CONTRIBUTIONS TO THE SEGMENTATION OF MOVING OBJECTS IN VIDEO SEQUENCES

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Motivation of the work

Unsupervised segmentation of moving objects in video sequences, by **background subtraction (BS):**

- fundamental step in many vision systems and critical factor for the success of the overall system,
- **hard and challenging task**.

Complex and challenging scenarios include poor lighting conditions, sudden illumination changes, nighttime videos, shadows, parasitic background motion, ...

State-of-the-art methods [1]:

- no method has been able to fully deal with all challenges,
- most widely used methods build a statistical model of background pixels [2],
- methods appear to be complementary in nature [3],
- better performance usually at the cost of significant increase in complexity and computational load.

Comparison of methods:

- most datasets do not contain a balanced set of videos presenting real challenges,
- hard or impossible to compare results computed on different datasets,
- metrics used to evaluate only average performance do not reveal performance frame by frame.

Thesis Objectives

In this PhD research we want to further explore some of the most efficient approaches to propose a more robust algorithm.

Research Question:

Is it possible to improve widely used approaches, such as GMM, by proposing more robust algorithms while keeping complexity low?

Can this method be further improved in order to cope with more difficult cases, such as nighttime videos, even if sacrificing the complexity?

Research Plan

1st Year

- ✓ State-of-the-art literature review.
- ✓ Development of a new scheme exploiting two different approaches: a bio-inspired motion detection method and a BS algorithm based on color information.
- ✓ Review of objective segmentation evaluation methods in order to identify different metrics that could be used in this context [7].

2nd Year

- ✓ Exploration of the discrimination capability of different color spaces in the context of a GMM-based algorithm.
- ✓ Development of a robust and computationally efficient method, based on GMM [6], suitable for real-time applications.
- ✓ Development of a new approach to model the local texture at the pixel neighborhood.
- ✓ Proposal of a new method, based on a combination of local texture and pixel color representations, to address the problem of moving objects segmentation in night videos.

3rd Year

- ✓ **Preparation, submission and publication of a paper in an international journal**
- ✓ **Writing of the PhD dissertation**

4th Year

Next Year Planning

- **Thesis conclusion and submission (Oct/2018)**
- **PhD defense**

Publications & International Conferences Presentations

- Martins, I., Carvalho, P., Corte-Real, L., Alba-Castro, J.L. (2016) ***Bio-inspired Boosting for Moving Objects Segmentation***. In: A. Campilho, F. Karray (eds) Image Analysis and Recognition. ICIAR 2016. Lecture Notes in Computer Science, vol. 9730, pp. 397-406, Springer, Cham.
  - ➢ **Oral presentation** at ICIAR 2016, July 13-15, 2016, Póvoa de Varzim, Portugal.
- Martins, I., Carvalho, P., Corte-Real, L., Alba-Castro, J.L. (2017) ***BMOG: Boosted Gaussian Mixture Model with Controlled Complexity***. In: L. A. Alexandre, J. S. Sánchez, J. M. F. Rodrigues (eds) Pattern Recognition and Image Analysis. IbPRIA 2017. Lecture Notes in Computer Science, vol. 10255, pp. 50-57, Springer Int. Publishing.
  - ➢ **Oral presentation** at IbPRIA 2017, June 20-23, 2017, Faro, Portugal.

NEW

- **Martins, I., Carvalho, P., Corte-Real, L., Alba-Castro, J.L. (2018) *BMOG: boosted Gaussian Mixture Model with controlled complexity for background subtraction*. Pattern Analysis and Applications (2018). DOI: 10.1007/s10044-018-0699-y.**
- **Martins, I., Carvalho, P., Corte-Real, L., Alba-Castro, J.L., *Texture Collinearity Foreground Segmentation for Night Videos*** (provisional title), **submitted** to **IEEE Transactions on Circuits and Systems for Video Technology** on **May 2018**.

Results & Discussions

Bio-Inspired Boosting for Moving Objects Segmentation

1

(presented and discussed in 2016 Annual Defense)

The **main novelty** introduced is the fusion of **low-level information from the modeling of the human visual system** [5] with state-of-the-art methods used in **BS**.

BMOG: boosted Gaussian Mixture Model with controlled complexity for background subtraction

2

Explores a **novel classification mechanism** that combines:

- **Color space discrimination capabilities**
- **Pixel classification with hysteresis**

and

- **Dynamic learning rate, independent for each pixel**

Testing & Evaluation:

- CDnet 2014 dataset;
- submitted to **CDnet benchmark** [4];
- **compared** with: MOG2 [6], RMoG, SuBSENSE.

