Proceedings of the Federated Conference on Computer Science and Information Systems pp. 849–852
DOI: 10.15439/2016F143
ACSIS, Vol. 8. ISSN 2300-5963

# Toward adaptive heuristic video frames capturing and correction in real-time

Marcin Woźniak*, Dawid Połap*, Giacomo Capizzi‡, Grazia Lo Sciuto‡§
*Institute of Mathematics, Silesian University of Technology, Kaszubska 23, 44-100 Gliwice, Poland
Email: marcin.wozniak@polsl.pl, dawid.polap@gmail.com
‡Department of Electrical and Informatics Engineering, University of Catania, Viale A. Doria 6, 95125 Catania, Italy
Email: capizzi@dieei.unict.it
§Department of Electronic Engineering, University of Roma Tre, Via della Vasca Navale 84, 00146 Roma, Italy
Email: glosciuto@dii.unict.it

***Abstract*—Multimedia devices are widely used in professional applications as well as personal purposes. The use of computer vision systems enables detection and extraction of important features exposed in images. However constantly increasing demand for this type of video with high quality requires simple however reliable methods. The objective of presented research is to investigate applicability of heuristic method for real-time video frames capturing and correction.**

***Index Terms*—Video Stream Correction, Real-time Processing, Heuristic Method.**

## I. Introduction

MULTIMEDIA devices are widely used in professional applications as well as personal purposes. We can find cameras applied in security systems present in CCTV (Closed Circuit TeleVision) applications where several cameras are detecting motion to supervise it against criminal actions and unlawful activities. Various types of these are used in financial institutions like banks, airports and any other railway/bus stations, sport stadiums and culture institutions like cinemas, theaters and concert places. Similarly to these, video recording is very useful for houses and car-parks where we use vision systems to prevent robbery. Recent years have also shown that modern video technologies with their various multimedia applications are also supported by international and national organizations and authorities which are exploring possibilities of implementations of computer aided analysis in order to assist i.e. law officers on duty. For these reasons it is paramount to develop automated systems that can actively improve precision of capturing in real time in various conditions, lightening and other factors that can actively influence CCTV.

Therefore in this article we want to discuss a new tracking model for image capturing, where dedicated version of heuristic attempt is applied to assist in detecting proper camera orientation in real time. Research presented in this work tend to move toward development of such a model.

### A. Related Works

Image capturing and feature extraction efficiency in multimedia applications have been investigated in various research projects. Pope and Lowe proposed probabilistic approach to the problem of various 3-D object recognition [1], while Grycuk et al. proposed approach to use SURF for video key features detection for following frames [2]. With development in technology it became possible to evaluate more features with higher precision. Drozda et al. presented proposition of different orderings for visual sequences alignment implemented as algorithms for image classification [3]. Knop et al. discussed improvements in application of neural methods into video compression based on dedicated scene change detection algorithm [4], while Capizzi et al. proposed novel attempt to process images of oranges to be classified by proposed neural network architecture [5], Stateczny et al. discussed application of intelligent methods for image processing in batymetric systems [6]. Intelligent methods are also widely adapted into detection processes: Starzyk developed visual saccades for object recognition [7], Pabiasz et al. proposed three–dimensional facial landmarks recognition [8] and novel approach to 3D face images processing [9]. Similarly heuristic methods, as newly developed algorithms inspired by nature, gave new possibilities to multimedia streaming aspects. Panda et al. developed edge magnitude solution, where classic heuristic approach based on Cuckoo Search Algorithm was implemented to search over multilevel thresholding [10]. Mishra et al. proposed heuristic attempt to watermarking on gray-scale images by application of Firefly Algorithm [11]. Heuristic methods are extensively examined in recent years, and various new or hybrid methods are developed for multimedia applications in detection and image capturing systems. Woźniak and Połap presented extensive comparison of efficiency in key-points extraction between developed Cuckoo Search Algorithm and classic methods like SIFT and SURF [2], [12]. Similarly Firefly Algorithm application was proposed by Woźniak and Marszałek [13]. Walendzik et al. reported development in gaming technologies for automatically generated evaluation [14] and Swiechowski et al. discussed self adapting strategies to gaming reality [15]. Decision making systems widely use adaptive strategies to simulate intelligent data streaming processing as reported by Rutkowski et al. [16].

