TEC2011-25995 EventVideo (2012-2014)

Strategies for Object Segmentation, Detection and Tracking in Complex Environments for Event Detection in Video Surveillance and Monitoring

D6.2v6.1

EVENTVIDEO RESULTS REPORT

Video Processing and Understanding Lab

Escuela Politécnica Superior

Universidad Autónoma de Madrid

Supported by GOBIERNO DE ESPAÑA MINISTERIO DE ECONOMÍA Y COMPETITIVIDAD

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CHANGE LOG

Version	Date	Editor	Description
0.0	20/06/2012	José M. Martinez	Initial version
1.0	29/06/2012	José M. Martínez	Version 1 (D5.4v1)
2.0	29/12/2012	José M. Martínez	Version 2 (D5.4v2)
3.0	29/06/2013	José M. Martínez	Version 3 (D6.2v3)
4.0	13/12/2013	José M. Martínez	Version 4 (D6.2v4)
5.0	30/06/2014	José M. Martínez	Version 5 (D6.2v5)
6.0	30/12/2014	José M. Martínez	Version 6 (D6.2v6)
6.1	16/03/2015	José M. Martínez	Version 6.1 (D6.2v6.1)

CONTENTS:

1. Introduction

This *report* recapitulates the results obtained within the EventVideo project. The results are disseminated both at the Web site (http://www-vpu.eps.uam.es/eventvideo) and via the eVi Newsletters.

The EventVideo project started officially January 2012, nevertheless the Video Processing and Understanding Lab (VPULab) has been working during part of 2011 in the research lines proposed in the project. Therefore the project started to produce related results even before the project official start.

1.1. Document structure

This document contains the following chapters:

- Chapter 1: Introduction to this document
- Chapter 2: Publications
- Chapter 3: Content Sets
- Chapter 4: Project Documents
- Chapter 5: Workshops and Seminars
- Chapter 6: Main achievements of the project

2. Publications

2.1. Journals

1. Álvaro García-Martín, José M. Martínez, Jesús Bescós, "**A corpus for benchmarking of people detection algorithms"**, Pattern Recognition Letters, 33(2):152-156, Jan. 2012. (DOI 10.1016/j.patrec.2011.09.038)
2. Juan Carlos San Miguel, Luis Caro, José M. Martínez, "**Pixel-based colour contrast for abandoned and stolen object discrimination in video surveillance"**, IET Electronic Letters, 48(2):86-87, Jan. 2012. (DOI 10.1049/el.2011.3160)
3. Juan Carlos San Miguel, Andrea Cavallaro, José M. Martínez, **"Adaptive on-line performance evaluation of video trackers"**, IEEE Transactions on Image Processing 21(5):2812-2823, May 2012. (DOI 10.1109/TIP.2011.2182520)
4. Álvaro García-Martín, José M. Martínez, **"On collaborative people detection and tracking in complex scenarios"**, Image and Vision Computing, 30(4-5):345-354, May 2012, Elsevier, ISSN 0262-8856. (DOI 10.1016/j.imavis.2012.03.005).
5. Juan Carlos San Miguel, José M. Martínez, **"A semantic-based probabilistic approach for real-time video event recognition"**, Computer Vision and Image Understanding, 116(9):937-952, September 2012, Elsevier, ISSN 1077-3142. (DOI 10.1016/j.cviu.2012.04.005).
6. Álvaro García-Martín, José M. Martínez, "**Enhanced people detection combining appearance and motion information**", IET Electronic Letters, 49(4):256-258, February 2013, IET, ISSN 0013-5194 (DOI 10.1049/el.2012.3817).
7. Juan Carlos San Miguel, José M. Martínez, **"A semantic-guided and self-configurable framework for video analysis**", Machine Vision and Applications, 24(3):493:512, April 2013, Springer, ISSN 0932-8092 (DOI 10.1007/s00138-011-0397-x)
8. Juan Carlos San Miguel, Sergio Suja, "**Skin detection by dual maximization of detectors agreement for video monitoring**", Pattern Recognition Letters, 34(16):2102-2109, December 2013, Elsevier Science Inc., ISSN 0167-8655 (DOI 10.1016/j.patrec.2013.07.016).
9. Fulgencio Navarro, Marcos Escudero-Viñolo, Jesús Bescós, "**SP-SIFT: Enhancing SIFT discrimination via super-pixel based foreground-background segregation**", IET Electronic Letters, 50(4):272-274, Feb. 2014, IET, ISSN 0013-5194 (Print), 1350-911X (Online) (DOI: 10.1049/el.2013.3949)
10. Rafael Martín, José M. Martínez, "**Correlation study of video object trackers evaluation metrics**", IET Electronic Letters, 50(5):361-363, Feb. 2014, IET, ISSN 0013-5194 (Print), 1350-911X (Online) (DOI: 10.1049/el.2013.3209)
11. Rafael Martín, Jose M. Martinez, "**A semi-supervised system for players detection and tracking in multicamera soccer videos**", Multimedia Tools and Applications, 73(3):1617-1642, Dec. 2014, Springer, ISSN 1380-7501 (Print), ISSN 1573-7721 (Online) (DOI 10.1007/s11042-013-1659-6).

