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Review of Software for Automated Analysis of Digestive Tract Images

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This paper is devoted to development of software, which allows automatically processing the gastrointestinal tract images obtained by wireless endoscopic capsule. This paper considers software of automated workplace of a physician from different manufacturers of endoscopic complexes in detail. Further, the description of software architecture for gastrointestinal tract images processing and the results of software testing are given in this paper. This software is a part of Landish capsule endoscopic complex.

Key words: Software of an automated workplace, pathologies recognition, images processing, capsule endoscopic complex, medical atlas..

Software of an automated workplace (SAW) of a doctor is required for automated analysis of gastrointestinal tract images (GIT) obtained by endoscopic capsule and for further projects of medical reports based on the results of patient examination.

A lot of attention in different scientific papers is paid to the issues of automated analysis of gastrointestinal tract images[1-7]. Software for GIT pathologies recognition can significantly reduce time for analysis of images flow that was obtained from wireless capsule[8].A new method aimed for abnormal region detection in images focuses on local color features[9]. Some methods suggest abnormal pattern detection in Wireless Capsule Endoscopy images using non-linear analysis in RGB color space[10]. The techniques include anomaly detection for capsule endoscopy images using higher-order Local Auto Correlation features[11] or modified anomaly detection method using non-linear color conversion and Higher-order Local Auto-Correlation (HLAC)[12]. There are also new methods for the rejection of the parts of the video resulting not valid for analysis by means of automatic detection of intestinal juices. It is achieved via applied Gabor filters for the characterization of the bubble-like shape of intestinal juices in fasting patient[13].

Existing solutions have both advantages and disadvantages. This paper considers software of automated workplace of aphysician from different manufacturers of endoscopic complexes in detail.

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MATERIAL AND METHODS

Olympus software is considered convenient in use for manual analysis and has only one intellectual function – search of bleeding (Fig. 1). [14]

Fig. 1. Olympus software interface (bleeding recognition)

Due to technical solutions ofthe Olympus capsular endoscopic complex, the GIT area, where the capsule is presumably located, is simultaneously determined during the review of images.This option is attained because not only images are saved, but data about the strongest signal received from endoscopic capsule, which the antenna of reading sensors captured (in Fig. 2 this sensor is marked in blue colour).

Fig. 2. Data about the capsule location received from external sensors of the Olympus capsular endoscopic complex

According to specialists, this function is not very effective because data about the location received by sensors is not quite accurate. However, this function is used when small intestine is analyzed because there the capsule moves slowly and periodically stops. In this case we can note that information from external sensors about the capsule's location in the patient's body stays unaltered, but the picture fixed by capsular endoscope changes. This effect is caused by the rotation of the capsule in GIT due to peristaltic contractions and body movements. In this case the image of the place, where the capsule was delayed, can be missed and not considered in details.

The Olympus software has the function of speed adaptation during the review of data obtained by capsule. The software compares two neighboring GIT images and if they have significant differences, the speed of the picture review is slown down. Moreover, there is a function for manual control of images review, a function of pathologies saving and a function of automatic reports creation.

As to the Given Imaging endoscopic complex, it has similar functions to Olympus software.

There is significant difference between the Given Imaging software and the Olympus software. The Given Imaging software can be installed on any personal computer with Windows operating system, while the Olympus software is supplied with a special computer.

The Given Imaging software has similar functional opportunities with the Olympus software. The program for video processing gives the endoscopist an opportunity to view images taken by the capsule in the form of a unified video sequence. There are other opportunities in this program such as multi-viewing (simultaneous viewing of up to 4 images), video frame zoom in and zoom out. The bleeding sensor automatically marks frames with suspected bleeding with a red strip in the time line. Archiving of detected pathological changes in the database of this system and in removable media is effected during the video processing. The localizer of the video system allows detecting the capsule in GIT during the procedure. It facilitates the localization of pathological and morphological changes of GIT[15].

The Given Imaging software has a system of diseases detection based on an endoscopic atlas (Fig. 3). The atlas of GIT images (which is also part of the software) allows the user to compare obtained images with the picture of a known pathology. Necessary photos can be found in the atlas: with the help of terms describing pathologies or with the help of diagnosis. The picture of a known pathology and the image, chosen by the endoscopist, are simultaneously demonstrated on the screen. The atlas gives an opportunity to widen knowledge for advanced users, but it is not a replacement of endoscopy[8].

Fig. 3. Given Imaging endoscopic atlas

The system of GIT pathologies detection uses pathologies, which have already been made by doctors, to compare obtained frames with the atlas. The system is not free of errors of the first kind (the image with symptoms stays invisible) because it is impossible to collect all cases of diseases. It is an informational mechanism accelerating the work of a doctor.

IntroMedic (MiroView, fig. 4 [16]) software has the following functions:

a) function of multiwindow display allows simultaneously demonstrating 2 or 4 consistent images for accelerated viewing;
b) fast preview regime (about 5-15 minutes);
c) control of image viewing speed;
d) display of capsule location in GIT;
e) detection of bleedings in GIT – the areas with suspected bleedings are automatically chosen for displaying;
f) zoom function.

What is more, this software has:

a) box of capture – it is replenished by images with supposed deceases for viewing;
b) atlas of images – it compares the results with available images for help in diagnosis[11].

Fig. 4. Interface of IntroMedic software

In the Table 1 we can see some functional specification of Olympus, Given Imaging and Intro Medic.

