Ministry of 3ublic +ealth of Ukraine
"Ukrainian Medical Stomatological Academy"

"APPROVED"
at the meeting of the Department
of Medical Informatics, Medical Biophysics
«27» august 2020
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Head of departmentBBBBBBBBBB296LONRYD

METHODICAL GUIDANCE

IRUVWXGHQWVHOI-directed work when preparing and during the practical session

Academic Subject	Medical Information Science
Module No 1	Fundamentals of Information Technology in the Health Care System. Treatment and analysis of medical and biological data
Topic	Biosignal analysis. Methods of processing biosignals.Visualization of medical and biological data. Processing and the analysis of medical images.
Year of study	2
6SHFLDOLW\	Foreign Student Training (0HGFLQH6WRPDWRORJ\)
Number of academic hours	2

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1. Relevance of the topic:

Features of early and accurate diagnosis and therefore treatment in recent years have increased dramatically. To a large extent this is due to the development of various research methods that give the doctor an image of normal and pathological changes in organs and tissues - medical diagnostic images. Medical image – is the main source of information at diagnosis. With the rapid growth of the general level of computerization and technological upgrade health care institutions Ukraine acute problem systematize acquired image information obtained in the course of diagnosis, treatment and prevention. That’s why using the visualization.

2. The specific aims:

To know the definition of medical image;
To know methods of medical imaging;
To have general knowledge of the topic studied;
To understand, to remember and to use the knowledge received;
To form the professional experience by reviewing, training and authorizing it;
To be able to carry out laboratory and experimental work.

3. Basic knowledge and skills necessary to study the topic (inter-disciplinary integration).

Previous (providing disciplines)	**Obtainable skills**
Bases of medic sciences	To know assignment methods of medical image.

4. The tasks for students’ individual work

4.1. The list of basic term, parameters, characteristics, which student should master while preparin for the class.

Term	Definition
Medical imaging	The imagining which provides visual information about the internal structure and functions of the human body
Radiology (conventional radiology)	The method, which use ionizing radiation from X-ray source. It is the most common method in the Department of Radiology. The image is obtained from the radiographic film which is sensitive to X-rays, and can be later of these films digitized.
Digital Angiography	The method, which shows the tubule, removing unwanted image of the structure (bones and internal organs).
Computed tomography (CT)	The method, which uses X-rays, but instead of a single flat image CT shows multiple images taken in different directions.
Ultrasonography	The method, which is based on the acoustic study. The probe emits ultrasonic waves and receives reflection that by piezoelectric crystal is converted into electrical signals. Signals are received from a number of parallel channels are converted to digital form and processed.
Scintigraphy	The method, during which into the organism is introduced radioactive label, which has a tropism to a particular type of tissue. The radiation is recorded by a camera sensitive to the radiation.

4.2 Theoretical questions for the class (to the topic):

1. The concept of a medical image.
2. Groups of medical image.
3. The importance of Digital image processing.
4. Modern trends in image processing.
5. Medical image as an object of medical informatics.
6. Methods of medical imaging.

7. The basic principles of image processing.

4.3 Practical tasks pertaining to the topic and to be completed during the class:
Test

1. WHICH OF THE OPTIONS INCLUDE METHODS OF NON-RADIOLOGICAL IMAGE?

a) endoscopy
b) all methods
c) ultrasound diagnosis
d) angiography
e) none of the above

2. WHICH METHOD IS THE MOST COMMON METHOD IN RADIOLOGY DEPARTMENTS?

a) angiography
b) computed tomography
c) scintigraphy
d) radiography
e) MRI

3. WHAT ITEMS CAN BE ATTRIBUTED TO THE DYNAMIC MEDICAL IMAGING FACILITIES?

a) pelvic bone
b) soft tissue structures
c) the skull
d) heart
e) all of above

4. WHICH METHODS COMBINE THE MEDICAL IMAGING FIELD WITH MODERN COMPUTER VISION, MACHINE LEARNING AND PATTERN RECOGNITION?

