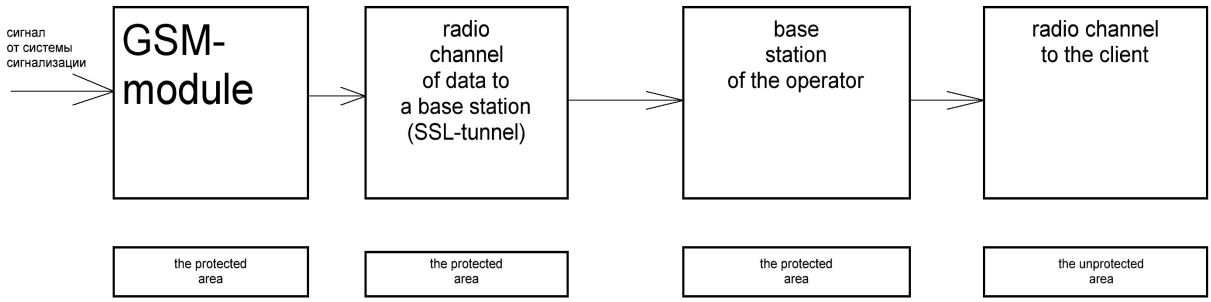

Fig. 8. SSL enciphering

Let's consider GSM modules on J2ME. Java ME (J2ME) is a powerful built-in platform intended for mobile devices and security systems. It allows expanding functionality of GSM modules. Its advantages are the following:

– high level of safety and security of the system according to certificates of X.509;
– built-in debugging facilities;
– high stability, lack of system resets;
– means of difficulty of perception of a code.

Developers can build in the GSM module appendices on the JAVA platform with several peripheral interfaces [6].

In summary let's mention some of the problems which developers of security systems should solve to increase reliability and to reduce unauthorized access to the protected perimeter. Further development of security systems (including the studied A6-04 system) needs more modern and functional element base. Then full microprocessor information processing will be possible. It, in turn, will allow using more modern algorithms of signal processing.

One more important moment is energy consumption reduction. A big problem for security systems is autonomy, i.e. independence of power supplies. It is necessary to look for alternative sources of electric energy more carefully. It is necessary to avoid the breakings connected with loss of electric energy from a network.

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UDC 681.5

PAYMENT RECEIPTS IMAGE PROCESSING FOR DATA INPUT AUTOMATION WITH MOBILE DEVICES

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In this paper we propose an approach for payment receipts image processing obtained from the camera mobile devices. The main steps of the algorithm and the experimental results are presented.

Modern specialized optical character recognition solutions (OCR), developed by ABBYY or Nuance allow organizing complex optical input of financial documents with the help of special scanners or ordinary appliances for making digital images (such as a home scanner, a camera etc.). Despite the fact that all financial institutions try to get

rid of paper document flow, using barcoding systems and distant client service, for observance of legitimacy while working with clients it is still necessary to reflect some information in papers (checks, invoices etc.). That's why the development of OCR systems based on using embedded mobile device cameras is important for optical input of financial information by a client. Images obtained by embedded mobile device cameras have a range of features: a high level of noise, low sharpness, inaccuracy of a color rendition and others.

As a rule, at the stage of obtaining full receipt image, we get a low quality image, which can't be processed automatically. So it is reasonable to obtain a receipt image by its fragments. At this stage we can check image quality using methods of prior quality test [1].

Images obtained by mobile phone camera are usually received in case of poor lighting. For making the acceptable image brightness, one can raise matrix light sensitivity which leads to the appearance of brightness and chromatic noise on the image. The absence of sufficient illuminance of the paper document and shooting conditions, specific to the mobile device (trembling of a camera, etc.) do the image smoothed and low-contrast. To be saved, an image is compressed by algorithms with data lossy (for example JPEG), that often leads to the appearance of artifacts. One more feature of mobile images is the appearance of geometrical and perspective distortions. The source fragment of the document is shown in Picture 1.

