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Graphic object feature extraction system based on Cuckoo Search Algorithm

Marcin Woźniak[a,*], Dawid Połap[a], Christian Napoli[b], Emiliano Tramontana[b]

[a] Institute of Mathematics, Silesian University of Technology, Kaszubska 23, 44-100 Gliwice, Poland
[b] Department of Mathematics and Informatics, University of Catania, Viale A. Doria 6, 95125 Catania, Italy

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ABSTRACT

Multimedia systems often use various detection methods to track relevant objects in images and video frames. The tracking scheme is often based on capturing of significant points in the object, which are used by implemented methods to extract the shape, dimensions, etc. and then further process these information. In recent years many advances in Computational Intelligence methods and approaches have been reported. Therefore the question has arisen if these, i.e. heuristics, are applicable to multimedia tracking systems?

This article is to discuss developed heuristic methods for Key-Points tracking and shape extraction. In the following sections of this work developed approaches, in particular a dedicated Cuckoo Search Algorithm and Firefly Algorithm versions, are presented and discussed in comparison to some classical methods to show potential advantages and disadvantages. Benchmark tests and experimental research results are presented to show efficacy and extraction precision on test images.

1. Introduction

Computer Science (CS) involves many aspects of Computational Intelligence (CI) to solve arising problems and develop solutions. CI methods and approaches very often simulate intelligence of nature in their applications in economic and industrial expert systems. One of these applications are in multimedia systems, where it is necessary to find something peculiar in the image or extract some features from the image for further processing.

Feature extraction is crucial for identification of users based on data streams. Cpalka, Zalasinski, and Rutkowski (2016) proposed new algorithm for dynamic handwritten signature analysis based on extraction of some typical aspects of lines that each person does while signing documents. Similarly these objects can be identified by devoted partitioning, where even on-line systems can efficiently extract information from signatures for verification purposes as presented by Cpalka and Zalasinski (2014). Lines and object Key-Points are also important for other extraction purposes, i.e. Meng and He (2016) presented consistent quadrangulation for shape feature line co-extraction, where devoted approach was implemented to assist in shape detection from images. However efficiency of this depends not only on the applied method but also on the image quality. Bera and Sychel (2016) described some improvement for object extraction from blurred images. Similarly hyperspectral images require sophisticated methods to process information and extract important features. Zabalza et al. (2016) presented devoted approach for these images where implemented auto encoder was processing segmented images. Other peculiar methods for feature extraction use i.e. dual-tree complex wavelet transforms as presented by Yang and Yang (2016), where gray-level co-occurrence matrix was used to calculate positions of the objects. However not all types of images can be processed like that. Multispectral Earth observation images present surface of our planet from the distance therefore to extract features it is necessary to apply multi-level systems where objects in the image will be processed for various aspects, this type of comparison is called patched-based classification, i.e. developed by Georgescu, Vaduva, Raducanu, and Datcu (2016). Sometimes classification methods can be tuned for faster processing. Korytkowski, Rutkowski, and Scherer (2016) proposed approach based on fuzzy classifiers to speed up the process of feature comparison. Acceleration of extraction has great importance for video-based tracking, where objects move and in case of low quality equipment the images can

* Corresponding author. Tel.: +48-32-2371341.
E-mail addresses: Marcin.Wozniak@polsl.pl (M. Woźniak), Dawid.Polap@gmail.com (D. Połap), Napoli@dmi.unict.it (C. Napoli), Tramontana@dmi.unict.it (E. Tramontana).

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lose sharpness. Mithun, Howlader, and Rahman (2016) described methodology for vehicles tracking using multiple time-spatial images, which is devoted for video processing. Medicine is one of these fields of science and life, where all developments in automated expertise can find applications the fastest. In medicine various medical examinations are based on images, therefore developments in feature extraction and Key-Points search are very beneficial for medical systems. Gedik (2016) presented multi-resolution approach to extract important features from mammograms. Liu et al. (2016a) described methodology for identification of lesion images from gastrointestinal endoscope. Similarly pathology in internal organs of our bodies can be detected by extraction of information from images. Liu, Jiang, Xia, and Yi (2016b) proposed liver examinations based on multispatial mapping and statistical properties of images.

1.1. Related works

Among CI methods applied to extraction of important features from images heuristic approaches have been reported to show various advances in recent years. Walia and Kapoor (2014) developed intelligent video target tracking method using dedicated Cuckoo Search Algorithm, where heuristic method was used to filter the image from unnecessary information. Wozniak, Polap, Kosmider, Napoli, and Tramontana (2015) presented Cuckoo Search Algorithm (CSA) and Firefly Algorithm (FA) efficiency in medical images processing for extraction of degenerated tissues of lungs from x-ray images. Bhandari, Singh, Kumar, and Singh (2014) developed application of CSA in optimization of satellite image segmentation for multilevel thresholding, while Panda, Agrawal, and Bhuyan (2013) used CSA to edge magnitude. Mishra, Agarwal, Sharma, and Bedi (2014) presented these methods applied to gray-scale image watermarking over DWT SVD data. Heuristic approaches can also help in identification of humans as discussed by Rodrigues, Silva, Papa, Marana, and Yang (2016). Therefore the question has arisen if heuristics are also applicable to multimedia tracking systems?

