A computer system for the collection and analysis of information for cataract

K D Kirillovykh1, V G Nikitaev1, S E Ulin1, E V Polyakov1, V N Trubilin2 and O M Orlova2

1National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe highway 31, Moscow, 115409, Russia
2Ophthalmology Centre FMBA of Russia, Gamalei st., 15, Moscow, 123098, Russia

E-mail: VGNikitayev@mephi.ru

Abstract. Automation system for ophthalmologist proposed. The system allows to collect anamnesis(pre-history) using a questionnaire. Its use contributes to the early detection of cataracts. This system will allow the doctor to choose the possible types of intraocular lenses for phacoemulsification. Results of system work are shown.

1. Introduction

The human eye has a spherical shape, hence its name - the eyeball. It consists of three layers: external, vascular and retinal, as well as the internal content.

Front and back (between the iris and lens) cameras are enclosed inside the shells. They are filled with intraocular liquid, and most importantly - the lens and vitreous. The lens of the eye has the shape of lenticular lens.[1-2]. Like the cornea, it misses and refracts light rays focusing on the retina the image.

Senile cataract is a physiological condition associated with clouding of the eye lens, which leads to reduction in light transmittance on the retina[3]. Today, cataract is one of the most common eye diseases. According to the National Eye Institute (NEI), in 2010 24.4 million cataract patients have been identified in the United States. According to forecasts, by 2050 the number of such patients will double to 50 million people [4].

Cataract is the cause of almost half of all cases of blindness, there are about 18 - 19 million gone blind due to cataracts (according to the World Health Organization estimates).

Modern methods of determining of the degree of lens opacity (cataract stage) are based on a subjective assessment of an ophthalmologist. Currently, cataracts are diagnosed with slit lamp - the device that allows for microscopic analysis of the visible parts of the eye. [5]
Figure 1. Example of photo, which is made with a slit lamp.

Slit lamp is one of the most important diagnostic tools in the arsenal of ophthalmologists. This device allows biomicroscopy of visible parts of the eye: the cornea and sclera, conjunctiva and eyelids, iris and lens (figure 1). Inspection of the slit lamp is the best way to see the eye tissue under high magnification, so it has long been a routine procedure when it is necessary ophthalmologic examination.

2. Diagnosis of cataracts

The diagnostic of cataract is used for determination of visual acuity, visible field, the intraocular pressure, character of the retina and optic nerve.

With the help of a slit lamp the doctor will determine the degree of maturity of the cataract and lens opacity. In addition, additional inspection might need to identify other likely visual impairment - glaucoma or retinal detachment.

After determining the degree of cataract the decision will be made about on phacoemulsification surgery with one of the following implantation of intraocular lenses: monofocal, multifocal or toric, as well as combinations thereof.

According to the Russian Ministry of Health Order N290H from 02.06.2015 while taking a patient's ophthalmologist should not exceed 14 minutes (including filling a doctor with all the necessary documentation). During this period of time it is not always possible to completely collect anamnesis, diagnosing pathology of the eyeball, and explain to the patient the need for further treatment and tactics, to help patient to make the right choice.

This problem can be effectively solved by a computer system diagnostics cataract.

Objective of research: create a computer system consisting of cataract diagnosis of online testing patients for the collection of prior medical history and automation diagnosis of cataract stages.

3. Implementation

Cataract diagnosis system consists of two parts: a test system of patients and cataract stages diagnostics system [5].

Testing includes 23 issues: general issues (gender, age); questions relating to lifestyle and the subjective assessment of the state of visual functions by the patient.

After the patient has responded to all the questions, the answers are stored in the database, which compares with a particular reference set of responses. The knowledge base proposes recommendation after checking for compliance with a set of patient responses to a set of standard answers. The examples of recommendation: "yes / no suspicion of the presence of cataracts, need / do not need surgery, which of the types of intraocular lenses best suited for the operation. In total there are 7 answers.
After passing the test the patient will can leave personal data, these data ophthalmologist can see how a specific patient responded to questions and assess the current state of the patient's body at the time of filling in the questionnaire. This allows to plan treatment strategy before the start of the reception.

Cataract stages diagnosis is performed by image processing of the eye lens using a slit lamp. Lens image processing system is based on the texture analysis (figure 2 and figure 3).

The input system is fed color digital image. Ophthalmologist selects the original image informative zone, which in turn determines the spatial zone of adjacency matrix formation, by which the system calculates the textural attributes [6].

4. Results
The system of computer diagnostics of cataract stages were calculated textural features of the original 32 digital images lens opacity varying degrees. The revealed experiment is sown that 10 images are not suitable for use in the diagnostic system, as they do not meet the standards of the shooting conditions for the system object. On sifted 10 photos in front of the interior space is reflected ophthalmologic office, making it impossible for the allocation of an informative zone.

To check compliance with the calculation of the cataract, Ophthalmologist signed each digital photograph its corresponding degree.

Objects of research - digital photos one by one (from stage 1 to 4) were loaded into the system and calculated their textural characteristics (energy, entropy, maximum probability, moment of inertia, linear homogeneity). As a result, signs counted in 22 pictures, in which 4 pictures of the first stages of cataract, 5 pictures of second stage, 6 pictures of the third stage of cataract and 7 pictures of the fourth stage of cataract[7].

| File name | Energy | Max probability | Inertia moment | Linear heterogeneity |
|-----------|--------|-----------------|----------------|---------------------|
| 1.jpg     | 428    | 5               | 0.011          | 9                   |
| 1.jpg     | 451    | 5               | 0.011          | 9                   |
| 1.jpg     | 415    | 5               | 0.011          | 9                   |
| 1.jpg     | 439    | 5               | 0.011          | 9                   |
| 2.jpg     | 665    | 6               | 0.017          | 5                   |
| 2.jpg     | 684    | 6               | 0.017          | 5                   |
| 2.jpg     | 704    | 6               | 0.017          | 5                   |
| 2.jpg     | 679    | 6               | 0.017          | 5                   |

Table 1. Results of calculation of textural features in patients with cataract.
Preliminary analysis of the test results showed that the system allows to evaluate the state of the eye, based on subjective patient data. A computer program helps to reduce the time to collect the anamnesis in primary reception at the ophthalmologist, which is especially needed to improve the efficiency of examinations, early diagnosis of cataracts and a decision on further tactics of treatment. The program helps the ophthalmologist to determine the degree of opacity of the lens and make an accurate diagnosis, eliminating subjectivity in the decision.

5. Conclusion
Ophthalmic system of computer diagnostics contributes to the early detection of cataracts. This system reduces time spent on medical history doctor, which increases the time of the survey on medical reception and allows the physician to choose the patient the possible form of intraocular lenses for phacoemulsification.

References
[1] Kessel L et al. 2016 Acta ophthalmologica 94(1) 10
[2] Peredery V A 2008 (in Russian) Eye diseases. A comprehensive guide p 44 (Moscow: Eksmo publisher) (Original Russian title: Glaznyye bolezni. Polnoye rukovodstvo M.:Eksmo)
[3] Xu Y et al. 2013 Medical Image Computing and Computer-Assisted Intervention – MICCAI (Nagoya: LNCS series from Springer) p 468
[4] https://nei.nih.gov/eyedata/cataract#
[5] Li H et al. 2010 3rd Int. Conf. on Biomedical Engineering and Informatics vol 1 (Yantai: IEEE) p 253
[6] Davydov M I et al. 2015 Bulletin of the Lebedev Physics Institute 42(8) 237
[7] Materka A et al. 1998 Texture analysis methods - A review (Brussels: Technical University of Lodz, Institute of Electronics) pp 1–33