a) group analysis
b) statistical analysis
c) classification
d) shape analysis
e) longitudinal studies

5. WHICH IMAGIN IS A STRUCTURAL MAGNETIC RESONANCE IMAGING MODALITY THAT ALLOWS MEASUREMENT OF THE DIFFUSION PROCESS OF MOLECULES?

a) diffusion MRI
b) computer tomography
c) scintigraphy
d) radiography
e) ultrasound image

Practical work:

Practical work "Preparation and Analysis of Biomedical Images"

Objective: To get acquainted with methods of obtaining medical and biological data, learn how to process medical images.

Task 1

1. Start **3D-DOCTOR Viewer** program using a shortcut on the desktop.
2. Open the file with the *D:\Visualization_MBD\ Task_2*.
3. View the look of the program.

4. Compare all types of images. Choose the most convenient.

Task 2

1. Start **RadiAnt DICOM Viewer** program on your desktop.
2. View the interface and **RadiAnt DICOM Viewer** toolbar.
3. View and analyze medical images in *Task_3* folder.

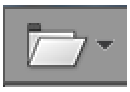
You should:

In the program **RadiAnt** click on the button  select "Open DICOM directory", select the path to the folder *D:\Visualization_MBD \ Task_3 \ ...*

Record the names of medical images in a table in your notebook:

Medical image	**Description**
	CT angio
	Aneurysm
	Intestinal lymphoma
	Normal Cardiac MRI
	pelvic fracture
	MR spine
	Prostate cancer

Task 3

1. In **RadiAnt** click on the button  select "Open DICOM directory" path - *D:\Visualization MDB \ Task 4 \ cerebri.*

Perform the following actions:

• increase (decrease) image size (separate anatomical structures of the image);
• change the contrast of the image;
• divide the screen into 6 parts, and download each image created by the window;
• rotate the image 90 degrees (180 degrees).

Task 4

1. Open the medical images in the folder (*D:\Visualization_MBD \ Task_5).*
2. View files. Relate images and methodology of its receipt.

The results draw in a notebook in the form of a table:

№	file name	Methods of imaging	target organ	Objects Medical image (Static, dynamic)

Task 5

1. Open the directory *(D:\Visualization_MBD\melanoma*). Wait for a full load of pictures, find the picture 25 corresponding to Figure 1 (without marks for measurement).

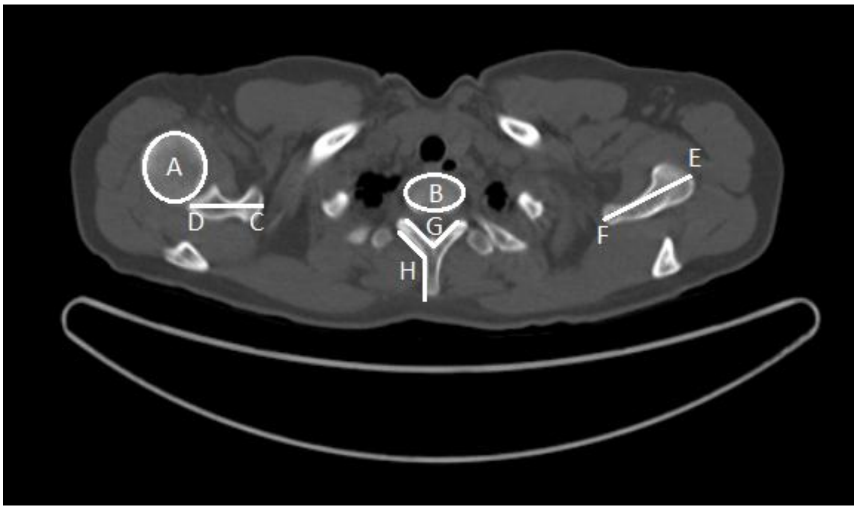
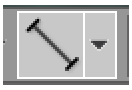