Prior image processing is aimed at image quality improvement and contains noise filtering, increase of sharpness and image contrast, alignment and conversion to the format used by the system. For the suppression of uneven lighting during mobile shooting, and also for the normalization of the illuminance local levels the algorithm of SSR (SingleScaleRetinex) [2] is used:

$$R_i(x,y) = \log I_i(x,y) - \log\left[F_i(x,y) * I_i(x,y)\right],$$

where $R_i(x,y)$ – output image, $I_i(x,y)$ – source image; $F_i(x,y)$ – Gauss function.

The method based on the use of Bezier patch [3] is used to eliminate geometrical and perspective distortions. It takes into account implementation on mobile devices and provides the high speed of operation and simplicity.

For adaptive binarization it is recommended to apply modified, robastny to noise, Christian's algorithm. The example of the algorithm applying for the image shown in fig.1 is given in fig. 2. The binarization threshold (T) for the sliding window is calculated as [4]:

$$T = (1-\alpha_1)*\mu + \alpha_2 * \left(\frac{\sigma}{R_\sigma} * [\mu - M] + \alpha * M\right)$$

where $\alpha_1 = k_1 * \left(\frac{\sigma}{R_\sigma}\right)^\gamma$, $\alpha_2 = k_2 * \left(\frac{\sigma}{R_\sigma}\right)^\gamma$, k_1 *and* k_2 – positive constants, at $\gamma = 2$, k_1 *and* k_2 is recommended to be in ranges 0.1 – 0.2, 0.15 – 0.25 and 0.01 – 0.05;

σ – mean squared deviation of brightness in the given window;

R_σ – maximum of mean squared deviation in the given window;

μ – mathematical expectation of brightness in the given window;

M – minimum brightness in the given window.

Fig. 1. Receipt image fragment, obtained with embedded mobile device camera

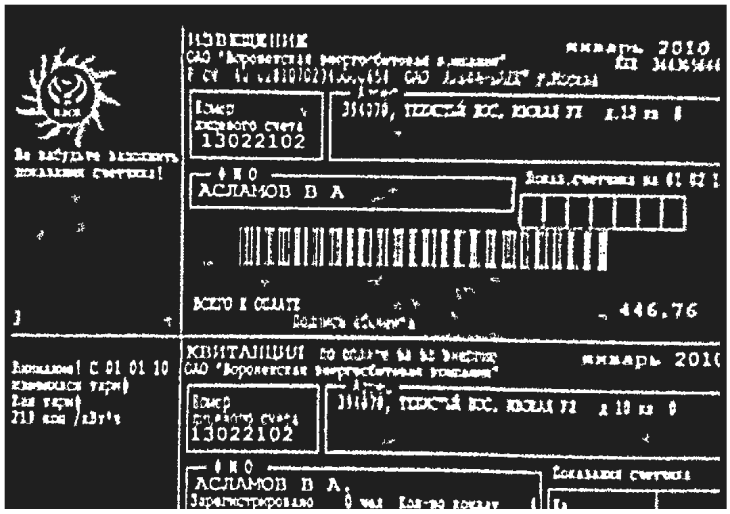

Fig. 2. Example of receipt fragment adaptive binarization with Christian's algorithm

Then automatic image fragments patching from already processed parts is applied by comparison of SIFT descriptors (Scale Invariant Feature Transform). SIFT is one of the most effective characteristic points search algorithms on two or more images, it is invariant to image scale and brightness changes, and is also rather steady against foreshortening changes [5]. As a result of algorithm the set of special points on each couple of images with a set of the descriptors turns out. These points are compared in pairs on adjacent images and if descriptors of two selected points match in repartitions of the given accuracy, two points are accepted as the conjugate. It is possible to read that these points were received as a projection of the same three-dimensional point to the planes of two cameras. The example of operation of algorithm is shown in fig. 3.

Markers separation and search is based on the set of SIFT descriptors and on binary document image. The main markers types are partitioned into 3 main groups concerning their significance for document identification:

- the most significant signs are seals, logos, barcodes, stylized texts;
- the second group includes lines, intersections (angles), text units and separate labels;
- the least significant signs are separate characters.

