is useful to apply the 'establish conformity' tasks to reveal the knowledge of definitions, because one question helps reveal the knowledge of several definitions. Also it's better to reduce the number of tasks of the completion type, because the check is performed automatically and there is high risk of correct answers, but in the wrong form, with misprints, connected with the usage of synonymous, etc.

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CONTENT RECOGNITION OF BANK CARDS IN iOS MOBILE DEVICES

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In this article we propose research for existing recognition methods of text fields on documents with flexible forms. Description of adaptability of flexible forms processing from different spheres for bank card details recognition is presented. This approach will allow us to recognize all the information fields by a bank card image with minimum user contribution. This will get rid a user of routine procedures.

M-banking takes a special place among innovative systems and gives an opportunity to manage banking account with the help of a mobile device (smartphone or tablet computer). Full access to the personal account for the client gives a bank card. It is very important and frequently used instrument and it is necessary to rise its usability convenience in the process of mobile applications development. Many M-banking apps require manual entry of bank card details (all information fields data applied on the card) into the system for payment transactions and it is not an easy task for the user. This process is time-consuming, it requires attentiveness and diligence. This article is to help to solve this problem.

Many bank cards have a size of special standard ISO 7810 ID-1. Card design has some restrictions. In a specified place there is a payment system logo to which a card belongs and bank card details information fields. The other card space design is decided by the bank. Card number is embossed a bit lower of the card center and it contains 16 numbers. There is a validity period under its number. Beginning date is not an obligatory field while an expiration date is an obligatory element. Cardholder's name and surname are embossed on the line below. Embossers with Cyrillic script are used in Russian and Belarusian systems, international payment systems use Latin characters. Cards with microchips have a standard microchip place – in the left part, over the first numbers of the card number. On the other side there is a magnetic strip with the main identification information. Lower there is a stripe for the cardholder's subscription.

Plastic bank card design is an important carrier of bank brand and it gives freedom and unpredictability for the card-issuing bank designers' and marketing specialists' invention. That's why it is impossible to rely on any graphic characteristics of the card. It can have any background color. Its color can coincide with the ground color on which it is placed (camouflage effect). It leads to the insufficient contrast at the card borders and "false" borders or gaps. The same effect can be observed when for the card backgrounds such textures as leather or wood are used. Taking it into account, there can be a problem with bank card recognition when a cardholder places a card on the wooden table ground (fig. 1a) or leather wallet. Glossy surface plastic is the main material of which bank cards are made. It has strong reflective characteristics and with the bright light it gives highlights and flashings (fig. 1b). And vice versa, if there is not enough light, and imagination can be soft or unexposed. A mobile device will perform card details recognition and it imposes strict requirements for the computational complexity and algorithms implementation period.

a *b* *c* *d*

Fig. 1. Bank card problem spots examples:
a – coincidence of the card background color andbackground color of the image; *b* – highlights and flashings;
c – insufficient contrast with the card background color; *d* – complete color coincidence of the card details and its number

The following problem is unpredictability of placement, angle of rotation and the degree of perspective distortion, depicted on the bank card shot taken by the camera. It is necessary to take into account that the cardholder can place a card in any way. Characters recognized on the card surface have strict print type and fixed position but can be placed on its surface in a different way. It is also necessary to take into account that there can be Cyrillic script in the cardholder's name field. Sublimate heat transfer printed data will be different from embossed one. Embossed characters are over the card surface and it can make shady parts around every symbol and there can be slight flashings on the tops. There can also be an insufficient contrast of the placed characters on its borders with the background (fig. 1b) or full coincidence of symbol color with the background color (fig. 1c). This is the case of sublimate heat transfer printed text. The presence of other characters on the card (apart from bank card details) for example payment system name ("Belcard") shouldn't also be excluded.

Bank cards are typical examples of documents with flexible form so any data recognition algorithm can be applied during its processing. There are characteristics of the studied algorithms related to the processing stages in table.

Algorithm suggested by Sheshkus-Nikolaev describes an approach to the flexible forms fields recognition using an example of credit card expiration date. Authors don't describe image pre-processing, but focus on the template search of data fields on the card surface and on the ways of algorithms improvement through shortening of the number of fields and template framework improvement (fig. 2).