Multimedia processing by possible applications of various methods of Computational Intelligence started important trend in nowadays technology. Multimedia storing systems are aplied to manage visual information [17]. Korytkowski et al.

proposed boosted fuzzy classifiers for captured images [18].

In this article we propose novel approach to implement heuristic method to work as real-time detector for cameras and vision systems.

## II. Proposed Frame Processing Technique

Computational Intelligence (CI) methods widely use various soft computing techniques for detection and extraction of features. One of these processes is frame capturing. It is non-trivial to preform this operation in real-time along with correction of quality. Proposed in this article technique is based on application of CI method, in particular dedicated versions of bio-inspired heuristic approach, as a dedicated solution to improve vision tracking in CCTV systems or any image recognition systems that use this or similar type of vision capturing.

In this type of bio-inspired simulation approach we can adapt birds, fish or any other species which together as a cluster behave in a very specific way. The population adapts to given initial conditions of the environment following to the destination. This type type of behavior is very useful in various applications, i.e. where we want to search object space for specific features.

### A. Ad-hoc Filtering Method

Before application of heuristic detection we need to extract features from video frames. These features will serve as objects, which will be traced along rotation of the camera. To extract features we have applied simplified filtering method, which is run ad-hoc to filter video frames and extract objects to be forwarded to heuristic tracking method. In proposed filtering we introduce evaluation of the luminosity to extract edges of the traced objects. Extraction leaves pixels of high luminosity which extract shapes as bright pixels over dark background. We simply approximate both dimensions of the luminance gradient along exes of the video frame.

*1) Applied Operator:* Extraction of objects is based on idea to use directional differential operator $\vec{\nabla}$ on brightness $\phi$ as:

$$\vec{\nabla}\phi \cdot d\mathbf{x_i} = [\partial_1\phi, \partial_2\phi] \cdot [dx_{i,1}, dx_{i,2}], \quad (1)$$

where partial derivatives $\partial_1\phi$ and $\partial_2\phi$ are computed for video frame points $\mathbf{x_i}$ according to each coordinate.

Proposed ad-hoc frame filtering is using luminance intensity matrix $L$ to compute function

$$\begin{cases} \tilde{\phi}(\mathbf{x_i}) = \sqrt{\sum_{k=1}^{2} \phi_k^2(\mathbf{x_i})} \\ \phi_k(\mathbf{x_i}) = \sum_{m,n=1}^{3} \max_{k=1,2} (M_{mn}^k \cdot L(x_{i,1}+m-2, x_{i,2}+n-2)) \end{cases} \quad (2)$$

as convolution of matrices

$$\begin{cases} M^1 = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix} \\ M^2 = \begin{pmatrix} -1 & 0 & -1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \end{cases} . \quad (3)$$

Matrix $M^1$ is applied for vertical extraction and matrix $M^2$ is applied for horizontal extraction, however application of $\max_{k=1,2}(\cdot)$ returns only highest convolution value to the output bit of video frame points $\mathbf{x_i}$ to enable faster shape features extraction. Composed in this way filtered frame is forwarded to applied heuristic method for tacking.

### B. Proposed Bio-Inspired Heuristic Approach

The main idea of bio-inspired heuristic approach is to simulate entire population of mapped organisms into implemented algorithm. During iterations we assume that individuals can exchange information to find destination. This make the implemented population act similarly to swarms of fish, birds or other species. This assumptions are composed into mathematical model, where destination of the swarm in each iteration is the object traced by the CCTV camera. The algorithm is implemented to search the following video frames for destination objects by matching trajectories of individuals (particles) and therefore trace the object in real-time. Each of individuals is a vector of coordinates that move along the rotation of the camera tracing the object.

Movement of tracing individuals is based on stochastic and deterministic approach, where we combine random walk toward optimum with deterministic distance between particles. The knowledge about traced object is updated in each iteration according to positions of particles that correctly detected traced object. This information serves as a staring location for further iteration, where particles compare new situation to previous frame and follow the best situated individual to the destination.

*1) Applied Model:* To keep the randomness of movements along with so called "communications between particles" we introduce deterministic and random factors along with the following assumptions:

- Tracing points are moving along the captured video frames in search of the object,
- Each individual is referring to it previous position while tracing the object,
- At the end of each iteration, all the individuals exchange information,
- Number of tracing individuals is constant.