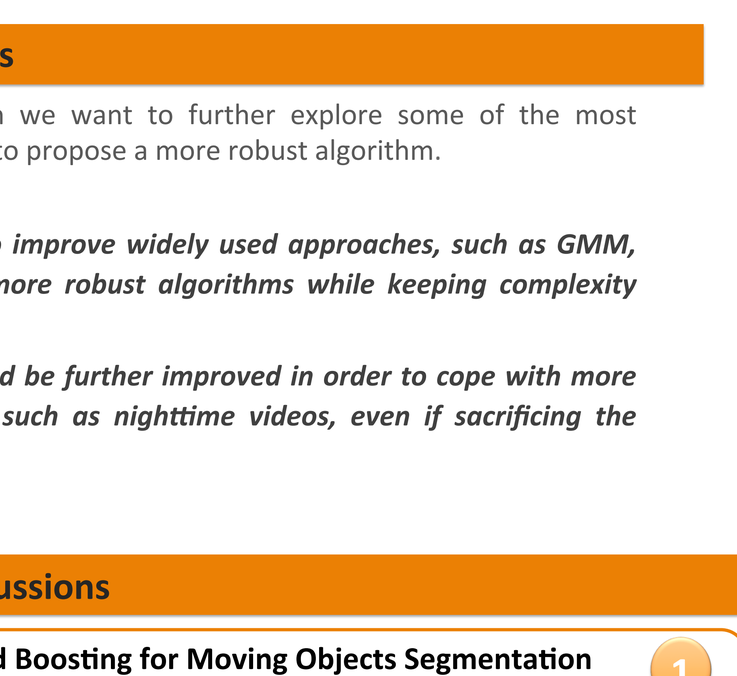

Fig. 1. Visual example of the dynamic behaviour: (from top) sample frames from input video *highway*; corresponding segmentation masks; pixel classification as BG/FG; decision threshold for channel L, th_L; number of components in the mixture, M; learning rate α.

Results show that BMOG consistently outperforms the widely used MOG2 method, and that it approaches top ranking, but much more complex, algorithms.

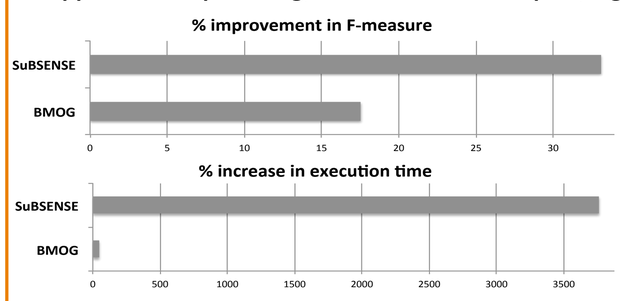

Fig. 2. Comparison of improvement in performance and increase in complexity for BMOG and a top-ranked method (reference: 0=MOG2).

- **Boosts the overall detection accuracy while keeping complexity low.**
- **Good choice for real-time applications.**

Presented and published at **IbPRIA2017** proceedings. **NEW** Invited, as a revised and extended version, for Springer journal **Pattern Analysis and Applications**. **Online: 02/4/2018**.

COLBMOG: Texture Collinearity Foreground Segmentation for Night Videos

3

The proposed method is based on a **local texture feature** integrated with a **parametric background model** (BMOG).

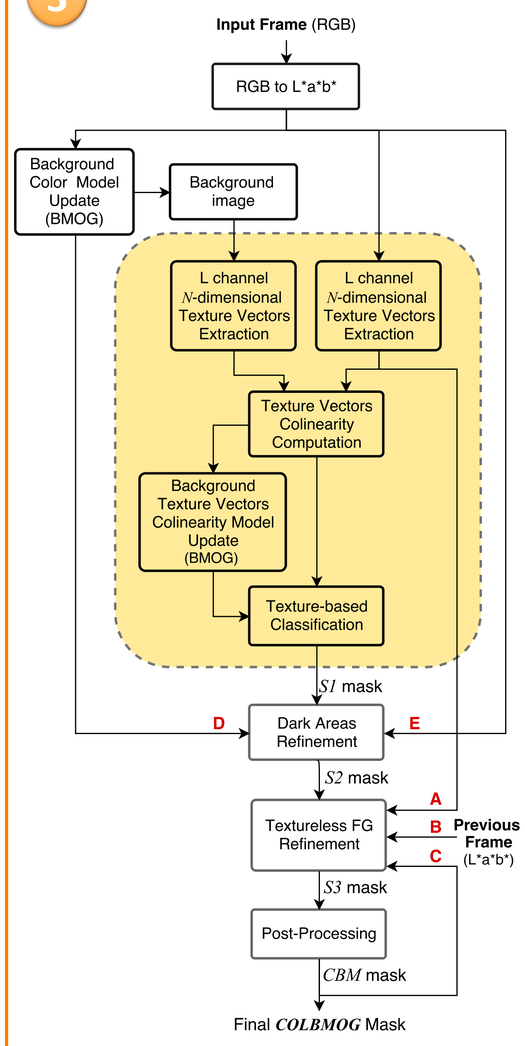

Fig. 4. COLBMOG block diagram.

