Analysis and classification of X-ray images on the basis of intelligent agents in distributed systems

R A Tomakova¹, I S Egorov¹, M V Tomakov¹ and N A Korsynskiy¹

¹Southwestern State University, 94, 50 Let Oktyabrya str., Kursk, 305040, Russia

E-mail: rtomakova@mail.ru

Abstract. The purpose of the research is to create new informative Internet technologies that would provide creators of intellectual research systems with available information for constructing training and control samples. An information and diagnostic system based on the formation of a unified structured knowledge base, which is intended for the analysis and classification of X-ray images, is proposed. Research methods for the developed information technology for the synthesis of X-ray classifiers are “the Interior”. The Interior can be presented as a computer program, an autonomous Interior agent, which allows interactively carrying out research on meta-analysis of the classifiers efficiency. The function of the Interior is to build an X-ray classifier with the connection of many users with different databases. The result of the research is the formation of a unified structured knowledge base. The basis of the Interior is a DBMS containing: image files, files of marks of morphological formations, files of personal data, files of meta-analysis results, and files of classifiers. Integration into the Interior’s associates allows you to build a distributed system of intelligent agents. Based on this system, it becomes possible to form classifiers for global use, as well as to carry out a meta-analysis of the diagnostic procedures effectiveness.

1. Introduction

Nowadays, the analysis of medical X-ray images is made by a radiologist with the visual examination of the images. However, the informativeness of the images can be lost due to the peculiarities of subjective visual perception of a human being. In this case, X-ray images are complexly structured images [1, 2], the segmentation and classification of objects on them requires a high classification of the doctor. Therefore, the task of using artificial intelligence in the analysis and interpretation of objects in X-ray images is can be useful. In order to provide the information support and classification of X-ray images, it is necessary to create their database (DB) with various combinations of pathologies. It is obvious that hospitals themselves cannot create such a database. In addition, the available X-ray image databases contain various conceptual models and data formats. All this makes it difficult to share medical X-rays in a single information center. Therefore, it becomes necessary to form a full-fledged radiological information system (RIS), equipped with modern IT-joint equipment in radiology rooms. The development of RIS contributes to the creation of distributed databases of X-ray images, which makes it possible to establish a Unified Diagnostic Information Space (UDIS). The tasks of RIS research are to create an information diagnostic system of any scale, to form a single structured knowledge base (KB) for scientific research and training [3, 4].

The database of images is needed because of the increased requirements for the formation of training and control samples for the creation and testing of intelligent systems. It should be considered...
that the images contained in the database should be unified, have the same size (scale), resolution and processed by the same program [5, 6].

2. Materials and methods

The analysis of existing X-ray databases showed that the process of forming the necessary collection of images for training an intelligent classifier is very difficult. Currently there is no database on the Internet, although it is needed to build classifiers for a wide class of X-ray images and pathologies. Thus, the goal is to create new informative Internet technologies that allow developers to provide accessible information for building training and control samples.

The main structural element of the developed information technology for the synthesis of X-ray classifiers is "the Interior". The Interior is a computer program, an autonomous Interior agent (AIA), designed for decision makers, which allows interactively carry out experimental studies on the meta-analysis of X-ray classifiers efficiency [7, 8].

The scheme of the Interior is shown on Figure 1. The main purpose of the Interior is to form an X-ray image classifier with the connection of users with different databases of X-ray images. In order to unify the information space with diverse X-ray presented, a search identifier is required. The search identifier contains such data as: type of X-ray equipment, the anatomical area, the type of projection, the image format and size, the diagnosis. The Identifier makes the unification of the groups working in the same field of research possible.

![Figure 1: Structural scheme of the Interior.](image)

The structure of the Interior has the form of a record, the fields of which are intended for searching for colleagues on the Internet. The structure of the Interior is shown in Figure 2.
Figure 2. The structure of the Interior.