Each tracing individual position is denoted as $\mathbf{x}_i^t$ whose $i$ components correspond to dimensions of the video frame and $t$ is iteration in the algorithm. Move is denoted as $\mathbf{m}_i^t$ with appropriate symbols for each iteration $t$ according to the formula:

$$\mathbf{m}_i^{t+1} = \mathbf{m}_i^t + \alpha \cdot \epsilon_1 \cdot [g_*^{t-1} - f(\mathbf{x}_i^t)] + \beta \cdot \epsilon_2 \cdot [\mathbf{x}_*^t - \mathbf{x}_i^t], \quad (4)$$

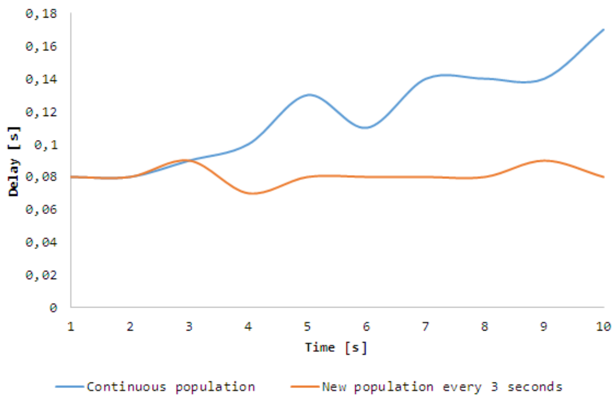


Fig. 1. Image capturing process in real-time improvements in two examined solutions: blue line for continuous usage of the same population of $tracing\_individuals$, orange line for new population of $tracing\_individuals$ introduce in each 3 sec.

where the symbols are: $\mathbf{m}_i^t$ – tracing move of $i$ individual in $t$ iteration, $\alpha$ – optimum value memory factor, $\beta$ – optimum individual position memory factor, $\epsilon_1, \epsilon_2 \in [0,1]$ – random values, $g_*^t$ – previous position of the tracing individual at the frame in $t-1$ iteration, $f(\mathbf{x}_i^t)$ – present position of the tracing individual at the frame in $t$ iteration, $\mathbf{x}_*^t$ – position of best situated individual in $t$ iteration, $\mathbf{x}_i^t$ – position of tracing individual $i$ in $t$ iteration.

For that modeled trace move we perform movements of all tracing individuals using formula:

$$\mathbf{x}_i^{t+1} = \mathbf{x}_i^t + (-1)^K \cdot \mathbf{m}_i^t, \quad (5)$$

where the symbols are: $\mathbf{x}_i^t$ – position of tracing individual $i$ in $t$ iteration, $\mathbf{m}_i^t$ – trace move $i$ particle in $t$ iteration according to (4), $K$–random factor applied to randomize direction of movements.

Equations (4) and (5) allow trafing of objects in real-time using implementation of the proposed Algorithm 1. To start tracing we place initial population of individuals at random over first video frame. While camera is rotating along the axis implemented However, to improve tracing abilities we can also apply some boundary criteria to enable additional movements control.

## III. Experimental Results

In the experimental tests we have applied two sample video streams. First was captured at one of polish parks. Second was captured in egyptian pyramid. The task for proposed system was to follow rotation of the camera to trace the object in real-time and therefore improve quality of video recording. Based on tests, the maximum displacement of particles between two frames has been appointed as 5 pixels. With this value, the amount of calculations in the proposed algorithm is significantly minimized - in the last stages of the algorithm only circles of radius equal to 5 are analyzed. Results of proposed real-time heuristic tracking are presented in Fig. 2. Chart of the delay for both solutions is presented in Fig. 1.