Authors emphasize that this algorithm is oriented on the mobile devices. The way of separation from a background is not reflected in this article, there are only references to the sources. Having studied these sources, we can distinguish some transformations that allow to get a rectangular area on the image: the median filter is a nonlinear digital filtering technique, often used to denoise**,** Canny edge detector operator usage and Radon transform for line detection on the image. Authors have a database of 4000 bank card images and estimate the accuracy of the developed algorithm at 99,51%. Taking into account those restrictions that a card image should be placed in parallel with the camera plane, all the scripts should be embossed and Cyrillic characters recognition won't be supported.

Modern algorithms of data recognition on the documents with flexible form and its characteristics

Surname of the author of the algorithm	Stages						
	Pre-processing	Object positioning	Projective transformation	Object positioning by the template	Binarization	Clustering	Recognition and classification
Sheshkus A., Nikolaev D., Ingacheva A., Skoryukina N. [1]	+	+	+	+	–	+	+
Mollah A., Basu S., Das N., Sarkar R., Nasipuri M., Kundu M. [2]	+	–	–	–	+	–	–
Christian T. H. Gustavsson D. [3]	+	+	+	+	+	+	+
BhaskarS., LavassarN., Green S. [4]	+	–	–	–	+	+	+

Fig. 2. Strictly labeled search zone using VISA card example

Next Algorithm [2] is a description of steps series processing of business cards that allows getting fields containing textual information. At the pre-processing step this algorithm makes the original card image into grayscale. After that there are two stages. At the first stage it divides background by crude approximation, at the second on the surface that is divided from business card background connected components are found and classified. Crude approximation algorithm is described as following: an image is divided into fixed-size sets. The longer is a set, the more likely that words staying in one string can be included into one set processing. The less is set height, the less likely this set will cover some lines. Authors identified an optimal balance between width and height of the set depending on the initial image and approximate font size. Every set was classified as an information set or back-

ground set based on dispersive volume. If dispersion volume wasn't more than a specific threshold, the area was a background set, and vice versa, if it was more than a specific threshold, it was marked as information set. Information sets selected by iteration connect and make coherent components. Further experiments showed that coherent components can be not only in a form of a text but also in a form of photos, logos or speckle. Too small sets (less than one symbol size) are regarded as speckles; sets which height is more than one threshold symbol and width is more than maximum possible threshold symbol are regarded as horizontal line; height of which is more than two lines and width-less than some characters are regarded as vertical line. Logos are also divided by the size of threshold sets. Then there is a process of threshold binarization which divides a text from image background. Authors estimate the accuracy and effectiveness of the developed algorithm at 98%. This algorithm can only be used with simple images without any background or if an object is placed on monotone surface. Background text is not taken into account.Projective transformations are not made. Text size is fixed.

Algorithm in [3] also presupposes information recognition on the business card. An image captured by the camera is transformed into grayscale. The first task is to localize business card within an image. An approach to the card search on the image is based on the edges segmentation technique. Sobel edge detection is used to find a border between card and image background. Detected borders are projected onto parametrically set lines. There are crossings between lines. The final result of the detecting is four crossbar units assigning a business card angles. The Sobel edge detection algorithm use convolution filters across the image to highlight the edges with 3×3 size folding an initial image. Hough transformation is used to transform detected edges into parametrical mode. Card image center is evaluated by the diagonal lines crossingpoint and required transformations are calculated. Sentences, words and characters segmentation is considered as two different types of segmentation. External segmentation is the distinguishing of articles, sentences and words. Internal segmentation distinguishes characters. To classify characters the author uses feed forward neural network based on obtaining histogram principle.