The identifier of the Interior contains a module for setting priority labels. Using this module makes it possible to set labels on objects that are not of interest while searching for interiors-colleagues. The core of the Interior is the DBMS. The file structure of DBMS contains: the image files, the files of marks of morphological formations, files of personal data, and files of meta-analysis results. There are also classifier files that represent the Interior knowledge base. The integration into interiors-colleagues allows you to build a distributed system of intelligent agents. Based on this system, it becomes possible to form classifiers for global use, as well as to carry out a meta-analysis of the effectiveness of diagnostic procedures. The diagnostic efficiency of the X-ray classifier can be
determined in three stages. At the first stage, a selected classifier helps to understand which X-ray images belong to the selected class of diseases. The synthesis of the classifier and the plan of the experiment are carried out by the decision-maker outside the Interior. At the second stage, a distributed database (interiors-colleagues) is created, in order to train and check the diagnostic efficiency of the selected classifier. At the third stage, a meta-analysis of information about the quality indicators of the classification of the selected classifier is carried out. Based on the obtained results, a decision about the effectiveness of this classifier can be made.

Figure 3. The structure of the Web service and its main software modules.

Since the Interior is connected to the outside world via the Internet, the tools must be available over the Internet, that is, be on a web service. There is also a part of the Interior databases. Thus, by using the software tools of the web service, the decision maker creates a community of remote users or colleagues who can provide X-ray images that satisfy the Interior ID. The Interior allows you to control the dynamics the patient’s functional state in the process of the controlled impact. In this case the following scheme can be implemented: pathology → therapeutic procedure → X-ray → meta-analysis.

The Interior software (IS) provides its work with a web service, which is a manager of a distributed database and a community of interiors-colleagues. Software modules for the implementation of the proposed algorithmic solutions are presented in the structure of the Web service in Figure 3. The
developed software of the web service implements algorithms for areas of interest and their classification makes it possible to control the change in these areas during therapeutic operations. To make the software modules of the web service functional, we used the annotated X-ray images presented on the website: http://academictorrents.com/details/557481faacd824c83fbf57dcf7b6da9383b3235a.

3. Results and discussion
One of the most important applications of the research results is algorithms for monitoring the effectiveness of therapeutic procedures and identifying adverse reactions based on the corresponding surrogate markers.

Scientific and technical results can be used in the clinical diagnosis of various diseases, the formation of atlases of reference X-ray images of anatomical objects in the course of therapeutic treatments. By providing the appropriate services to the remote user, the web service grows its own X-ray database. Using the capabilities of working with remote users, the web service will provide information about the effect of therapeutic operations on pathological structures can be seen on X-ray images.

Prospects for further research. The research results can be attributed to the development of M-to-M technologies (SMS messages) for two-way interactive client interaction with smart grids. The novelty of this direction services development connected with the fact that expert and intelligent automatic systems are connected in order to analyze data and personify medical messages. The interaction with a person is carried out by a computer. The software works with such factors as: a socio-economic status, the client's (patient's) condition and other personal specifics (little data). The messages for the patient are formed in an understandable form, even to a non-specialist.

4. Conclusion
An Internet technology has been developed with autonomous intelligent agents - Interiors, designed for meta-analysis of the efficiency of X-ray classifiers.

Autonomous intelligent agents – Interiors which are necessary for the formation of distributed databases of X-ray images and the synthesis of classifiers of pathological morphological formations, are proposed.

The structure of a web service providing the creation of distributed databases of X-ray images, as well as the Internet interaction of Interiors in solving meta-analysis problems, is considered.

The structure of a distributed database has been developed. It contains Interiors, a search engine, interface modules and synchronization modules. On its basis, a collection of X-ray images is formed from the databases of remote users intended for the synthesis of classifiers of pathological morphological formations.

The proposed decision-making models need to be developed and should be available through the federal services of the Unified State Information System in the healthcare sector of the Russian Federation.

The obtained results will contribute to the expansion of the volume of remote preventive models for the provision of medical services, as well as the development of virtual medical services based on cloud platforms and BigData technologies.

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