All these solutions have both

Table 1. Software of different endoscopic complexes

Specification unit	Olympus	Given Imaging	IntroMedic
Display on the screen	Fast preview mode	Up to four images on the screen	Up to four images on the screen
Pathologies	Bleeding	Bleeding	Bleeding
Work with images	-	Color correction, brightness and contrast correction	-
Real-time control	Real-time viewing of images	Real-time viewing of images	Real-time viewing of images

advantages and disadvantages. So, the aim was to develop new software with precise requirements of the endoscopic complex, but without disadvantages of known analogs.

Software of an automated workplace (SAW) of a doctor provides:

a) systematized storage and processing of patients data;
b) automated analysis of obtained data;
c) viewing and processing of the analysis results;
d) preliminary formation of an automated medical report (as a result of medical examination).

SAW detects frames with anomalous images,the identified pathology and the suspected pathology are based on frames analysis in accordance with the atlas of GIT pathologies. SAW detects problematic areas such as tumors, ulcers, bleedings, polyps, etc. Then SAW creates a videoreport with the most important frames (Fig. 5). It significantly accelerates and simplifies the work of doctors during the creation of medical report about patient's state.

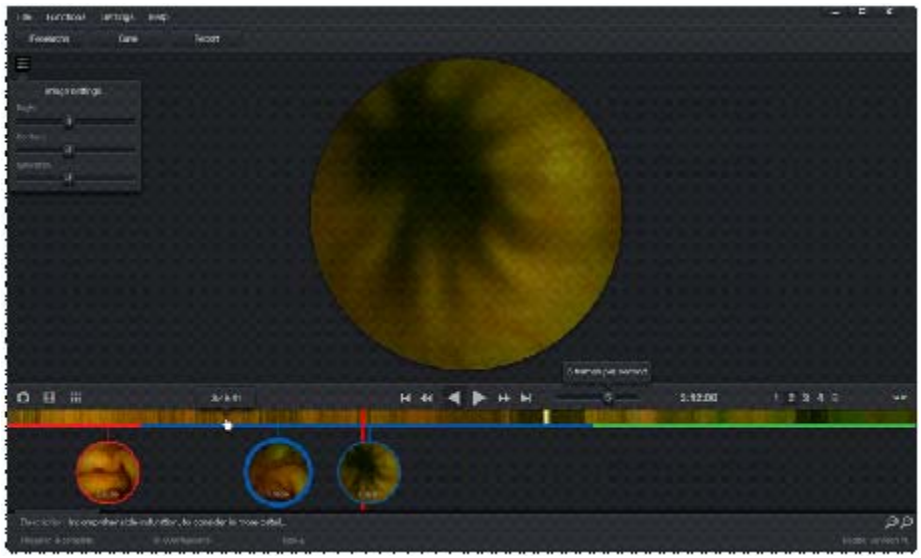

Fig. 5. Videoreport as a result of medical examination

It is necessary to notice that unlike its world analogs[8,17], the developed SAW has the following functions:

a) automated detections of color anomalies and texture anomalies[18];
b) editing of obtained images (marking, resizing, zooming, image improvement).

It increases the performance of the specialist when analysising the materials obtained in medical examination. What is more, SAW allows displaying up to 15 frames of patient GIT (fig. 6) and any type of medical report recording.

Fig. 6. Image output to the screen

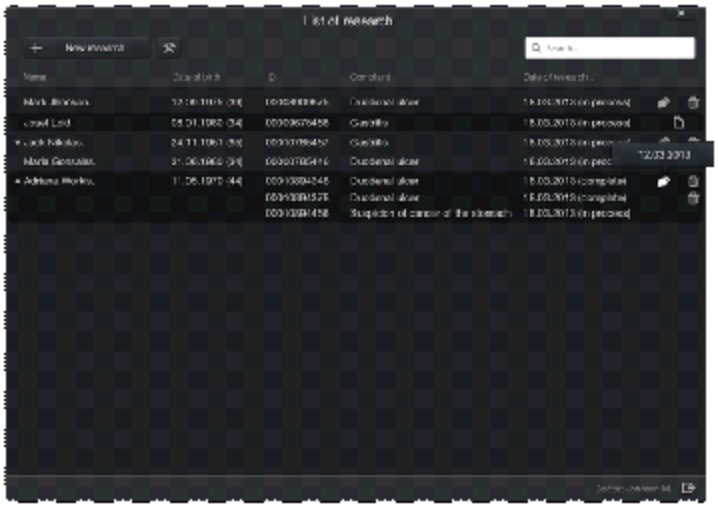

Fig. 7. SAW interface

SAW interface is shown in the figure 7. It demonstrates a list of examined patients.

SAW can process data obtained from other capsular endoscopic complexes due to standard JPEG2000.

Maximum time, which is necessary for primary video information processing and for automated preliminary medical report forming, is about 10 minutes. Average time of one medical examination processing with report formation is not more than 5 minutes[19].

SAW functions under the control of Microsoft Windows OS (Vista, XP, 7, 8). SAW is protected against unauthorized copying and exploitation by using a special registration key[19].

RESULTS AND DISCUSSION

Thus, the software enables automated analysis of GIT images of a patient. This software is a part of Landish capsular endoscopic complex. Recognition of pathological images is one of the most important tasks in images processing. The optimal solution is software based on histogram analysis. This method allows realizing the analysis. It increases the effectiveness of GIT analysis based on automated computer diagnostics. Moreover, it increases significance of the endoscopic examination.

In the future it is planned to create a virtual model of GIT. It will be a new way of storage and

analysys of medical data. Moreover, a constantly updated base of processed images is to be created. Such database can be updated from different remote computers through the Internet. Based on this database the expert system for GIT diagnosis will be created. This system will be able to function on-line.

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