12. Juan C. SanMiguel, Álvaro Calvo, "Covariance-based online validation of video tracking**"**, IET Electronic Letters, 51(3):226-228, Feb. 2015, IET, ISSN 0013-5194 (Print), 1350-911X (Online) (DOI: 10.1049/el.2014.3405)
13. Álvaro García-Martín, José M. Martínez, "**Post-processing approaches for improving people detection performance**", Computer Vision and Image Understanding, 131(2):42-55, Feb. 2015, Elsevier, ISSN 1077-3142. (DOI 10.1016/j.cviu.2014.09.010).
14. Juan C. SanMiguel, Andrea Cavallaro, "**Temporal validation of particle filters for video tracking**" , Computer Vision and Image Understanding, 133(4):76-89, April 2015, Elsevier, ISSN 1077-3142. (DOI 10.1016/j.cviu.2014.06.016).
15. Álvaro García-Martín, Borja Alcedo, José M. Martínez, "**PDbm: People detection benchmark repository**", Electronics Letters, (accepted Feb. 2015).
16. Álvaro García-Martín, José M. Martínez, "**People Detection in Surveillance: Classification and Evaluation**", IET Computer Vision (accepted Mar. 2015)

17. Marcos Escudero-Viñolo, Jesús Bescós, Victor Fernandez-Carbajales, "**Part-based Object Recognition trough Neural-Oriented Modelling in Severe Occlussion Scenarios**", Computer Vision and Image Understanding, (second revision –*major*- submitted Feb 2015), Elsevier, ISSN 1077-3142.,

2.2. Book chapters

1. Juan Carlos San Miguel, Álvaro García-Martín, José M. Martínez, "Performance evaluation in video-surveillance systems: the EventVideo Project evaluation protocols", cáp. 9, pp. 171-192, *Intelligent Multimedia Surveillance: Current Trends and Research*, Pradeep K. Atrey, Mohan S. Kankanhalli, Andrea A. Cavallaro (eds.), 2013, Springer (ISBN 978-3-642-41511-1 – Print; 978-3-642-41512-8 - Online)(DOI 10.1007/978-3-642-41512-8_9).
2. Rafael Martín, José M. Martínez, "Automatic Players Detection and Tracking in Multi-camera Tennis Videos", cáp. 9, pp. 191-209, *Human Behavior Understanding in Networked Sensing: Theory and Applications of Networks of Sensors*, Paolo Spagnolo, Pier Luigi Mazzeo, Cosimo Distante (eds.), 2014, Springer (ISBN 978-3-319-10806-3– Print; 978-3-319-10807-0 - Online)(DOI 10.1007/978-3-319-10807-0).

2.3. Conferences

1. Juan Carlos San Miguel, Andrea Cavallaro, José M. Martinez, "**Standalone evaluation of deterministic video tracking**", en Proc. of 2012 IEEE International Conference on Image Processing, ICIP 2012, Orlando, E.E.U.U., 30 September-3 October 2012, pp.1353-1356
2. Álvaro García-Martín, Andrea Cavallaro, José M. Martinez, "**People-background segmentation with unequal error cost**", en Proc. of 2012 IEEE International Conference on Image Processing, ICIP 2012, Orlando, E.E.U.U., 30 September-3 October 2012, pp. 157-160
3. Diego Ortego, Juan Carlos San Miguel, "**Stationary foreground detection for video-surveillance based on foreground segmentation and motion history**

images", in Proc. of 2013 IEEE International Conference on Advanced Video and Signal-based Surveillance, AVSS 2013, Kraków, Poland, 27-30 August 2013, pp. 75-80