**Algorithm 1** Heuristic Approach to Video Frames Processing in Real-Time

```
Define coefficients: α – memory factor, β – position memory factor, generation – number of iterations, tracing_individuals – number of individuals in swarm,
while video frames are captured from rotating CCTV camera do
  Capture 2 following video frames with a delay of 1 sec,
  Perform Ad-hoc Filtering Algorithm on each of them,
  Start tracing using first video frame,
  Create at random initial population,
  t:=0,
  while t ≤ generations do
    Move tracing_individuals according to (5) and (4),
    Sort tracing_individuals according to brightness,
    Evaluate tracing_individuals and take best_ratio of them to next generation,
    Rest of tracing_individuals take at random,
    Next generation: t++,
  end while
  Place tracing_individuals from last generation over second filtered video frame,
  Divide this frame into 4 parts,
  Take this part where we have highest concentration of tracing_individuals,
  for −5 ≤ α ≤ 5 do
    for −5 ≤ β ≤ 5 do
      Move tracing_individuals using correction (α, β),
      Calculate percentage of all points whose adaptation is the same as for the first frame,
      Save point for which the percentage is highest,
      β++,
    end for
    α++,
  end for
  Determine the direction on the basis of selected point.
end while
```

### A. Conclusions

In the experimental tests we have compared two attempts for proposed solution: to continue heuristic processing using only one population of $tracing\_individuals$ and to change population in each 3 seconds. Comparing results of benchmark tests we can see that introduction of new population in regular intervals can increase efficiency of the real-time processing. Chart presented in Fig. 1 show relation of delay between two compared solutions. With increasing time of video processing newly introduced population tends to reduce delay what influence efficiency of tracking, therefore proposed processing becomes faster and even more adapted for CCTV real-time video systems.

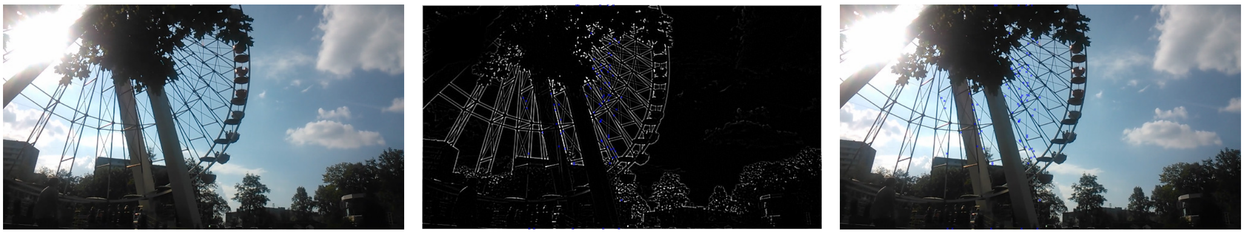

Fig. 2. Image capturing process of wheel in in real-time improvements. From left to right: original frame, filtered with heuristic points, original with heuristic points.

## IV. Final Remarks

Proposed solution enabled us to obtain the direction of camera movement at the time of recording. The proposed method uses heuristic processing and ad-hoc filtering. Due to simple implementation and low number of operations it is possible to perform it all in real-time during video recording, when CCTV system is already loaded. The results, i.e. the average delay is constant over time, allow for practical use in various applications such as sport equipment or systems of the virtual view. Moreover, such a solution in conjunction with the navigation system GPS can create real guidance system.

In future work, it is planned to reduce the calculations and the inclusion of additional factors such as navigation system in order to create an easy-to-use solutions for a variety of purposes.

## Acknowledgment

Authors acknowledge contribution to this project of Operational Programme: Knowledge, Education, Development financed by the European Social Fund under grant application POWR.03.03.00-00-P001/15.

## References

[1] A. Pope and D. Lowe, "Probabilistic models of appearance for 3-d object recognition," *International Journal of Computer Vision*, vol. 40, no. 2, pp. 149–167, 1998.

[2] R. Grycuk, M. Knop, and S. Mandal, "Video key frame detection based on SURF algorithm," *Lecture Notes in Artificial Intelligence - ICAISC'2015*, vol. 9119, pp. 566–576, 2015, DOI: 10.1007/978-3-319-19324-3.

[3] P. Drozda, K. Sopyla, and P. Górecki, "Different orderings and visual sequence alignment algorithms for image classification," *Lecture Notes in Artificial Intelligence - ICAISC'2014*, vol. 8467, pp. 693–702, 2014, DOI: 10.1007/978-3-319-07173-2.

[4] M. Knop, T. Kapuscinski, W. K. Mleczko, and R. A. Angryk, "Neural video compression based on RBM scene change detection algorithm," *Lecture Notes in Artificial Intelligence - ICAISC'2016*, vol. 9693, pp. 660–669, 2016, DOI: 10.1007/978-3-319-39384-1_58.

