CAPTURING DIRECTION OF VIDEO CAMERA IN REAL-TIME BY THE USE OF HEURISTIC ALGORITHM

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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.

Video frames captured with a digital camera, are evaluated and corrected to increase quality of video stream in real-time. Developed technique is very robust and can assist even in specific conditions when camera is in front to light source tracking objects. Therefore proposed method can be widely applicable in various multimedia systems.

Keywords: Video Stream Correction, Real-time Processing, Heuristic Method.

1. 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. However quality of video recordings from all these systems depend on several features

connected with visibility, weather conditions, lightening, accurate tracking and camera definition. Unfortunately, while video recording of the crowd is a powerful source ofreliable information these to be properly analyzed must be of good quality. 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. An appropriate   automatic tool should: (i) be able to automatically extract data record, (ii) integrate the missing information by interpolation, (iii) reach a sufficient generalization degree, (iv) constitute a robust approach due to a low sensibility to data noise, (v) associate the raw data to the related knowledge and (vi) discover relations among different data.

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, satisfying the above requirements. Proposed developed approach is based on some important features that if properly analyzed can improve quality of capturing independently of surrounding conditions in order to more efficiently assist detection of potential offenders involved in unlawful activities or just simply to any related to different people and areas captured video time-frames of location sites.

1.1. *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 [Pope (1998)], while Nelson and Selinger presented interesting large-scale tests for various models of these systems [Nelson (1988)]. With development in technology it became possible to evaluate more features with higher precision. Se et al. presented proposition of extraction of objects using global feature model for distinctive objects [Lowe (2002)]. Along with comprehensive analysis of possible aspects of possibilities to use various models for image processing presented by Parker [Parker (2010)] new applications techniques appeared. Wen and Tao proposed dedicated vision system, which is able to conduct an automatic apple defect inspection [Wen (2000)], while Capizzi et al. proposed novel attempt to process images of oranges to be classified by proposed neural network architecture [Capizzi (2016)]. Similarly heuristic methods, as newly developed algorithms inspired by nature, gave new possibilities to multimedia streaming aspects. Baonabeau et al. proposed modeling of nature inspired systems into computation techniques what gave an impact to develop various implementations [Baonabeau (1999)]. Panda et al. developed edge magnitude solution, where classic heuristic approach based on Cuckoo Search Algorithm was implemented to search over multilevel thresholding [Panda (2013)]. Mishra et al. proposed heuristic attempt to watermarking on gray-scale images by application of Firefly Algorithm [Mishra (2014)]. 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. Polkowski and Artiemiew proposed various methods to classify data from objects using rough approach [Polkowski and Artiemiew (2015)]. Similarly Artiemiew discussed this methodology for decision based on visual words [Artiemiew et. Al (2012)]. Walendzik et al. reported development in gaming technologies for automatically generated evaluation [Waledzik (2014)] and Swiechowski et al. discussed self-adapting strategies to gaming reality [Swiechowski (2014)]. Decision making systems widely use adaptive strategies to simulate intelligent data streaming processing as reported by Rutkowski et al. [Rutkowski (2015)] and extensive deep processing structures based on Gaussian approximation [Rutkowski (2014)]. Where for all these types of data processing devoted computer programming techniques are important to increase performance. Sulir et al. presented devoted concerns based methodology [Sulir (2016)], while Nosál et al. proposed code annotations for programming languages [Nosál(2016].

Multimedia processing by possible applications of various methods of Computational Intelligence started important trend in nowadays technology. Multimedia storing systems are applied to manage visual information [Grycuk (2015)].Korytkowski et al. proposed boosted fuzzy classifiers for captured images [Korytkowski (2016)]. Finally Walia and Kapoor developed solution to track video targets [Walia (2014)], while in this article we propose novel approach to implement heuristic method to work as real-time detector for cameras and vision systems.Burdescu et al. proposed a technique devoted to planar color models where images are processed for extraction of important features [Burdescu (2016)] which was further improved for multimedia used to implement efficient systems of detection of visual objects [Burdescu (2017)].

2. 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 perform 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.