4. Rafael Martín, Jose M. Martinez, "**An automatic system for sports analytics in multi-camera tennis videos**", in Proc. of Activity Monitoring by Multiple Distributed Sensing (AMMDS) Workshop 2013 in conjunction with 2013 IEEE International Conference on Advanced Video and Signal-based Surveillance, AVSS 2013, Kraków, Poland, 27-30 August 2013, pp. 438-442
5. Fabricio Tiburzi, Jesús Bescós, "**Robust camera motion estimation in presence of large moving objects**", en Proc. of 2013 IEEE International Conference on Image Processing, ICIP 2013, Melbourne, Australia, 15-18 Septiembre 2013, pp. 2509-2513
6. Rafael Martín, José M.Martínez, "**Evaluation of Bounding Box Level Fusion of Single Target Video Object Trackers**", en Hybrid Artificial Intelligence Systems - HAIS 2014, M.Polycarpou et al. (eds.), Lecture Notes in Computer Science, Vol. 8480, Springer Verlag, 2014, pp. 200-210. (ISBN 978-3-319-07616-4)
7. Fulgencio Navarro, Marcos Escudero, Jesús Bescós, "**Enhancing region-based object tracking with the SP-SIFT feature**", in Proc. of 2014 Interational Workshop on Content-Based Multimedia Indexing, CBMI 2014, Klagenfurt, Austria, 18-20 Jun. 2014
8. Álvaro Garcia-Martin, Ruben Heras Evangelio, Thomas Sikora: "**A Multi-configuration Part-based Person Detector**", in Proc. of International Conference on Signal Processing and Multimedia Applications, SIGMAP 2014, pp. 321-328, Vienna, Austria, 2-4 Sept. 2014.
9. Álvaro García-Martín, Rubén Heras Evangelio, Thomas Sikora, "**Multi-configurations for Part-based Person Detectors**", Third International Workshop on Parts and Attributes in Conjunction with the European Conference on Computer Vision, ECCV 2014, Zurich, Switzerland, 12 Sept. 2014.
10. Diego Ortego, Juan Carlos San Miguel, "**Multi-feature stationary foreground detection for crowded video-surveillance**", in Proc. of 2014 IEEE International Conference on Image Processing, ICIP 2014, Paris, France, 27-30 Oct. 2014, pp-2403-2407
11. Antonio González, Rafael Martín-Nieto, Jesús Bescós, José M. Martínez, "**Single Object Long-term Tracker for Smart Control of a PTZ camera**", in Proc. of 2014 ACM/IEEE International Conference on Distributed Smart Cameras, ICDSC 2014, Venezia, Italy, 4-7 Nov. 2014

2.4. PhD thesis

1. **Contributions to robust people detection in video-surveillance**, Álvaro García Martín (advisor: José M. Martínez), Tesis Doctoral (PhD Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Oct. 2013.
2. **Técnicas basadas en el análisis de regiones para la segmentación y seguimiento de objetos en secuencias de video**, Marcos Escudero Viñolo (advisor: Jesús Bescós), Tesis Doctoral (PhD Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Sept-Oct. 2015.

2.5. Masther thesis

1. **Evaluación comparativa de algoritmos de seguimiento de objetos (Comparative evaluation of object tracking algorithms)**, Mónica Lozano Cruz (advisoradvisor: Juan C. San Miguel, ponente: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Feb. 2012.
2. **Generación de fondo de escena en secuencias de video-seguridad (Background generation in video-surveillance sequences)**, Alberto Muñoz García (advisor: Juan C. San Miguel, ponente: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Sep. 2012.
3. **Detección de robo/abandono de objetos en interiores utilizando cámaras de profundidad (Indoor stolen/abandoned object detection using depth cameras)**, Fabricio A. Córdova Lucero (advisor: Juan C. San Miguel, ponente: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Dec. 2012.
4. **Análisis de interacciones y actividades en entornos controlados (Analysis of interactions and activities in controlled environments)**, Sergio Suja Garrido (advisor: Juan C. San Miguel, ponente: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Dec. 2012.
5. **On the Fusion of Single-Target Video Objects Tracking Algorithms**, Rafael Martín Nieto (advisor: José M. Martínez), Trabajo Fin de Master (Master Thesis), Master Universitario en Investigación e Innovación en TIC (i2TIC), Escuela Politécnica Superior, Universidad Autónoma de Madrid, Sep. 2013.
6. **Detección de objetos estáticos de primer plano en escenarios altamente concurridos de video-seguridad (Detection of foreground static objects in crowded video-surveillance scenarios)**, Diego Ortego Hernández (advisor: Juan C. San Miguel, ponente: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Sep. 2013.
7. **Anomaly Detection in Video Sequences**, Luis A. Caro Campos (advisor: Juan Carlos San Miguel), Trabajo Fin de Master (Master Thesis), Master Universitario en Investigación e Innovación en TIC (i2TIC), Escuela Politécnica Superior, Universidad Autónoma de Madrid, Oct. 2013.
8. **Entorno de desarrollo de aplicaciones de vídeo-seguridad multicámara (Development environment for multicamera video-surveillance applications)**, Carlos Sánchez Bueno (advisor: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Jun. 2014.
9. **Seguimiento de personas en vídeo basado en detección (Detection-based people tracking in video sequences)**, Raúl Porras Martín (advisor: José M. Martínez), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Jun. 2014.
10. **Evaluación comparativa de algoritmos de detección de personas en secuencias de vídeo (Comparative evaluation of people detection algorithms in video sequences)**, Borja Alcedo Moreno (advisor: Álvaro García-Martín),

Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Jul. 2014.

11. **Estimación de fiabilidad del seguimiento de objetos en video (Realibility estimation of object tracking in video)**, Álvaro Calvo Tapia (advisor: Juan Carlos San Miguel), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Jul. 2014.
12. **Detección jerárquica de grupos de personas (Hierarchical detection of groups of people)**, Ricardo Sánchez Matilla (advisor: Álvaro García-Martín), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Sep. 2014.
13. **Background initialization for the task of video-surveillance**, Diego Ortego Hernández (advisor: José M. Martínez), Trabajo Fin de Master (Master Thesis), Master Universitario en Investigación e Innovación en TIC (i2TIC), Escuela Politécnica Superior, Universidad Autónoma de Madrid, Oct. 2014.
14. **Segmentación persona-fondo usando información de segmentación frente-fondo (People-background segmentation using foreground-background segmentation information)**, Raúl Lara Arranz (advisor: Álvaro García-Martín), Proyecto Fin de Carrera (Master Thesis), Escuela Politécnica Superior, Univ. Autónoma de Madrid, Dec. 2014.

2.6. Graduate thesis

1. **Detección de personas en tiempo real (Real-time people detection),** Patricia Marín Belinchón (advisor: Álvaro García), Trabajo Fin de Grado (Graduate Thesis), Grado en Ingeniería y Tecnologías de Telecomunicación, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Jun. 2014.
2. **Detección de caídas para vídeo-monitorización en entornos domésticos (Fall Detection for Video-monitoring in domestic environemnts),** Sara Cerro Pardo (advisor: José M. Martínez), Trabajo Fin de Grado (Graduate Thesis), Grado en Ingeniería y Tecnologías de Telecomunicación, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Jun. 2014.
3. **Detección de intrusión con cámaras móviles en tiempo real (Real-time Intrusion detection with mobile cameras)**, Alberto Palero Almazán (advisor: Jesús Bescós), Trabajo Fin de Grado (Graduate Thesis), Grado en Ingeniería y Tecnologías de Telecomunicación, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Jun. 2014.
4. **Detección de anomalías en tiempo real (Real-time anomaly detection)**, Ana Huélamo Vallejo (advisor: Luis Caro), Trabajo Fin de Grado (Graduate Thesis), Grado en Ingeniería y Tecnologías de Telecomunicación, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Jul. 2014.
5. **Detección de intrusión en exteriores en tiempo real (Real-time outdoor intrusion detection),** Alejandro Blanco Carrasco (advisor: Marcos Escudero), Trabajo Fin de Grado (Graduate Thesis), Grado en Ingeniería y Tecnologías de Telecomunicación, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Jul. 2014.
6. **Seguimientos de objetos en tiempo real (Real-time object tracking),** Jorge Sanjuán García (advisor: Rafael Martín), Trabajo Fin de Grado (Graduate Thesis), Grado en Ingeniería y Tecnologías de Telecomunicación, Escuela Politécnica Superior, Universidad Autónoma de Madrid, Jul. 2014.