Figure. 1

2. Using the button  (Segment, angle, ellipse), perform the following measurements of the *Figure 1* and complete the table:

№	Task	The measurement result
1.	The distance from point D to G (mm)	
2.	The distance from the point F to E (sm)	
3.	Angle G	
4.	Angle H	
5.	Square shape A (mm^2)	
6.	Square shape B (sm^2)	

Content of the topic:

The concept of a medical image

One of the areas of computer application in medicine is to work with graphic information. This trend is being studied in a special section of Medical Informatics - analysis of medical images. Medical imaging provides visual information about the internal structure and functions of the human body. It can be obtained by radiological or non-radiological methods.

Appointment of radiological methods – make it accessible to the visual perception of information that is not directly perceived by sight. Such information is obtained via radiation. This radiation is usually an electromagnetic nature. Medical images of organs obtained by means of radiological diagnostics, the main source of health information. Non-radiological methods receive images captured by camera (endoscopy) or by photograph (microscopic images in histology, pathology, dermatological images, etc.). These types of images may also be digitized and processed over time. In the future, we will consider mainly medical images obtained by radiological methods. That is why the term “medical image” we mean the available visual perception picture of the spatial distribution of any type of radiation, transformed into the visible portion of the optical range.

Medical image as an object of medical informatics

All medical images, regardless of their methods of preparation, belong to one of two groups: analog and matrix image. The **analog images** are those that have a continuous nature of the information. For example: the image on the radiograph. The **matrix images** include images obtained by computer. They are based on a matrix which is contained in the memory of the PC. Thus, the matrix images, as opposed to analog, have discrete in nature. As the basis of the matrix image is computer technology, they are available for a variety of computer processing. It should be noted that the analog image may be converted to the matrix, and vice versa. For this purpose are used special devices: analog-to-digital and digital-to-analog converters. A matrix image is formed by scanning the electron beam. Memory display processor is organized in a matrix, each element of which corresponds to a certain area of the display. This basic unit matrix image, which corresponds to the numbered section of memory called “pixel” (an element of the picture). Thus, the entire area of the screen which is a matrix – is a set of pixels. The X-ray diagnostics display area may be formed in the following matrix: 32×32, 64×64, 128×128, 256×256, 512×512, 1024×1024, 1024×1280. The greater the number of pixels on the display area is divided, the greater the system's ability to display the distribution.

All medical images in diagnostic may exist in the form of hard copies – X-rays, reflects on paper, photo paper; or on magnetic media – tapes, disks; or non-fixed form – on the display or x-ray diagnostic apparatus.

Objects of medical images can be divided into solid fragments (eg. bone), and fragments which can be deformed (eg. a soft tissue structure); or static fragments (eg. the skull) and dynamic fragments (eg. heart).

Methods of medical imaging

For one or two-dimensioned medical images can be used:

- electromagnetic radiation;
- ultrasound.

Methods for preparation of two-dimensional medical images are:

- digital Radiology;
- computed tomography;
- nuclear-magnetic resonance;
- 2D-ultrasound.

Methods and sources of three-dimensional images are:

- sequence of radiological images, or dynamic tomographic image of the object;
- volumetric tomographic image of the static object.

Let’s see the describe some of these methods:

Radiology (conventional radiology) use ionizing radiation from X-ray source (Fig. 6. 1). It is the most common method in the Department of Radiology. The image is obtained from the radiographic film which is sensitive to X-rays, and can be later of these films digitized.

But you can obtain a digital image of bypassing the stage of radiographic film – in the new devices, which use special films instead of the matrix.

Fig 6.1 X-ray of the lungs

Digital Angiography shows the tubule, removing unwanted image of the structure (bones and internal organs). The study conducts in two stages. First, get images before injection of contrast material and translate them into digital form. Then they used to create a mask, which is removed from the images obtained after injection (Fig. 6.2).