[5] G. Capizzi, G. Lo Sciuto, C. Napoli, E. Tramontana, and M. Woźniak, "Automatic classification of the fruit defects based on co-occurrence matrix and neural networks," in *Proceedings of the Federated Conference on Computer Science and Information Systems - FedCSIS'2015*. 13-16 September, Lodz, Poland: IEEE, 2015, pp. 861–867, DOI: 10.15439/2015F258.

[6] A. Stateczny, M. Wlodarczyk-Sielicka, and G. Zaniewicz, "Different orderings and visual sequence alignment algorithms for image classification," *Annual of Navigation*, vol. 19, no. 2, pp. 99–108, 2012, DOI: 10.2478/v10367-012-0020-x.

[7] J. A. Starzyk, "Visual saccades for object recognition," *Lecture Notes in Artificial Intelligence - ICAISC'2015*, vol. 9119, pp. 778–788, 2015, dOI: 10.1007/978-3-319-19324-3_70.

[8] S. Pabiasz, J. T. Starczewski, and A. Marvuglia, "A new three-dimensional facial landmarks in recognition," *Lecture Notes in Artificial Intelligence - ICAISC'2014*, vol. 8468, pp. 179–186, 2014, DOI: 10.1007/978-3-319-07176-3_16.

[9] S. Pabiasz, J. T. Starczewski, and A. Marvuglia, "SOM vs FCM vs PCA in 3d face recognition," *Lecture Notes in Artificial Intelligence - ICAISC'2015*, vol. 9120, pp. 120–129, 2015, DOI: 10.1007/978-3-319-19369-4_12.

[10] R. Panda, S. Agrawal, and S. Bhuyan, "Edge magnitude based multilevel thresholding using cuckoo search technique," *Expert Systems with Applications*, vol. 40, no. 18, pp. 7617–7628, 2013.

[11] A. Mishra, C. Agarwal, A. Sharma, and P. Bedi, "Optimized grayscale image watermarking using dwt svd and firefly algorithm," *Expert Systems with Applications*, vol. 41, no. 17, pp. 7858–7867, 2014.

[12] M. Woźniak and D. Połap, "Basic concept of cuckoo search algorithm for 2D images processing with some research results : An idea to apply cuckoo search algorithm in 2d images key-points search," in *SIGMAP 2014 - Proceedings of the 11th International Conference on Signal Processing and Multimedia Applications, Part of ICETE 2014 - 11th International Joint Conference on e-Business and Telecommunications*. 28-30 August, Vienna, Austria: SciTePress, 2014, pp. 157–164, DOI: 10.5220/0005015801570164.

[13] M. Woźniak and Z. Marszałek, "An idea to apply firefly algorithm in 2D images key-points search," *Communications in Computer and Information Science - ICIST'2014*, vol. 465, pp. 312–323, 2014, DOI: 10.1007/978-3-319-11958-8_25.

[14] K. Waledzik and J. Mandziuk, "An automatically generated evaluation function in general game playing," *IEEE Trans. Comput. Intellig. and AI in Games*, vol. 6, no. 3, pp. 258–270, 2014, DOI: 10.1109/TCIAIG.2013.2286825.

[15] M. Swiechowski and J. Mandziuk, "Self-adaptation of playing strategies in general game playing," *IEEE Trans. Comput. Intellig. and AI in Games*, vol. 6, no. 4, pp. 367–381, 2014, DOI: 10.1109/TCIAIG.2013.2275163.

[16] L. Rutkowski, M. Jaworski, L. Pietruczuk, and P. Duda, "A new method for data stream mining based on the misclassification error," *IEEE Trans. Neural Netw. Learning Syst.*, vol. 26, no. 5, pp. 1048–1059, 2015, DOI: 10.1109/TNNLS.2014.2333557.

[17] R. Grycuk, M. Gabryel, R. Scherer, and S. Voloshynovskiy, "Multi-layer architecture for storing visual data based on WCF and microsoft SQL server database," 2015, pp. 715–726, DOI: 10.1007/978-3-319-19324-3_64.

[18] M. Korytkowski, L. Rutkowski, and R. Scherer, "Fast image classification by boosting fuzzy classifiers," *Information Sciences*, vol. 327, pp. 175–182, 2016, DOI: 10.1016/j.ins.2015.08.030.