3. Content Sets

1. Abandoned and Stolen Object Discrimination dataset - ASODds (http://www-vpu.eps.uam.es/DS/ASODds/)
2. Event Detection dataset - EDds (http://www-vpu.eps.uam.es/DS/EDds/)
3. Person Detection dataset - PDds (http://www-vpu.eps.uam.es/DS/PDds/)
4. An Anomaly Detection Dataset – ADds (http://www-vpu.eps.uam.es/DS/ADds/)
5. Teacher Tracking Dataset – TTds (http://www-vpu.eps.uam.es/DS/TTds/)
6. People Detection benchmark repository - PDbm (http://www-vpu.eps.uam.es/PDbm/)
7. Single-Object Video Tracking dataset – SOVTds (http://www-vpu.eps.uam.es/DS/SOVTds/) (restricted – associated publication in revision)

4. Project Documents

4.1. Deliverables

D1.1v1 – System Infrastructure (public) – June 2012
D1.1v2 – System Infrastructure (public) – June 2013

D1.2v1 – DiVA Documentation (public) – June 2012

D2.1v1 – Segmentation for static cameras (public) – July 2014

D2.2v1 – Segmentation for moving cameras (public) – December 2014

D3.1v1 – People detection in dense environments (public) – June 2014

D3.2v1 – Events detection in dense environments" (public) – December 2014

D4.1v1 – Tracking in dense or cluttered environments – (public) June 2014

D4.2v1 – Visual attention driven tracking (public) – June 2014

D5.1v1 – Description of demonstrators and applications (public) – December 2014

D5.2v1 – Quality measures and feedback-driven analysis approaches (public) – December 2014

D5.3v1 – Description of exploration of the use Kinect's depth data in analysis stages (public) – XXX 2014

D5.3v1 – EventVideo Test Sequences, Ground-truth and Evaluation Methodology (public) – June 2012

D5.4v1 – EventVideo Results Report (public) – June 2012
D5.4v2 – EventVideo Results Report (public) – December 2012
D6.2v3 – EventVideo Results Report (public) – June 2013
D6.2v4 – EventVideo Results Report (public) – December 2013
D6.2v5 – EventVideo Results Report (public) – June 2014
D6.2v6 – EventVideo Results Report (public) – December 2014
D6.2v6.1 – EventVideo Results Report (public) – March 2015

4.2. Technical Reports

TR.01 "Evaluation results and future research lines" (restricted) - April 2013

5. Workshops and Seminars

5.1. eVi Workshop 23rd May 2014

The workshop was held during the morning of 23rd May of 2014 with over 30 attendees (not including the presenters). After a presentation of the project and an overview of the workshop program the technical sessions started with a description of the infrastructure used in the project, both material and software development framework. Afterwards four sessions were devoted to the main research areas of the project. Session 2 presented the work done in segmentation, presenting two works: foreground-background segmentation in multimodal environments and Segmentation for PTZ cameras, both including a live demos. Session 3 presented results in people detection, detailing after an overview of all the work done, the results obtained in real-time people detection (demonstrating live several real time people detectors) and people-background segmentation. In Session 4, devoted to object tracking, two works were presented: visual attention based tracking and long-term object tracking, the later showing a live demo with cameras installed in the workshop room and allowing the public to interactively test the system. The last session on Event detection included three presentations on specific topics: people activities and interactions detection, stolen and abandoned objects detection and anomaly detection, including two live demos.

6. Main achievements of the project

The TEC2011-25995 EventVideo project, focused on segmentation, detection and tracking in video sequences for complex environments, has covered its objectives, yielding 16 articles in international journals, 2 book chapters and 11 articles in international conferences, as well as several evaluation datasets of utility for the scientific community.

In the segmentation stage, a multimodal technique for foreground segmentation robust to light changes and camouflage has been developed. An algorithm based on RANSAC has also been designed for estimating camera motion when the background is smaller than the moving objects or it contains homogeneous regions. A background generation algorithm based on iterative analysis of visual features has also been proposed.

In the people detection stage, various state-of-the-art algorithms have been evaluated. In addition, an algorithm that applies tracking to retrofit the fusion of motion and appearance has also been developed. Moreover, a technique for person-background segmentation has been proposed. Finally, two post-processing techniques (fusion of independent detectors and use of person-background maps) and a detector of people in groups have been proposed for dense environments.

In the event detection stage, various algorithms based on anomalous and static regions have been designed, as well as some finite-state machine models to define sets of rules.

As horizontal tasks, several techniques have been developed to assess the quality of both generic and specific tracking algorithms (Particle filter and MeanShift). Feedback techniques for skin detection through dynamic integration of detectors have also been proposed. Finally, both the hardware and software (DiVA platform) of the distributed video surveillance system have been updated, adding an application development environment.

A very active collaboration with Dr. Andrea Cavallaro from the Queen Mary University of London has been carried out all over the project and a new collaboration with Dr. Thomas Sikora from Technische Universität Berlin has been established.