Fig 6.2. Angiography

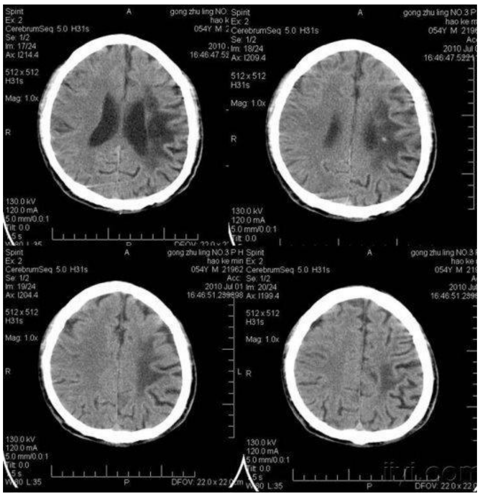


Fig 6.3. CT of brain

Computed tomography (CT) also uses X-rays, but instead of a single flat image CT shows multiple images taken in different directions (Fig 6.3). In nuclear magnetic resonance (NMR), computer reconstructs the image from the received radio signal, the intensity and duration of which depends on the characteristics of the biological tissue. MRI doesn't use ionizing radiation; it provides an image which depends from metabolism and tissue characteristics.

Ultrasonography is based on the acoustic study. The probe emits ultrasonic waves and receives reflection that by piezoelectric crystal is converted into electrical signals. Signals are received from a number of parallel channels are converted to digital form and processed (Fig 6.4).

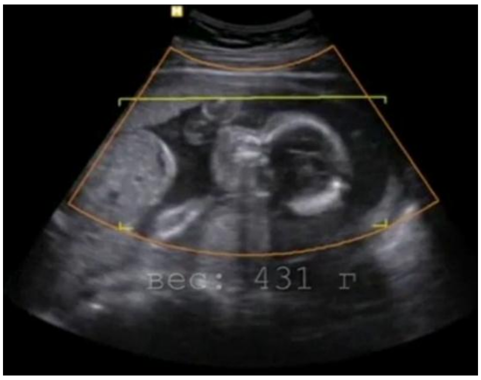


*Fig 6.4.*Fetal ultrasound

During *scintigraphy* into the organism is introduced radioactive label, which has a tropism to a particular type of tissue. The radiation is recorded by a camera sensitive to the radiation. This is an image captured by a video camera (endoscopy) or photograph (microscopic images in histology, pathology, dermatological images, and so on.).

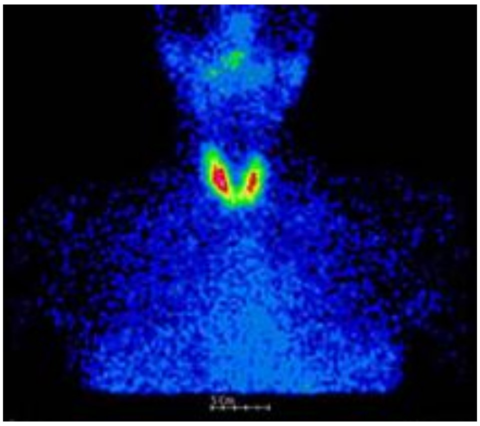


Fig 6.5. Scintigraphy

Magnetic resonance imaging instrument uses powerful magnets to polarize and excite hydrogen nuclei (i.e., single protons) of water molecules in human tissue, producing a detectable signal which is spatially encoded, resulting in images of the body.The MRI machine emits a radio frequency (RF) pulse at the resonant frequency of the hydrogen atoms on water molecules. Radio frequency antennas ("RF coils") send the pulse to the area of the body to be examined (Fig. 6.6).

