Nowadays and future computer application in medicine

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Abstract

This article presents selected applications of computer methods in field of contemporary medical informatics. As personal health is among most important aspects of everyone life nearly all computer methods that have proven to have technical and scientific potential are quickly utilized in medicine. Because of that it is impossible to mention all practicable applications of computers in contemporary medicine because nearly all aspects of applied informatics are used in practical medical solutions. In the first part of this article we will only summarize applications of artificial intelligence, numerical methods, signal processing, parallel and distributed computing, databases, computer networks and mobile applications, computer graphic and e-learning in medical informatics. Then we will present some of our projects and achievements in this subject.

Keywords: Computer methods in medicine, computer graphic, classification methods, natural user interfaces, advanced computer systems

1 Introduction

The electronic devices supplied with processing units became an important component of our everyday life. Computers, smartphones and other apparatuses that give us mobile access to Internet are fundaments of modern business, education and sometimes even relationships. Health care as a vital part of contemporary society model is also affected by the same technical trends as the other branches of business. As personal healthcare is among most important aspects of everyone life many efforts are put into medical researches on new treatment techniques. Because of that, all computer methods that have proven to have technical and scientific potential are quickly developed and utilized in medicine. Now it is impossible to mention all possible applications of computers in contemporary medicine because nearly all aspects of applied informatics are used in practical medical solutions. The motivation of this article is presenting subjective list of up to date applications of computer methods in medicine that might be good introduction to this subject. In our opinion the role of computer methods in medicine is changing as quick as computer science itself and there is a need for this type of review. Moreover we will describe our contribution to the state of the art methodology by introducing some of our projects and achievements in this subject. Our work is mainly concentrated on two- three- and four dimensional image data: image processing and recognition (classification tasks), semantic interpretation, as well as visualization and user interfaces. The data we are dealing with are mainly medical images acquired from patients

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with suspicious of early stages of brain stroke. The proper diagnosis of medical data in first hours after appearing the stroke syndromes is crucial not only for patience live but also for further convalescence. In the first part of this article we will only summarize selected applications of computer methods (CM) in this field. Then we will present our impact to this field. Last part of paper summarizes the article and indicates trends of upcoming researches.

2 Selected applications of CM in medicine

In this section we will summarize main directions of applied computer science in medicine. This selection is of course our personal and subjective choice we had to make because of limitation of paper size. Figure 1 presents relationship of branches of computer science to particular applications in medicine that was mentioned in this chapter.

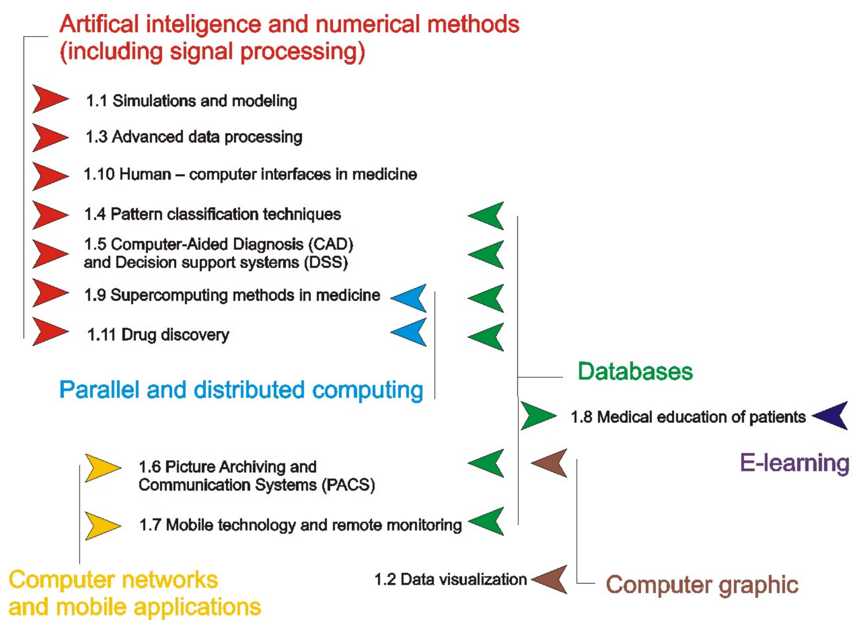

Figure 1: Relationship of branches of computer science to particular applications in medicine that was mentioned in chapter 2. The medical informatics uses methodology from many different fields of computer science like artificial intelligence, numerical methods, signal processing, parallel and distributed computing, databases, computer networks and mobile applications, computer graphic and e-learning.