This paper presents our experimental research results on application of devoted approach based on CSA and FA into a 2D image features extraction. Benchmark tests presented in this article are performed for sample images from open test databases.[1,2] Our results are compared to other conventional methods, the applied heuristic solution emerges as efficient in processing of various pictures. Performed experiments have low complexity, which makes the solution efficient, precise and easy to implement in comparison to classic methods.

2. 2D Image Key-Points search methods

A computer image is a composition of points (pixels). Each pixel $\mathbf{x_i}$ in the image $\mathcal{I}$ has measurable components of spatial coordinates $x_{i,k}$, where i is the number of the pixel and $k = 1, 2$, as in the image $\mathcal{I}$ there are two coordinates representing axes (see Fig. 1). In the proposed system, 2D images are input objects. Therefore points $\mathbf{x_i} \in \mathcal{I}$ are defined in two notations $\mathbf{x_i} = (x, y)$ and $\mathbf{x_i} = (x, y) = (x_{i,1}, x_{i,2})$, as in the following sections both will be used to simplify the outlook of given equations.

Some pixels have special positions and properties like saturation, sharpness, brightness and more. All such properties define objects visible to our eyes. The position of each pixel, its brightness and saturation are crucial for the recognition process. In other words, to find the object in the picture we can search for areas that contain many important points of the same kind. They compose the object shape, which can be recognized by dedicated systems. Applied Bio-Inspired Methodology (BIM) will help to extract the most important shape features to help in this process. Let first definitions be given.

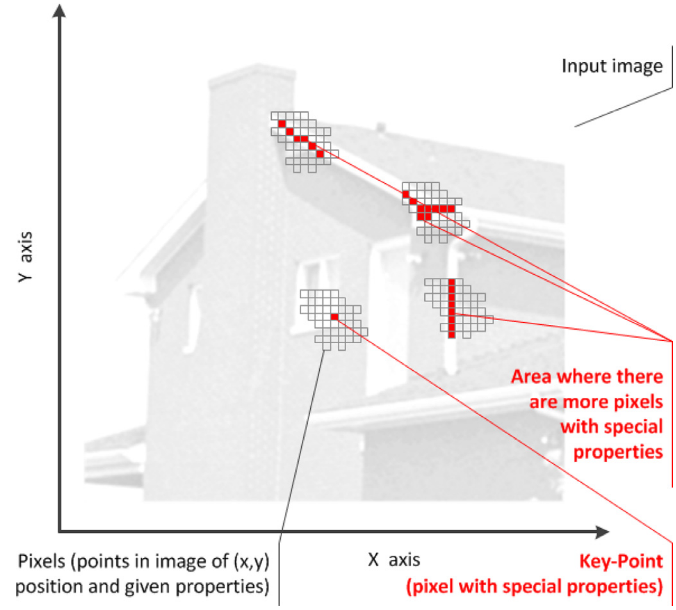

Fig. 1. Schematic *Key-Point* positions in a 2D input image.

Definition 1. *Key-Point* is a pixel in a 2D input image, which has peculiar properties making it important for shape extraction and recognition.

Definition 2. *Key-Area* is an area containing many *Key-Points* that all together give information about the object.

In the following sections a possible implementation of CSA with an ad-hoc filtering to find areas representing shapes is discussed. The presented novel solution is not only efficient but also easy to implement. Research results show the efficacy of the proposed solution if compared to classic image processing methods.

2.1. SURF - classic attempt

One of the classic methods used for recognition is SURF (Speeded-Up Robust Features) algorithm. This method describes the input image by selecting *Key-Points*. Abeles (2013) proposed a simplified, seeded-up SURF for classification purposes. For the experimental research we have modeled it using a simplified selection of *Key-Points* consisted in calculating a 64-element vector (descriptor) with an applied integrated image filter approximation of block Hessian determinant in order to detect the points of interest was discussed. Simplified SURF algorithm defines Hessian matrix $H(\mathbf{x_i}, \sigma)$ for point $\mathbf{x_i} = (x, y) \in \mathcal{I}$ at scale σ as

$$H(\mathbf{x_i}, \sigma) = \begin{bmatrix} L_{xx}(\mathbf{x_i}, \sigma) & L_{xy}(\mathbf{x_i}, \sigma) \\ L_{xy}(\mathbf{x_i}, \sigma) & L_{yy}(\mathbf{x_i}, \sigma) \end{bmatrix}, \tag{1}$$

where the notations are: $L_{xx}(\mathbf{x_i}, \sigma)$ – convolution of Gaussian second order derivative ∂^2_{xx}. Applied approximation uses partial derivatives D_{xx}, D_{yy} and D_{xy} calculated for each candidate *Key-Point* $\mathbf{x_i} \in \mathcal{I}$ as

$$H_{approx} = D_{xx}D_{yy} - \left(\frac{|L_{xy}(\sigma)|_F |D_{xx}(\sigma)|_F}{|L_{xx}(\sigma)|_F |D_{xy}(\sigma)|_F} D_{xy} \right)^2. \tag{2}$$

Then, an input image $\mathcal{I}$ is blurred to get DoG (Difference of Gaussian) images and to localize interesting points in non-maximum

[1] www.imageprocessingplace.com.
[2] www.ece.utk.edu/gonzalez/ipweb2e/downloads/.