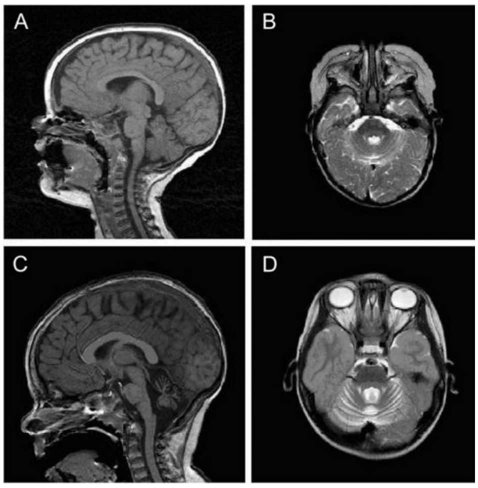


Fig 6.6. MRI of brain

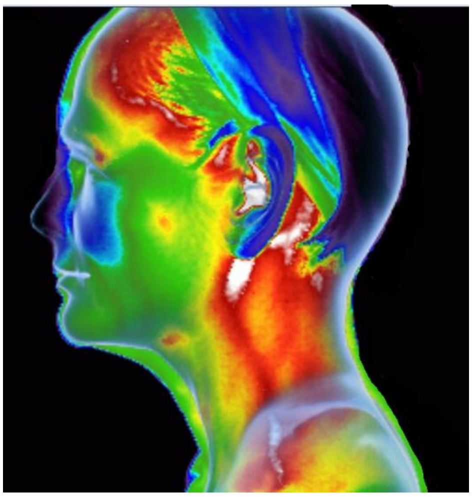


Fig 6.7. Thermography of head

Thermography. Primarily used for breast imaging (Fig.6.7). There are three approaches: tele-thermography, contact thermography and dynamic angiothermography. These digital infrared imaging thermographic techniques are based on the principle that metabolic activity and vascular circulation in both pre-cancerous tissue and the area surrounding a developing breast cancer is almost always higher than in normal breast tissue.

Medical imaging

In our time come to replace analog digital medical images. Digitizing simplifies processing of image, storage and transmission of medical image data. Information technology can help at all stages of preparation and processing of medical images. Computers are directly involved in creating certain types of images that cannot be obtained in another way: computed tomography, positron emission tomography, nuclear magnetic resonance.

Digital image processing can be used to:

- to improve the image quality, records system defect compensation and noise reduction;
- to calculate clinically important quantitative parameters (distance, area, volume, etc.);
- to facilitate interpretation (recognition structure, dose calculation of radiation therapy);
- image compression reduces the amount of memory for storing data and time for their transfer;
- storage of digital images on a hard disk or on CD simplifies the organization of the archives and access to them;
- transferring images in digital form between hospitals allowing fast consulted several experts for making diagnostic or therapeutic decisions and improve monitoring of the treatment of the patient.

The basic principles of image processing

Image processing and analysis includes the following steps.

1) Early treatment. It removes previous processing phase deviations associated with the image generation system, and reduces noise. Digital data is processed with special programs and this improves the visibility of certain anatomical structures.

2) Changing the contrast of the image. Calculating the histogram generates image representation of the number of pixels for each gray level in the image.

3) Segmentation. This phase image processing isolates the individual picture elements (organs, cells, etc.).

4) Dimensioning. Calculation of linear and volumetric parameters of anatomical structures.

5) The interpretation of the images. Automatic interpretation by computer still remains as a problem. For its quality performance is necessary knowledge base of comparative and pathological anatomy.

The resulting structures and parameters should be compared with known structures and with classification.

Modern trends in image processing

Current trends in medical imaging include two-dimensional and three-dimensional processing using a computer.

Today, an important issue is the creation of medical databases of visualization images. One of these bases – “visible human project” (www.nlm.nih.gov/research/visible/visible_human.html). The purpose of this project – is to provide data sets for use in the study of anatomy, research, for educational and diagnostic projects.

The design of digital anatomical atlases and other reference data sets.

Segmentation

A T1 weighted MR image of the brain of a patient with a meningioma after injection of a MRI contrast agent(top left), and the same image with the result of an interactive segmentation overlaid in green (3D model of the segmentation on the top right, axial and coronal views at the bottom).