2.1 Simulations and modeling

The very first level of medicine practice is formation during studies. Simulation-based medical education has gained tremendous popularity over the past two decades [25]. Thanks to CM it is now possible to simulate the process of surgery without the risk of patients health. Authors in [28] describe the computer program that can subsequently be employed for teaching purposes and for preoperative surgical planning. Their application synthesizes a customized bone model by integrating the patient-specific fracture into a generic full-length 3D bone model. Merging these two components forms a composite three-dimensional model that presents a realistic depiction of the entire fractured bone. The fracture was fitted into the generic bone models by rigid registration using a modified least-squares algorithm. Also paper [33] reports a case of complex wrist deformity caused by injury, which was successfully treated by gradual correction after computer simulation. The simulation enabled to develop an appropriate operative plan by accurately calculating the axis of the three-dimensional deformity using computer bone models.

2.2 Data visualization

Before making final diagnosis physicians often use medical information from multiple image sources. These include three-dimensional volumetric datasets such as computed tomography (CT), Positron emission tomography (PET), magnetic resonance tomography (MR), 2D datasets (such as endoscopic videos), and vector-valued datasets (such as computer simulations). That datasets has to be presented to medical personnel in reliable (without artifacts) and informative way (possibility of filtering irrelevant information). That task is done by computer graphic algorithms. The example approach for medical data visualization is presented in [23] where authors present a visualization approach that displays the information from various sources in a single coherent view. The system allows the user to explore and manipulate volumetric datasets, display analysis of dataset values in local regions, combine 2D and 3D imaging modalities and display results of vector-based computer simulations.

2.3 Advanced data processing

Before data can be visualized to physician it often requires preprocessing with dedicated image processing methods. For example in [36] authors propose a new method to estimate the extension and activity of the bone marrow by combining structural and functional maps provided by CT and PET. Another application of image processing methods is presented in [6] where authors describe the whole protocol for estimating the liver initial border (inner organs segmentation procedure).
Medical data might consist of information with no relevance for particular diagnostic procedure (or image acquisition artifacts) that appears as the high frequency noise. The presence of this noise can make diagnostic procedure difficult or even impossible to conduct. The most straightforward way reduce the influence of high frequency noise is application of low pass filtering on medical data. The filters that are used for those tasks are often well known approaches from signal processing domain. Among them most noticeable is linear filtering with convolution operator (averaging or Gaussian filter), non-linear filters (median filtering), filtering in the frequency domain with local Fourier coefficients or wavelet features [2].
The image registration is the process of finding a transformation that best matches two images according to a criterion of similarity. While rigid and affine transformations can just describe global geometric differences between images elastic schemes can additionally cope with local differences [42]. Image registration finds its application in many fields of medical imaging but most notably in deformable brain atlas construction. Deformable brain atlases are adaptable brain templates that can be individualized to reflect the anatomy of new subjects [40]. This allows an automated labeling of structures in new patients' scans. The image to be labeled (segmented) remains fixed during the registration process, while the template is deformed in the geometric space of the reference. After the procedure the template matches the fixed image supplying physicians with detailed description of visualized tissues.

Commonly image processing methods are executed agreeably to flow chart presented in Figure 2. After data acquiring the image data is preprocessed which enables regions of interests (ROI) outlining. ROI consists of tissues that are than segmented in order to detect tumors / important organic structure. Last step is tumor identification that is often made with pattern classification techniques [3], [4], [5].

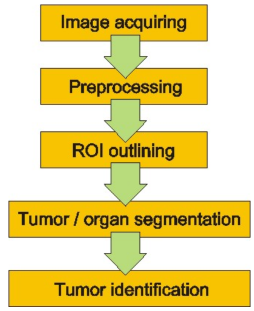

Figure 2: A flow chart that depict the steps of medical image processing. Detailed description is in text.

2.4 Pattern classification techniques

Image processing role is to enhance some individual features so they can be more easily spotted and interpreted (classified) by physician. Computer science offers large set of method that enables automatic identification of particular data set as a member of some general class (for example class of syndromes that are characteristic to particular illness). Those methods are called pattern classification techniques. For example the aim of [38] was to construct and validate a computer instrument that identifies asthma patients receiving - theoretically - suboptimal drug therapy in community pharmacies, by the use of patient medication records. This selection enables the pharmacist to assist these patients in using medicines appropriately. In [39] authors wanted to describe the characteristic of tongue images of patients with lung cancer of different Chinese medicine syndromes and to reveal the elemental rule on the changes of the tongue images (a tongue image digital analysis instrument can objectively describe the tongue features of patients with different syndromes of lung cancer). The purpose of study [[9] was to develop and analyze an open-source artificial intelligence program built on artificial neural networks that can participate in and support the decision making of nuclear medicine physicians in detecting coronary artery disease from myocardial perfusion SPECT (MPS). In paper [27] authors presented an enhanced fuzzy k-nearest neighbor (FKNN) classifier based computer aided diagnostic (CAD) system for thyroid disease. In paper [19] authors classify the breast cancer of medical diagnostic data. Information gain has been adapted for feature selections. Neural fuzzy (NF), k-nearest neighbor (KNN), quadratic classifier (QC), each single model scheme as well as their associated, ensemble ones have been developed for classifications. In addition, a combined ensemble model with these three schemes has been constructed for further validations.