Local texture feature:

N-dimensional vector of pixel intensities extracted from L channel according to a pre-defined pattern

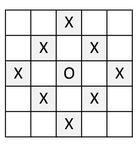

Fig. 3. Pattern of neighboring pixels representing local texture at pixel o.

Measure of similarity between both textures at pixel j:

the **collinearity** between the corresponding texture vectors in the input frame, $\vec{x}_j$, and in the background image, $\vec{b}_j$.

Measure of collinearity: the **angle between the texture vectors**, $\theta(\vec{x}_j, \vec{b}_j)$.

A model of the collinearity between texture vectors of background pixels in successive frames, based on BMOG, is created and updated at every frame.

Testing & Evaluation: CDnet 2014 NightVideos (NV) category benchmark [4]

Table 1. F-measure across the overall set of videos for COLBMOG and EFIC, C-EFIC (the two top-ranked unsupervised methods in NV category) [4].

F-Measure	EFIC	C-EFIC	COLBMOG
Average	0,6548	0,6677	**0,7564**
St Dev	0,1245	0,1034	**0,0435**

RANKS FIRST in CDnet NV benchmark [4] **for the unsupervised methods.**

Not only the **average F-measure is higher** but also the **standard deviation is significantly lower**, meaning a more consistent performance across different challenges.

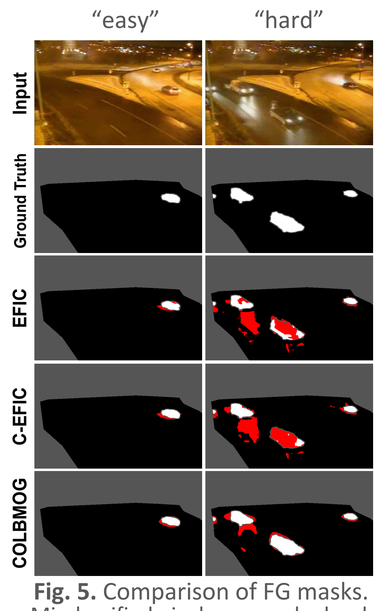

Fig. 5. Comparison of FG masks. Misclassified pixels are marked red.

NEW Tests using the Background Model Challenge (**BMC**) dataset.

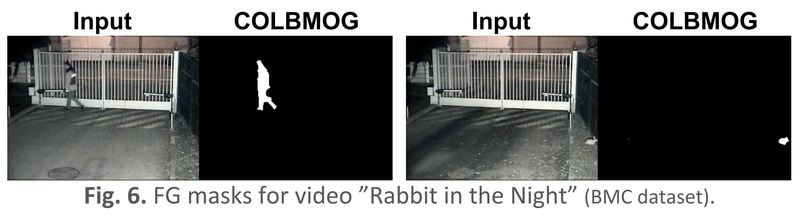

Fig. 6. FG masks for video "Rabbit in the Night" (BMC dataset).

NEW A paper with the provisional title ***Foreground Segmentation for Night Videos*** was **submitted** to **IEEE Transactions on Circuits and Systems for Video Technology,** on **May 2018**, and is now in the peer review stage.

References

[1] Bouwmans, T.: Traditional and recent approaches in background modeling for foreground detection: An overview. Computer Science Review 11, 31-66, May (2014)

[2] Stauffer, C., Grimson, E.: Adaptive background mixture models for real-time tracking. IEEE Int. Conf. Comput. Vision and Patt. Recogn. (CVPR) 2, 246–252, (1999)

[3] Wang, Y., Jodoin, P.-M., Porikli, F., Konrad, J., Benezeth, Y., Ishwar, P.: CDnet 2014: An Expanded Change Detection Benchmark Dataset. In Proc. CDW-2014, at CVPRW-2014, pp. 387–394 (2014)

[4] ChangeDetection.NET (CDNET), http://www.changedetection.net

[5] Benoit, A., Caplier, A., Durette, B., Herault, J.: Using human visual system modeling for bio-inspired low level image processing. Comput. Vis. Image Underst. 114,(7), 758–773 (2010)

[6] Zivkovic, Z., van der Heijden, F.: Efficient adaptive density estimation per image pixel for the task of background subtraction. Patt. Recogn. Lett 27(7), 773–780 (2006)

[7] Cardoso, J. S., Carvalho, P., Teixeira, L. F., Corte-Real, L.: Partition-distance methods for assessing spatial segmentations of images and videos. Comput. Vis. Image Underst. 113 (7), 811–823 (2009)