Segmentation is the process of partitioning an image into different segments. In medical imaging, these segments often correspond to different tissue classes, organs, pathologies, or other biologically relevant structures. Medical image segmentation is made difficult by low contrast, noise, and other imaging ambiguities. Although there are many computer vision techniques for image segmentation, some have been adapted specifically for medical image computing. Below is a sampling of techniques within this field; the implementation relies on the expertise that clinicians can provide.

Atlas-Based Segmentation: For many applications, a clinical expert can manually label several images; segmenting unseen images is a matter of extrapolating from these manually labeled training images. Methods of this style are typically referred to as atlas-based segmentation methods. Parametric atlas methods typically combine these training images into a single atlas image, while nonparametric atlas methods typically use all of the training images separately. Atlas-based methods usually require the use of image registration in order to align the atlas image or images to a new, unseen image.

Shape-Based Segmentation: Many methods parametrize a template shape for a given structure, often relying on control points along the boundary. The entire shape is then deformed to match a new image. Two of the most common shape-based techniques are Active Shape Models and Active Appearance Models. These methods have been very influential, and have given rise to similar models.

Image-Based segmentation: Some methods initiate a template and refine its shape according to the image data while minimizing integral error measures, like the Active contour model and its variations.

Interactive Segmentation: Interactive methods are useful when clinicians can provide some information, such as a seed region or rough outline of the region to segment. An algorithm can then iteratively refine such a segmentation, with or without guidance from the clinician. Manual segmentation, using tools such as a paint brush to explicitly define the tissue class of each pixel, remains the gold standard for many imaging applications. Recently, principles from feedback control theory have been incorporated into segmentation, which give the user much greater flexibility and allow for the automatic correction of errors.

Statistical analysis

Statistical methods combine the medical imaging field with modern Computer Vision, Machine Learning and Pattern Recognition. Over the last decade, several large datasets have been made publicly available (see for example ADNI, 1000 functional Connectomes Project), in part due to collaboration between various institutes and research centers. This increase in data size calls for new algorithms that can mine and detect subtle changes in the images to address clinical questions. Such clinical questions are very diverse and include group analysis, imaging biomarkers, disease phenotyping and longitudinal studies.

Group analysis

In the Group Analysis, the objective is to detect and quantize abnormalities induced by a disease by comparing the images of two or more cohorts. Usually one of these cohorts consist of normal (control) subjects, and the other one consists of abnormal patients. Variation caused by the disease can manifest itself as abnormal deformation of anatomy (see Voxel-based morphometry). For example, shrinkage of sub-cortical tissues such as the Hippocampus in brain may be linked toAlzheimer's disease. Additionally, changes in biochemical (functional) activity can be observed using imaging modalities such as Positron Emission Tomography.

Classification

Although group analysis can quantify the general effects of pathology on an anatomy and function, it does not provide subject level measures, and hence cannot be used as biomarkers for diagnosis (see Imaging Biomarkers). Clinicians, on the other hand, are often interested in early diagnosis of the pathology (i.e. classification,) and in learning the progression of a disease (i.e. regression). From methodological point of view, current techniques varies from applying standard machine learning algorithms to medical imaging datasets (e.g. Support Vector Machine), to developing new approaches adapted for the needs of the field. The main difficulties are as follows:

Small sample size (Curse of Dimensionality): a large medical imaging dataset contains hundreds to thousands of images, whereas the number of voxels in a typical volumetric image can easily go beyond millions. A remedy to this problem is to reduce the number of features in an informative sense (see dimensionality reduction). Several unsupervised and semi-/supervised, approaches have been proposed to address this issue.