2.5 Computer-Aided Diagnosis (CAD) and Decision support systems (DSS)

Physicians are responsible for they patients and have to made decisions about way of they treatment. Some of they decisions however might be consulted with special designed applications that suggests potential solution. Article [7] is a review about computer-driven weaning reduced duration of mechanical ventilation. After overcoming the perils of critical illness, patients should be weaned from mechanical ventilation as quickly as possible. Failure to do so exposes them to excess morbidity. The author expects computerized weaning to outperform physician weaning in units where limited resources inhibit clinicians from contemplating relatively early in a patient's course that he or she just might be able to breathe on his or her own. Another example of DSS is presented in [34]. The problem described in this article is adolescent idiopathic scoliosis (AIS), which due to the complexity of AIS geometry, clinical evaluation and treatment, might be treated with help of computer applications to improve its management. Fuzzy clustering and support vector classifiers can regroup AIS spines having similar curve and curve progression. Applications based on ANN and surface topography algorithms have been able to compute actual and predicted Cobb angle with good accuracy while limiting irradiation. Rule-based algorithms can increase classification reliability. Fuzzy logic can average multiple rules extracted from the literature and output a degree of certainty in domains where no clear consensuses exist such as AIS levels of fusion.

2.6 Picture Archiving and Communication Systems (PACS)

A picture archiving and communication system is a medical imaging technology that provides economical storage of and convenient access to images from multiple modalities (source machine types) [29]. The concept of PACS was initiated in 1982, since then PACS have been matured to become an everyday clinical tool for image archiving, communication, display, and review [20]. PACS have been widely introduced as a credible alternative to the traditional film-based radiological service. According to researches [29] The majority of physicians judged PACS to be a major advance for their hospitals with less frustration than using film high quality images and an improvement in their working lives and patient care. They reported that PACS gave them to radiology reports in short time. Also physicians believed that PACS has improved their consultations. PACS has been accepted well by a wide percentage of hospital physicians. The implementation of the PACS clearly contributes to an increase in the productivity of health professionals and physicians. The Digital Imaging and Communications in Medicine (DICOM) Standard facilitates interoperability of medical imaging equipment by specifying [35]:

- For network communications, a set of protocols to be followed by devices claiming conformance to the Standard.
- The syntax and semantics of Commands and associated information which can be exchanged using these protocols.
- For media communication, a set of media storage services to be followed by devices claiming conformance to the Standard, as well as a File Format and a medical directory structure to facilitate access to the images and related information stored on interchange media.
- Information that must be supplied with an implementation for which conformance to the Standard is claimed.

2.7 Mobile technology and remote monitoring

In same cases it is not necessary or not possible for doctor to have direct access to complicated PACS workstations or even face - to -face contact with particular patient. Report [22] suggests that over the past decade, handheld computers (or personal digital assistants - PDAs) have become a popular tool among medical trainees and physicians. Many medical students and residents use PDAs for educational purposes or patient care. Most of the studies included described PDA use for patient tracking and documentation, medical textbooks, medication references, and medical calculators as the most useful applications. Study [21] shows that the diagnosis of emergency conditions commonly encountered in after-hours calls on CT and MRI using tablet computers such as the iPad can be made with good agreement to those reviewed on dedicated PACS workstations. Tablet computers with their excellent portability and large screens may have potential as remote mobile radiological image review and teleconsultation devices. Paper [43] describes a wireless body sensor network with pulse rate sensors on nodes that are installed on monitored patient. The sensor node can transmit data over the air to a remote central control unit (CCU) for further processing, monitoring and storage. The developed system offers medical staff to obtain patient's physiological data on demand basis via the Internet.

From the other hand according to [24] patients reported that they would not feel comfortable using methods involving technology such as a secure website, email, mobile phone text message, or a computer voice on the telephone but that they would be more comfortable using more traditional methods such as a paper questionnaire, speaking to a nurse on the telephone, or giving information in person. It should be noticed that researches was made in a group of patients where more then the half of the people were over 60 years old and new generation of patients will have diffreent attitude to remote contact with physicians. Also [8] showed that effective use of computers in the outpatient exam room may be dependent upon clinicians' baseline skills those are carried forward and are amplified, positively or negatively, in their effects on clinician-patient communication.