Kennedy and Eberhard have shown idea to simulate behavior of groups of organisms into optimization purposes [Kennedy (1995)]. 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 of behavior is very useful in various applications, i.e. where we want to search object space for specific features. Hu et al. presented this type of simulation where multi levels of adaptation were applied to simulate various
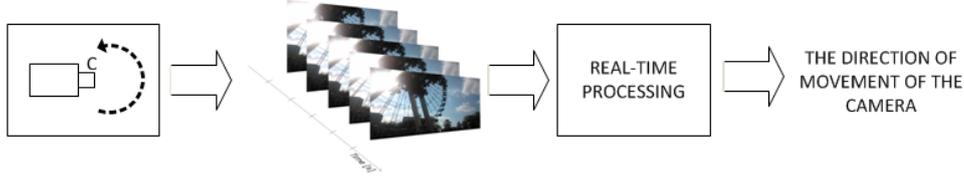
Fig. 2. Frame processing in the system: while camera is rotating following video frames are being processed using implemented ad-hoc filtering with heuristic approach to trace objects along the movement in real-time.

sophisticated conditions [Hu (2013)]. Yang and Koziel presented wide catalog of engineering systems where heuristic methods were used to optimize and simulate [Koziel (2011)], [Yang (2010)]. Bansal and Deep have shown that swarms are applicable in overcurrent relay times positioning [Bansal (2008)], Clerc and Kennedy [Clerc (2002)] presented modeling devoted to stabilization and fast convergence what was also presented by Gazi and Passino in extended theoretical model [Gazi (2011)].

2.1. *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.

3.1.1. *Applied Operator*

Extraction of objects is based on idea to use directional differential operator $\vec{\nabla}$ on brightness φ as:

$$\vec{\nabla} \cdot dx_i = [\partial_1 \varphi, \partial_2 \varphi] \cdot [dx_{i,1}, dx_{i,2}] \tag{1}$$

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

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

$$\begin{cases} \breve{\varphi}(x_i) = \sqrt{\sum_{k=1}^{2} \varphi_k^2(x_i)} \\ \varphi_k(x_i) = \sum_{m,n=1}^{3} \max_{k=1,2}(M_{mn}^k L(x_{i,1} + m - 2, x_{i,2} + n - 2)) \end{cases} \tag{2}$$

as convolution of matrices

$$M^1 = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix} \tag{3}$$

$$M^2 = \begin{pmatrix} -1 & 0 & -1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} \tag{4}$$

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 x_i to enable faster shape features extraction. Composed in this way filtered frame is forwarded to applied heuristic method for tacking. Algorithm 1 presents ad-hoc filtering.

2.2. *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.

3.1.1. *Applied Operator*

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.

```
1:  Import captured video frame luminance intensity matrix
    L,
2:  Calculate number of pixels xᵢ ∈ L,
3:  while n ≤ rows do
4:      while m ≤ columns do
5:          Calculate filtering operators φₖ(xᵢ) from (2) using
            matrices (3),
6:          Φ[m][n] = ccmv(L[m][n]),
            # ccmv is color channels mean value
7:          Calculate φ(xᵢ) on Φ[m][n] as Φ̃[m][n] using (2),
8:          if Φ̃[m][n] > φ(xᵢ) then
9:              Save Φ̃[m][n] as filtered frame point x̃ᵢ,
10:         else
11:             Save φ̃(xᵢ) as filtered frame point x̃ᵢ,
12:         end if
13:     end while
14: end while
15: Save all filtered frame points x̃ᵢ as output gray scale
    filtered video frame.
```

Algorithm 1. Ad-hoc Filtering Algorithm.

Each tracing individual position is denoted as x_i^t whose i components correspond to dimensions of the video frame and t is iteration in the algorithm. Move is denoted as m_i^t with appropriate symbols for each iteration t according to the formula:

$$m_i^{t+1} = m_i^t + \alpha\epsilon_1[g_*^{t-1} - f(x_i^t)] + \beta\epsilon_2[x_*^t - x_i^t] \tag{5}$$

where the symbols are: m_i^t -- tracing move of i individual in t iteration, α-- optimum value memory factor, β-- 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, $f(x_1^t)$ -- present position of the tracing individual at the frame in t iteration, x_*^t-- position of best situated individual in t iteration, 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:

$$x_i^{t+1} = x_i^t + (-1)^K m_i^t, \tag{6}$$

where the symbols are: x_i^t -- position of tracing individual i in t iteration, m_i^t -- trace move i particle in t iteration according to Eq. (4), K --random factor applied to randomize direction of movements.