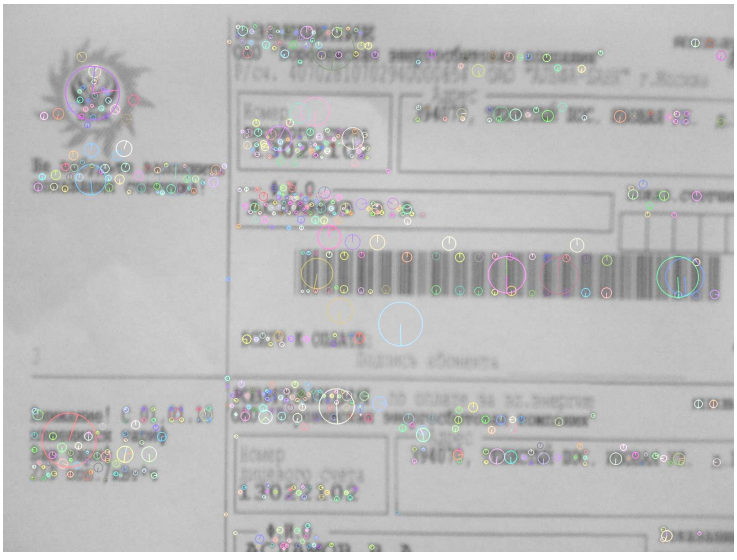

Fig. 3. Receipt image fragment, with SIFT characteristic points found on it

Carried out experiments showed that the provided algorithm of receipt image processing allows to present the document in the form of ordered, well perceptible signs set, and the intermediate algorithm result can be used by character recognition systems without prior processing.

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PROGRAM FOR PRACTICAL STUDYING OF GRAPHS

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This paper describes a program that was written to help students better learn the material on the graph theory. The article also contains a summary of the graphs, some algorithms and graph theory.

In mathematics and computer science, graph theory is the study of graphs which are mathematical structures used to model pairwise relations between objects. A "graph" in this context is made up of "vertices" or "nodes" and lines called edges that connect them. A graph may be undirected, meaning that there is no distinction between the two vertices associated with each edge, or its edges may be directed from one vertex to another. Graphs are one of the prime objects of study in discrete mathematics [1].

Discrete mathematics is the study of mathematical structures that are fundamentally discrete rather than continuous. In contrast to real numbers that have the property of varying "smoothly", the objects studied in discrete mathematics – such as integers, graphs, and statements in logic – do not vary smoothly in this way, but have distinct, separated values [3]. Discrete mathematics therefore excludes topics in "continuous mathematics" such as calculus and analysis. Discrete objects can often be enumerated by integers. More formally, discrete mathematics has been characterized as the branch of mathematics dealing with countable sets [3] (sets that have the same cardinality as subsets of the natural numbers, including rational numbers but not real numbers). However, there is no exact definition of the term "discrete mathematics" [4]. Indeed, discrete mathematics is described less by what is included than by what is excluded: continuously varying quantities and related notions.

The set of objects studied in discrete mathematics can be finite or infinite. The term finite mathematics is sometimes applied to the parts of the field of discrete mathematics that deals with finite sets, particularly those areas relevant to business.

Graphs can be used to model many types of relations and processes in physical, biological, social and information systems. Many practical problems can be represented by graphs [2].

In computer science, graphs are used to represent networks of communication, data organization, computational devices, the flow of computation, etc. For instance, the link structure of a website can be represented by a directed graph, in which the vertices represent web pages and directed edges represent links from one page to another. A similar approach can be taken to problems in travel, biology, computer chip design, and many other fields. The development of algorithms to handle graphs is therefore of major interest in computer science. The transformation of graphs is often formalized and represented by graph rewrite systems. Complementary to graph transformation systems focusing on rule-based in-memory manipulation of graphs are graph databases geared towards transaction-safe, persistent storing and querying of graph-structured data [2].

There are some algorithms for working with graphs. They are:

1) Dijksta's algorithm;
2) Floyd-Warshall algorithm;
3) Kruskal's algorithm;
4) Prim's algorithm;
5) Depth-first search;
6) Nearest neighbor algorithm.

The essence of our program lies in the practical study of algorithms working with graphs. The algorithm for study is selected in the program, and after the generation of a graph, the program gives the tips that the user