2.8 Medical education of patients

It is natural that patient might demand the information about nature of his or her illness or about particular medical procedure. The study [32] showed that multimedia educational computer program was as effective as usual nurse counseling in educating patients and achieving adherence to fecal occult blood testing screening.

2.9 Scientific databases

Databases systems might be successfully applied to nearly each problem which requires storing and manipulating large amount of information. Scientific databases, and in particular chemical and biological databases, have reached massive sizes in recent years due to the improvement of bench-side high throughput screening tools used by scientists [31]. Many researches are made in the field of optimal construction of databases for medical tasks and method of fast retrieval of gathered data. Paper [31] discusses the design and implementation of the computation of a histogram to speed up access to large pharmaceutical databases. The purpose of study [26] was to integrate knowledge about drugs, drug targets, and topological methods. The goals were to build a system facilitating the study of adverse drug events, to make it easier to find possible explanations, and to group similar drug-drug interaction cases in the adverse drug reaction reports from the US Food and Drug Administration (FDA). The proposed system that analyses adverse drug reaction (ADR) cases reported by the FDA contains four modules. First, it uses drug and drug target databases that provide information related to adverse drug reactions. Second, it classifies drug and drug targets according to anatomical therapeutic chemical classification (ATC) and drug target ontology (DTO). Third, it builds drug target networks based on drug and drug target databases. Finally, it applies topological analysis to reveal drug interaction complexity for each ADR case reported by the FDA. A system can find possible explanations and cluster similar ADR cases reported by the FDA.

2.10 Supercomputing methods in medicine

Some calculations that are performed during discovery biological structures prosperities are to complex to be performed on typical workstations. For example protein structure prediction (PSP) is an open problem with many useful applications in disciplines such as medicine, biology and biochemistry [1]. This problem presents a vast search space and the analysis of each protein structure requires a significant amount of computing time, it is necessary to take advantage of high-performance parallel computing platforms as well as to define efficient search procedures in the space of possible protein conformations.

2.11 Human - computer interfaces in medicine

In recent years many novel computer systems with a non image-based navigation system have been introduced to hospitals and clinics [44]. Paper [37] reports using open-source software libraries and image processing techniques, that implement a hand tracking and gesture recognition system based on the Kinect sensor that enables surgeon to successfully touchlessly navigate through the image in the intraoperative setting through a personal computer.

2.12 Drug discovery

Modern computer aided drug design approaches take advantage of the recent breakthroughs in computational quantum chemistry. Understanding the molecular basis of drug action and exploring the chemical interactions involved in the complex processes of drug delivery are among the most important goals of contemporary drug design [30].

3 Selected projects in computer aided medicinepesetting

In this section we will shortly describe selected projects in computer-aided medicine that we have taken part (or still taking) in a few last years.

3.1 Recognition and understanding pathological changes in dynamic perfusion computed tomography brain maps

Dynamic perfusion computed tomography (CTP) is a neuroradiology treatment that is used to visualize changes in blood flow of inner organs of patient. It is currently used in cases of head injuries, epilepsy, and vascular brain disease and especially to diagnose strokes and brain tumors. The output of brain CTP is a set of two-dimensional perfusion maps the terms 'perfusion maps' and 'perfusion images' are popularly used as equivalents) that shows some important perfusion parameters of patients tissue like cerebral blood flow (CBF) or cerebral blood volume (CBV). The diagnosis is based on comparison of perfusion between hemispheres and detection of asymmetry regions. If one exists it might be caused by ischemic or hemorrhagic anomaly. In papers [11], [12] we present a novel method of detecting and describing pathological changes that can be visualized on CTP. The proposed by us Detection Measurement and Description System (DMS) operates on a set of dynamic perfusion computer tomography maps. Each set consisted of two perfusion maps (CBF, CBV) and one CT brain scan (for the image registration algorithm). DMD performs both quantitative analysis (detection and measurement and description with brain anatomy atlas (AA) of potential asymmetries/lesions) and qualitative analysis (decision about type of lesion: ischemic/hemorrhagic, is the brain tissue at risk of infraction or not). An example results produced by the system are presented in Figure 3. Input images (CBF, CBV and CT in first row) are transformed by image processing algorithms and the potential perfusion abnormalities are detected. In the next step an algorithm determines the type and position of abnormality (is it hemorrhagic or ischemic and in which hemisphere is it present). The last step is generation of prognostic map of potentially infarcted tissues (bottom row). The DMD system also measures all important from medical point of view parameters (like size of potential lesion, relative perfusion etc.).