Eq. (4) and Eq. (5) allow tracing of objects in real-time using implementation of the proposed Algorithm 2. Fig. 1 presents schematic operation in the system. To start tracing we place initial population of individuals at random over first video frame. While camera

1: Define coefficients: α – memory factor, β – position memory factor, *generation* – number of iterations, *tracing_individuals* – number of individuals in swarm,

2: **while** video frames are captured from rotating CCTV camera **do**

3:    Capture 2 following video frames with a delay of 1 sec,

4:    Perform Ad-hoc Filtering Algorithm 1 on each of them,

5:    Start tracing using first video frame,

6:    Create at random initial population,

7:    t=0,

8:    **while** $t \leq generations$ **do**

9:      Move *tracing_individuals* according to (5) and (4),

10:      Sort *tracing_individuals* according to brightness,

11:      Evaluate *tracing_individuals* and take *best_ratio* of them to next *generation*,

12:      Rest of *tracing_individuals* take at random,

13:      Next *generation*: $t++$,

14:    **end while**

15:    Place *tracing_individuals* from last *generation* over second filtered video frame,

16:    Divide this frame into 4 parts,

17:    Take this part where we have highest concentration of *tracing_individuals*,

18:    **for** $-5 \leq \alpha \leq 5$ **do**

19:      **for** $-5 \leq \beta \leq 5$ **do**

20:        Move *tracing_individuals* using correction (α, β),

21:        Calculate percentage of all points whose adaptation is the same as for the first frame,

22:        Save point for which the percentage is highest,

23:        $\beta++$,

24:      **end for**

25:      $\alpha++$,

26:    **end for**

27:    Determine the direction on the basis of selected point.

28: **end while**

Algorithm 2. Heuristic Approach to Video Frames Processing in Real-Time.

is rotating along the axis implemented However, to improve tracing abilities we can also apply some boundary criteria to enable additional movements control.

3. Experimental Results

In the experimental tests we have applied two sample video streams, and implemented procedures using C# in MS Visual Studio 2013. 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 5pixels. 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 5are analyzed. Results of proposed real-time heuristic tracking are presented in Fig. 3 - Fig. 6. Statics of conducted experiments are presented in Tab. 1. Chart of the delay for both solutions is presented in Fig. 2.

Table 1. Sample tracing results.