Clustering

Image-based pattern classification methods typically assume that the neurological effects of a disease are distinct and well defined. This may not always be the case. For a number of medical conditions, the patient populations are highly heterogeneous, and further categorization into sub-conditions has not been established. Additionally, some diseases (e.g., Autism Spectrum Disorder (ASD), Schizophrenia, Mild cognitive impairment (MCI)) can be characterized by a continuous or nearly-continuous spectra from mild cognitive impairment to very pronounced pathological changes. To facilitate image-based analysis of heterogeneous disorders, methodological alternatives to pattern classification have been developed. These techniques borrow ideas from high-dimensional clustering and high-dimensional pattern-regression to cluster a given population into homogeneous sub-populations. The goal is to provide a better quantitative understanding of the disease within each sub-population.

Shape analysis

Shape Analysis is the field of Medical Image Computing that studies geometrical properties of structures obtained from different imaging modalities. Shape analysis recently become of increasing interest to the medical community due to its potential to precisely locate morphological changes between different populations of structures, i.e. healthy vs pathological, female vs male, young vs elderly. Shape Analysis includes two main steps: shape correspondence and statistical analysis.

Shape correspondence is the methodology that computes correspondent locations between geometric shapes represented by triangle meshes, contours, point sets or volumetric images. Obviously definition of correspondence will influence directly the analysis. Among the different options for correspondence frameworks we can find: Anatomical correspondence, manual landmarks, functional correspondence (i.e. in brain morphometry locus responsible for same neuronal functionality), geometry correspondence, (for image volumes) intensity similarity, etc. Some approaches, e.g. spectral shape analysis, do not require correspondence but compare shape descriptors directly.

Longitudinal studies

In longitudinal studies the same person is imaged repeatedly. This information can be incorporated both into the image analysis, as well as into the statistical modeling.

In longitudinal image processing, segmentation and analysis methods of individual time points are informed and regularized with common information usually from a within-subject template. This regularization is designed to reduce measurement noise and thus helps increase sensitivity and statistical power. At the same time over-regularization needs to be avoided, so that effect sizes remain stable.

Intense regularization, for example, can lead to excellent test-retest reliability, but limits the ability to detect any true changes and differences across groups. Often a trade-off needs to be aimed for, that optimizes noise reduction at the cost of limited effect size loss. Another common challenge in longitudinal image processing is the, often unintentional, introduction of processing bias. When, for example, follow-up images get registered and resampled to the baseline image, interpolation artifacts get introduced to only the follow-up images and not the baseline. These artifacts can cause spurious effects (usually a bias towards overestimating longitudinal change and thus underestimating required sample size). It is therefore essential that all-time points get treated exactly the same to avoid any processing bias.

Post-processing and statistical analysis of longitudinal data usually requires dedicated statistical tools such as repeated measure ANOVA or the more powerful linear mixed effects models. Additionally, it is advantageous to consider the spatial distribution of the signal. For example, cortical thickness measurements will show a correlation within-subject across time and also within a neighborhood on the cortical surface - a fact that can be used to increase statistical power. Furthermore, time-to-even (aka survival) analysis is frequently employed to analyze longitudinal data and determine significant predictors.

Mathematical methods in medical imaging

A number of sophisticated mathematical methods have entered medical imaging, and have already been implemented in various software packages. These include approaches based on partial differential equations (PDEs) and curvature driven flows for enhancement, segmentation, and registration. Since they employ PDEs, the methods are amenable to parallelization and implementation on GPGPUs. A number of these techniques have been inspired from ideas in optimal control. Accordingly, very recently ideas from control have recently made their way into interactive methods, especially segmentation. Moreover, because of noise and the need for statistical estimation techniques for more dynamically changing imagery, the Kalman filter and particle filter have come into use. A survey of these methods with an extensive list of references may be found in.

Diffusion MRI

A mid-axial slice of the ICBM diffusion tensor image template. Each voxel's value is a tensor represented here by an ellipsoid. Color denotes principal orientation: red = left-right, blue=inferior-superior, green = posterior-anterior

Diffusion MRI is a structural magnetic resonance imaging modality that allows measurement of the diffusion process of molecules. Diffusion is measured by applying a gradient pulse to a magnetic field along a particular direction. In a typical acquisition, a set of uniformly distributed gradient directions is used to create a set of diffusion weighted volumes. In addition, an unweighted volume is acquired under the same magnetic field without application of a gradient pulse. As each acquisition is associated with multiple volumes, diffusion MRI has created a variety of unique challenges in medical image computing.