The test set for validation our algorithm was consisted of 75 CTP images triplets (one CBF, CBV and CT in each) from 30 patients (both man and woman) with suspicion of ischemia / stroke. Tests results presented in Table 1 were summed up according to terminology:

- TP - correctly predicted Positive samples (presence / position of lesions matched radiologist description).
- FP - incorrectly predicted Negative samples (Negative samples predicted as positives).
- TN - correctly predicted Negative samples (perfusion maps did not show lesions).

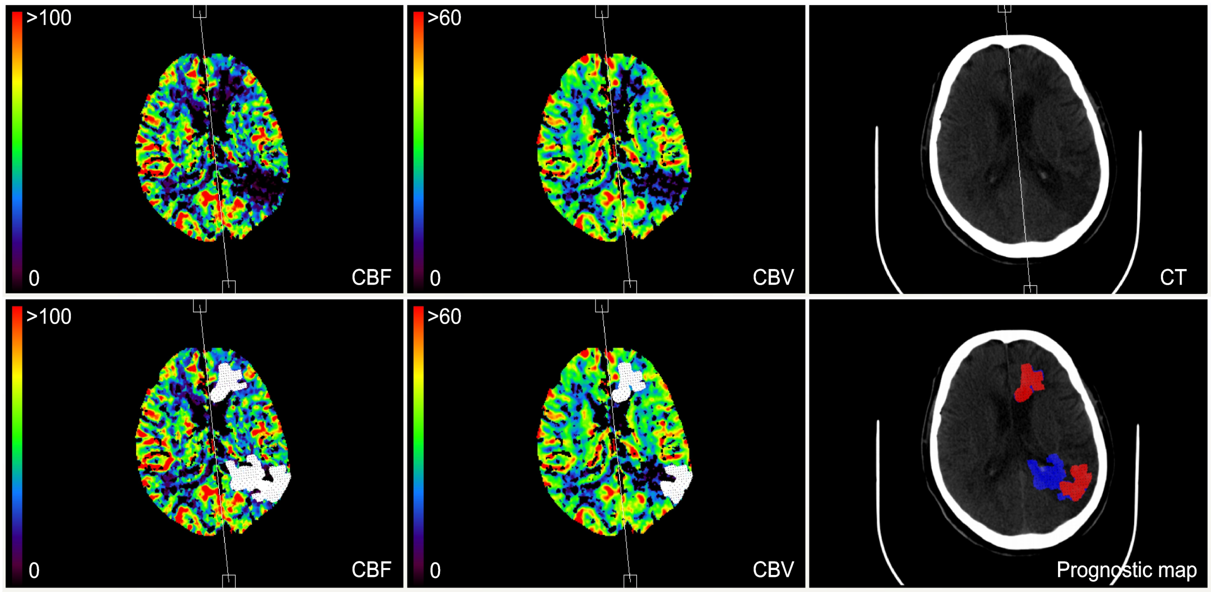

Figure 3: Example results produced by the DMD system. In the first row is an input data: CBF, CBV and CT images. In the second row is output data of the system: CBF and CBV maps with potential abnormalities marked as white region and prognostic map. Red regions are tissues that might become infarcted, blue regions mark ischemia where auto regulation mechanism might occur.

Test result	
TP	24
FP	8
TN	34
FN	9

Table 1: Validation results of proposed DMD algorithm.

- FN - incorrectly predicted Positive samples (Positive samples predicted as negatives).

As can be seen over 77% data samples very correctly classified what is accepted rate for that kind of advisory system.

The DMD system has strong advantage over state of the art algorithm [41]. Wintermark algorithm cannot be use for distinguishing between Positive and Negative cases, because this method was tailored for making ischemia evaluation on P CTP data. What is more that method requires manual placement or ROIs because it might also detects asymmetries without medical relevance as severe ischemia regions. Methodology proposed by us can both distinguish between P and N and generates prognostic maps. ROIs detected by proposed methodology might be also input data for Wintermark algorithm which is a clinically accept method.

