinds of tissue and body fluids are associated to the clusters of similar image intensity values. The brain is the most important part of central nervous system. The main task of the doctors is to detect the tumor which is a time consuming for which they feel burden. Brain tumour is an intracranial solid neoplasm. The only optimal solution for this problem is the use of MRI Segmentation. The Healthy brain tissue can generally be classified into three broad tissue types on the basis of an MR image. These are Grey matter (GM), white matter (WM) and Cerebro Spinal fluid (CSF).MRI imaging plays a major role to decide treatment strategy especially for brain injuries. MRI is used for a huge range of clinical applications.

MRI Segmentation is a main technique to differentiate abnormal and normal tissue in MR image data. In general, MRI segmentation is not a trivial task, because acquired MR images are imperfect and are often corrupted by noise and other image artifacts. The diversity of image processing applications has led to progress of various methods for image segmentation. This is for the reason that there is no particular technique that can be suitable for all images, nor are all

methods equally good for a specific type of image. For example, some of the methods use only the gray level histogram while some integrate spatial image information to be robust for noisy environments. Some methods use probabilistic or fuzzy set theoretic approaches, while some additionally integrate prior knowledge (specific image formation model, e.g., MRI brain atlas) to further improve segmentation performance. However, most of the segmentation methods developed for one class of images can be easily applied or extended to a different class of images. For example, the theory of graph cuts although firstly developed for binary images, can be modified and used for MRI segmentation of the brain tissue. Also, unsupervised fuzzy clustering has been successfully applied in different areas such as remote sensing, geology, and medical, biological, and molecular imaging. Some of the MRI segmentation methods are
edge detection, boundary tracing, thresholding, seed growing, template models, random field, mean-shift,
histogram thresholding, graph cuts segmentation, Fuzzy connectivity, Optimal single and multiple surface segmentation, K-means Clustering, etc.

Major difficulties in segmentation of brain MRI:

Even though cortical segmentation has developed for many years in medical research, it is not regarded as
an automated, reliable, and high speed technique because of magnetic field Inhomogeneity:
1. Noise: random noise associated with the MR imaging system, which is known to have a Rician distribution [8] 2. Intensity inhomogeneity (also called bias field or shading artifact): the non-uniformity in the radio frequency (RF) field during data acquisition, resulting in the shading of effect [9] 3. Partial volume effect: more than one type of class or tissue occupies one pixel or voxel of an image, which are called partial volume effect.
Bias Field:

Bias field is also called Intensity inhomogeneity, or shading artifact in MRI, which arises from the imperfections of the image acquisition process, manifests itself as a smooth intensity variation across the MRI image. Because of this phenomenon, the intensity of the same tissue varies with the location of the tissue within the image. Although bias field is usually hardly noticeable to a human observer, many medical image analysis methods, such as segmentation and registration, are highly sensitive to the spurious variations of image intensities. This is why a large number of methods for the correction of intensity inhomogeneity in MR images have been proposed in the past [12].A bias field is a low frequency smooth undesirable signal that corrupts

MRI images because of the in homogeneities in the magnetic fields of the MRI machine. Bias field blurs images and thus decreases the high frequency contents of the image such as edges and contours and changes the intensity values of image pixels so that the same tissue has different grey level distribution across the image. A low level difference will not have great influence on clinical diagnosis. Still it degrades the performance of image processing algorithms such as segmentation and classification or any algorithm that is based on the assumption of spatial invariance of the processed image [1]. A preprocessing step is needed to correct for the effect of bias field before doing segmentation or classification.

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