In medicine, there are two major computational goals in diffusion MRI:

- Estimation of local tissue properties, such as diffusivity;
- Estimation of local directions and global pathways of diffusion.

Functional MRI

Functional magnetic resonance imaging (fMRI) is a medical imaging modality that indirectly measures neural activity by observing the local hemodynamics, or blood oxygen level dependent signal (BOLD). fMRI data offers a range of insights, and can be roughly divided into two categories:

Task related fMRI is acquired as the subject is performing a sequence of timed experimental conditions. In block-design experiments, the conditions are present for short periods of time (e.g., 10 seconds) and are alternated with periods of rest. Event-related experiments rely on a random sequence of stimuli and use a single time point to denote each condition. The standard approach to analyze task related fMRI is the general linear model (GLM)

Resting state fMRI is acquired in the absence of any experimental task. Typically, the objective is to study the intrinsic network structure of the brain. Observations made during rest have also been linked to specific cognitive processes such as encoding or reflection. Most studies of resting state fMRI focus on low frequency fluctuations of the fMRI signal (LF-BOLD). Seminal discoveries include the default network, a comprehensive cortical percolation, and the linking of network characteristics to behavioral parameters.

Tasks for self-check:

Task 1:

1. WHICH METHOD USUALLY REQUIRE THE USE OF IMAGE REGISTRATION IN ORDER TO ALIGN THE ATLAS IMAGE OR IMAGES TO A NEW, UNSEEN IMAGE?

a) interactive Segmentation
b) image-Based segmentation
c) shape-Based Segmentation
d) atlas-Based Segmentation
e) non of these

2. IN WHICH METHOD THE OBJECTIVE IS TO DETECT AND QUANTIZE ABNORMALITIES INDUCED BY A DISEASE BY COMPARING THE IMAGES OF TWO OR MORE COHORTS?

a) group analysis
b) statistical analysis
c) classification
d) shape analysis
e) longitudinal studies

3. WHICH IMAGIN IS A MEDICAL IMAGING MODALITY THAT INDIRECTLY MEASURES NEURAL ACTIVITY BY OBSERVING THE LOCAL HEMODYNAMICS, OR BLOOD OXYGEN LEVEL DEPENDENT SIGNAL? PROPERTIES MUST BLOCK THE RADIATION DETECTOR WHEN RECEIVING MEDICAL IMAGE?

a) functional MRI
b) computer tomography
c) scintigraphy
d) radiography
e) ultrasound image

4. WHAT METHODS USED WITH EXTRACELLULAR RECORDING?

a) Single Unit recording
b) Amperometry, Field potentials and Single Unit recording
c) Amperometry
d) Single Unit recording and Amperometry
e) Field potentials

5. WHAT IS THE TRANSCUTANEOUS ELECTRICAL NERVE STIMULATOR?

a) All listed answers are right
b) With this device analog signals are converted to digital data

c) With this device signal may be amplified or deamplified, or may require filtering, or a lock-in amplifier is included to perform demodulation, etc

d) It is an electronic device that produces electrical signals used to stimulate nerves through unbroken skin

e) With this device digital data are converted to analog signals

Task 2

1. Open the ultrasound image of the thyroid gland and its anatomical image (*D:\Visualization_MBD\Task_1\thyroid.jpg*). Compare them. Determine the location of the left lobe, the right lobe, the isthmus, tracheal lumen of the common carotid artery.

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Basic.

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Additional.

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3. www.ncbi.nlm.nih.gov (Національна бібліотека медицини США)
4. www.cochrane.ru (Розділ Кохранівського співтовариства)

The methodical guidance has been completed by **S.Y. Olenets**