3.2 Segmentation and visualization of tubular structures in computed tomography angiography

Computed tomography angiography (CTA) is a popular medical imaging method that is often used beside standard computed tomography in acute stroke imaging. This technique enhances arterial and venous vessels in standard CT imaging. In many cases segmentation of vascular structures of patient is the first

task performed by radiologists. In [13] we proposed the novel path detection algorithm and the region growing based lumen detection algorithm. The proposed lumen segmentation method is consisted of two sub-algorithms. After preprocessing step the first algorithm detects the possible path between start and end point. In the second step it performs the thinning of previously obtained path. The second algorithm is a region - growing procedure with proper homogeneity criteria. The role of this procedure is to segment the whole lumen of considered vessel. The region growing is computed in axial slices and the seed point for growing method in each slice is a voxel taken from path computed in previous step. Example result of this algorithm for CTA data is presented in Figure 4 - vessel lumen segmentation.
The main contribution of article [14] is a new segmentation method of carotid artery based on original authors' inner path finding algorithm and active contours without edges segmentation method for vessels wall detection. Instead of defining new force to being minimized or intensity metric we decide to find optimal weight of image - dependent forces. This allows our method to be easily reproduced and applied in other software solutions. Example result of this algorithm is presented in Figure 4 - left and right carotid artery segmentation.

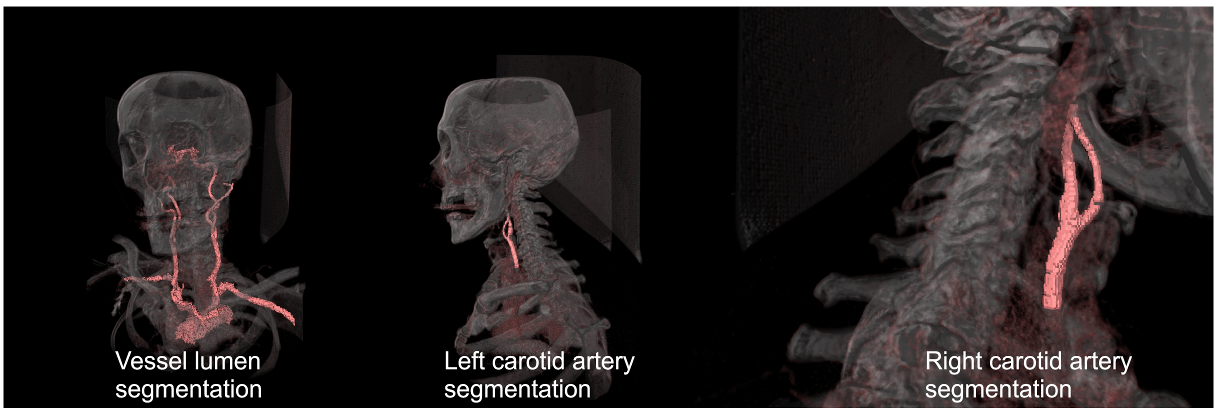

Figure 4: Example results of algorithms described in [13] and [14] for vessel lumen segmentation. The data to be segmented was CTA.

We judge the quality of carotid artery segmentation by dice coefficient between manual segmentation done by a specialist and automatic segmentation performed by our algorithm. We did not find any other publication in which such approach for carotid artery bifurcation region segmentation has been proposed or investigated. The proposed algorithm has shown to be reliable method for that task. The dice coefficient [14] at the level of 0.949 ± 0.050 situates our algorithm among best state of the art methods for those solutions.
It should be mentioned that both of those algorithms are not only limited to medical data. They can be used for segmentation of any type of continues tubular structures.

3.3 Real-time direct volume rendering

Contemporary medical imaging techniques produce large datasets that has to be visualized not only with high reliability (without artifacts that might influence the final diagnosis) but also with sufficient speed in order to make image browsing convenient for medical personnel. Among medical data modalities that have huge importance are three and four-dimensional data produced by tomography. Nowadays it is possible to visualize CT dataset with typical size (512^3 voxels or more) on standard (consumer) personal computer. That becomes possible thanks to programmable graphical processing units (GPU) that are now commonly installed on motherboard. In order to render such huge dataset in real time (with a speed of 30 frames per second or more) sophisticated multithread GPU techniques have to be utilized (so called direct volume rendering algorithms). The typical rendering algorithm is consisted of few parallel functions that all together creates so called rendering pipeline (Figure 5).

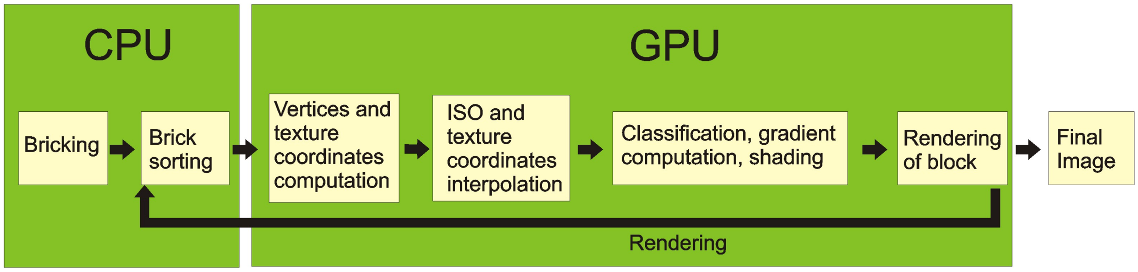

Figure 5: Pipeline of volume rendering algorithm. Description is in the text. Typically first step of the volume rendering algorithm is performed on CPU.