In [4] an approach to optical character recognition (OCR) on Android platform using an example of business card is described. The first algorithm implementation is carried out in mathematical space MATLAB. The author explains some moments important when preparing an image to get into Tesseract OCR system [5]. Then the author points out a simplified implementation of an app on Android. He considers this algorithm too resource-intensive and difficult for mobile devices. Tesseract OCR algorithm presupposes the following steps. Colorful or grayscale image gets on algorithm entry and an object should be close to the camera. OTSY self-adaptive binarization makes an image binary (black-and-white). Foreground object supposed to be black and background-white. Then optimal threshold value is calculated. It divides two pixel classes in such a way that dispersion is at a minimum rate. Connected components labeling. Tesseract looks the entire image' surface through and identifies foreground pixels and marks it as blobs or potential characters. Lines of the texture found by analyze the image space adjacent to potential characters. This algorithm does Y projection of the binary image and finds location having a pixel count less than a specific threshold. These areas are potential lines and are further analyzed to confirm. It finds baselines for each of the lines. After each line of text is found, Tesseract examines the lines of text to find approximate text height across the line. This process is the first step in determining how to recognize characters. The other half of setting up character detection is finding the approximate character width. This allows for the correct incremental extraction of characters as Tesseract walks down a line. Non-fixed pitch spacing delimiting – characters that are not of uniform width or of a width that agrees with surrounding neighborhood are reclassified to be processed in an alternate manner. After finding all of the possible character "blobs" in the document, Tesseract does the word recognition word by word, on a line by line basis. Words are then passed through a contextual and syntactical analyzer which ensures accurate recognition. Rectangular objects detection stage in all the algorithms considered is made with pre-processing transformations (Hough, Canny, Radon operators), but the difference is too slight among other algorithms and specified coefficients and threshold volumes can be applied for only particular cases.

In this article we examined main elements of the bank card, indicated problems arising in bank card invoice details recognition, enumerated existing algorithms and described its operations. On the basis of analyses we distinguished stages that should be used during recognition algorithm: distinguishing of an object from a background, characters location by template framework, characters recognition by the Tesseract OCR system. It is intended to improve image pre-processing algorithms adding perspective restoration steps and additional filtrations and also to make it possible to recognize Cyrillic characters. It will definitely improve the recognition process and make it more reliable for a larger number of cards.

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K-MEANS CLUSTERING ALGORITHM IMPLEMENTATION USING NVIDIA CUDA TECHNOLOGY

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The purpose of this paper is to describe the key points of the implementation of clustering algorithm k-means on the graphics adapter using Nvidia CUDA technology. To compare the performance for parallel processing and structured programming shows the implementation of the algorithm on the CPU. Results of experiments are presented.

Nvidia CUDA is an architecture for General-purpose computing on the GPU, which acts as a powerful coprocessor. With this technology, developers will be able to optimize applications using parallel computing on the GPU by using augmented essential functions the C language without learning a specific API for working with graphics accelerators. When using parallel computing becomes possible to speed up the audio and video encoding, calculations of various physical phenomena, modeling of complex systems, and other research tasks.

When developing applications using CUDA available flexible memory organization of the video card, allowing on the one hand to speed up access to frequently used data, and on the other to download large amounts of data for processing by the GPU. At the same time the scale of parallelization is not limited to a few tens of streams, and provide developers tens and hundreds of thousands of streams of threads simultaneously. The developer is not required program management of execution threads on physical cores of the GPU, since this concern takes on CUDA driver [1].

For a visual comparison of the performance in parallel computing let's apply the k-means clustering, as when it is running there is a lot of similar operations that can be performed in parallel.

When calculating the k-means algorithm, the elements of the input array are divided by the given number of clusters the most similar attributes. Choosing the number of clusters based on preceding observations or theoretical assumptions. The algorithm consists of several steps: original definition of cluster centers and iterative refinement technique. The algorithm is considered complete when the condition matches the new cluster centers with those calculated in the previous iteration of the centers, or after a certain number of iterations of the algorithm. Next, compare the speed of clustering k-means on the CPU and GPU with CUDA technology.

When implementing the algorithm of k-means on the CPU used procedural programming. As a result, each iteration is performed a large number of rounds of the input array elements and centers of clusters, as well as auxiliary arrays for storage elements and metrics for determining membership of each element to the desired cluster. Therefore, an increase in the number of input elements or the number of clusters increases in direct proportion to the execution time of the each iteration, and thus the entire algorithm as a whole. The code listing that implements the algorithm on the CPU is shown below.

```
do      {
        for (int i = 0; i < klnum; i++)
        {
                for (int j = 0; j < elcount; j++)
                {
                        tmp = (parr[j] - centroids[i]) * (parr[j] - centroids[i]);
```