| Avg. number of *tracing_individuals*	Iterations	Avg. delay	Avg. delay with new population
45	1	0,08	0,08
44	2	0,08	0,08
43	3	0,09	0,09
43	4	0,1	0,07
42	5	0,13	0,08
42	6	0,11	0,08
42	7	0,14	0,08
42	8	0,14	0,08
42	9	0,14	0,09
42	10	0,17	0,08
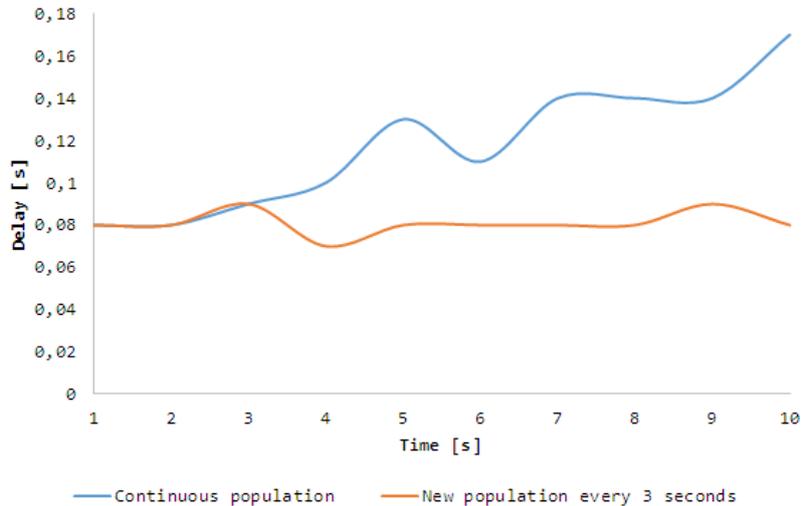
Fig. 2. Image capturing process in real-time improvements in two examined solutions: blue line for continuous usage of the same population of *tracing_individuals*, orange line for new population of *tracing_individuals* introduce in each 3 sec.
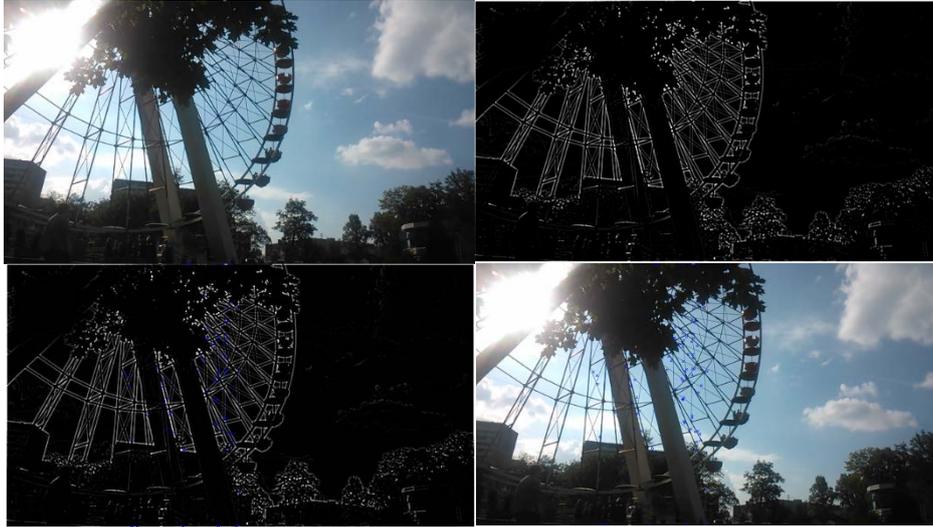
Fig. 3. Image capturing process of wheel in real-time improvements. From left to right and top to bottom: original frame, filtered, filtered with heuristic points, original with heuristic points.
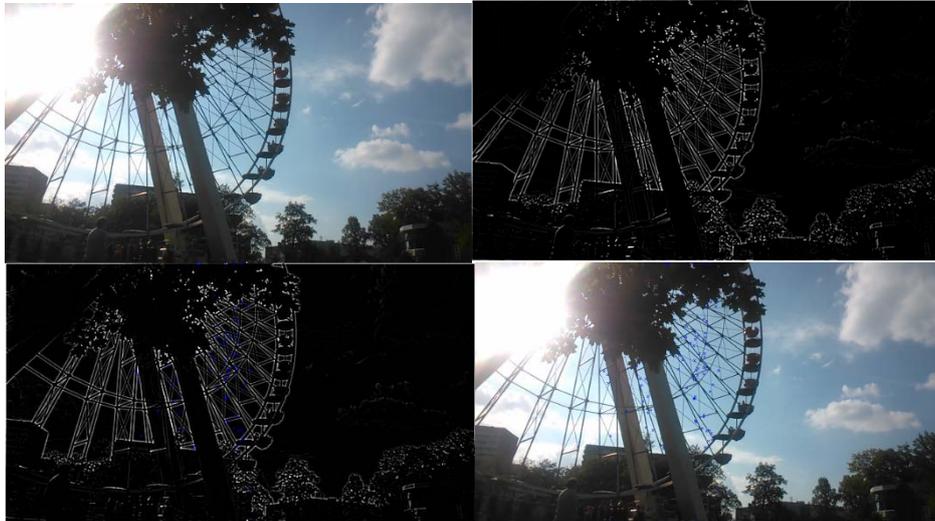

Fig. 4. Image capturing process of wheel in real-time improvements. From left to right and top to bottom: original frame, filtered, filtered with heuristic points, original with heuristic points.

Fig. 5. Image capturing process in real-time improvements. From left to right and top to bottom: original frame, filtered, filtered with heuristic points, original with heuristic points.

Fig. 6. Image capturing process in real-time improvements. From left to right and top to bottom: original frame, filtered, filtered with heuristic points, original with heuristic points.

4. 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. 2 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.

5. 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.

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