Bricking. Prior to the rendering, the volume dataset might be subdivided into uniform sized blocks. If the size of image is too big to be stored in RAM it is possible to store some of the block on the hard drive and switch them with those stored in RAM if it is necessary. Using this technique however will make the interactive work with program impossible because of long loading time of sub-volumes from hard drive.

Brick sorting. The sub-volumes (blocks) are sorted towards the observer from the farthest to the nearest one. This has to be done only ones and only if the position of the observer of the scene has changed since last sorting. The rest of algorithm is computed in parallel on GPU.

Vertices and textures coordinates computation. The algorithm determines the position of volume towards the observer. It requires applying the linear transform represented by 4x4 matrix to all vertices that represents volume data. Then vertices are projected to 2D space by projective transform. ISO and texture coordinates interpolation. When vertices and textures coordinates in 2D space are already known the GPU hardware interpolates the coordinates of the rest of points that lies inside primitives (triangles) that are designate by those vertices.

Classification, gradient computation, shading. In this step we replace the tissue ISO value with proper RGBA (red, green, blue and alpha channel) pixel. The RGBA value corresponding to ISO is determined by transfer function which discrete values are stored in lookup table. That process is commonly named classification. Illumination and shading within volume rendering refers to the same illumination models and shading techniques used in polygon rendering. The simulated light strongly enhances the appearance of rendered objects emphasizing their shape and structure. The most common local illumination model, which calculates light per pixel, is the Phong lighting model that requires numeric computation of gradient of volume.

Final image. After rendering all of the sub-volumes we get the complete 2D image of 3D volumetric data.

In [18] we present an innovative GPU-based solution for visualization of perfusion abnormalities detected in dynamic brain perfusion computer tomography maps. The benefit of this algorithm over previous versions is its ability to operate in real time to satisfy the needs of augmented reality simulation. Also our rendering algorithm [15] enables rendering large volumes on off-the-shelf hardware. This portability of rendering solution is very important because our framework can be run without using expensive dedicated hardware. The other important factors are theoretically unlimited size of rendered volume and possibility of trading of image quality for rendering speed. Such rendered, high quality visualizations may be further used for intelligent brain perfusion abnormality identification, and computer aided-diagnosis of selected types of pathologies. The results of realistic direct volume-rendering visualization of CTA data done by our algorithms is presented in Figure 6.

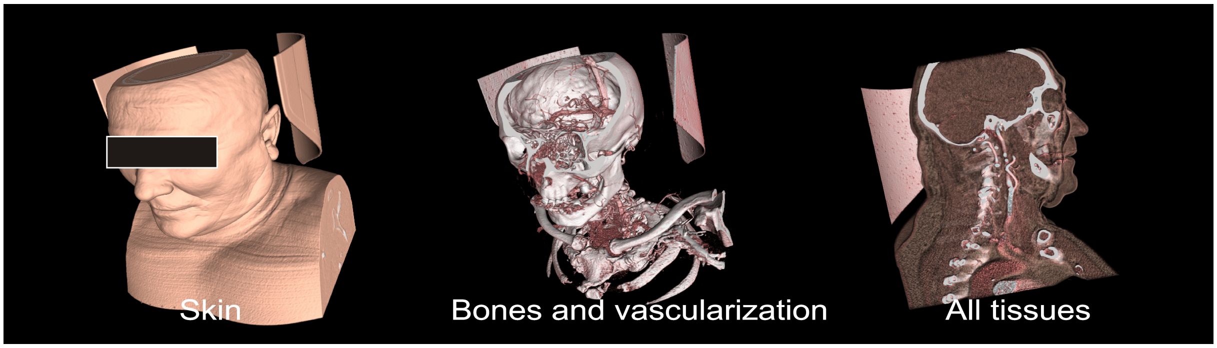

Figure 6: Visualization of CTA volumetric dataset. Each image visualizes same dataset but enhance different types of tissues by using appropriate transfer function.

We have validated and compared our approaches to state of the art methods taking into account many different criteria:

- Average performance speed (fps) of rendering algorithm on different CT volumetric data as a function of size of octree and view aligned slices count [15].
- Dependents of average speed of rendering 3D models on viewport size (megapixels) and transfer function characteristic [18].
- Average performance speed (fps) of 3D models as a function of rendering algorithm type, gradient computation method and transfer function [10].

The detailed results can be find in referenced papers.

3.4 Natural user interfaces in medicine

In past years typical medical diagnosis support systems to be accepted in medical society have to be reliable and generate the advices within few seconds. Today equelly important factor is the way in which those applications present data to user and intuitiveness of interface. The researches on human - computer interaction have been conducted for many years. The concept of human-device interaction based on human senses, mostly focused on hearing and vision is now known under term Natural Interaction or Natural User Interface (NI). The build-in cameras and cheap multimedia devices with USB connectivity became the standard equipment in contemporary home and mobile computer systems. Because of that there is heavy demand on applications that utilizes those sensors. In article [17] and [16] we introduce new approach for human body poses and movement sequences recognition. Our concept is based on syntactic description with so called Gesture Description Language (GDL). Approach uses forward chaining inferring schema performed on the set of rules that are defined with formal LALR grammar. The set of rules is called Gesture Description Language (GDL) script while automated reasoning module with heap-like memory is a GDL interpreter. We have also implemented a prototype of virtual three-dimensional desktop that can be used to display two and three-dimensional medical data with the methods described in the previous paragraph. The interaction with the desktop can be performed in classic way (by keyboard or mouse) or by gesture without the touch contact with any device.
The hardware set - up of prototype of virtual three-dimensional desktop and picture taken during performance test are presented in Figure 7.

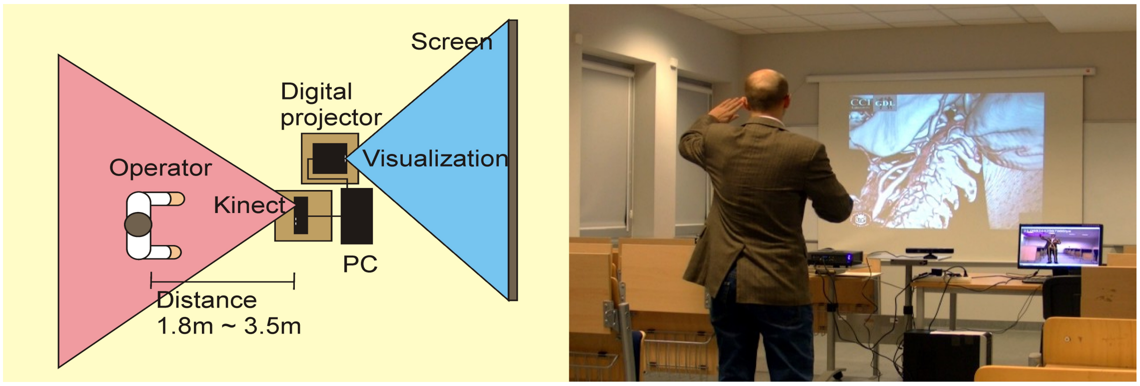

Figure 7: The hardware set - up of prototype of virtual three-dimensional desktop and picture taken during performance tests.

The right hand of the user is used for steering the visualizations. He or she can either perform translation of the volumes (sending to back of the desktop all send them to front in order to show details), rotation or steer the position of a clipping plane. Last functionality is changing the transfer function (prototype has three predefined functions: one that shows bones and vascular system; seconds that adds additional less dense tissues to visualization with high transparency; and third one that reconstruct the skin of examined patient - compare with Figure 6). In order to switch between translation / rotation / clipping mode user makes some predefined gestures by right hand. Those gestures are recognized by GDL.

4 Summary

In this paper we have summarized the most important directions and areas of computer sciences application in medical services and technologies. We have also presented our contribution in such important and fascinating from scientific point of view field. Our work is mainly concentrated on two- three- and four dimensional image data: image processing and recognition (classification tasks), semantic interpretation, as well as visualization and user interfaces. The one of remarkable research trends in this area is adaptation of existing state of the art methods and developing new algorithms in the way to make them suitable to mobile or low power consumption devices by using hardware optimization, web technologies and novel easy to learn and reliable interfaces. Also our up to date researches are concentrated in this area mainly on gesture recognition applied in medical system navigation.
The field of use of computer methods in medicine is very wide and surely will grow in near future with development of new diagnostic methods that mainly generate digitalized information that has to be processed by software or hardware algorithms. Also people quickly get use to new technologies like web and mobile applications, and in our opinion it is a matter of time while mobile applications will be used to for every day contact with chronically ill people that do not have to be under continuous observation in hospital. However it should be rememberd that no computer programm can replace the face-to-face contact of doctor with his or her patient.

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