

AVISADOS: A Multi-Agent System for Advanced Visual Surveillance TIN2007-67586-C02*

Antonio Fernández Caballero [†]
Universidad de Castilla-La Mancha

Rafael Martínez Tomás [‡]
Universidad Nacional de Educación a Distancia

Abstract

The use of visual surveillance systems has grown exponentially in the last decade. This expansion requires technological help for analyzing and interpreting the enormous amount of visual information produced. The AVISADOS project includes (a) the generation of a sufficiently rich communication language (scene description language) between the processing and understanding levels of the image, (b) the development of generic sensors (visual and non-visual) that integrate the physical data with the knowledge on environment and task, (c) the support to decision making (man-machine interaction) by means of augmented reality techniques, and (d) the creation of a tool for the generation of multi-sensorial surveillance environments modeled as multi-agent systems.

Keywords: Surveillance; Scene interpretation; Augmented reality; Multi-agent systems; Mobile robotics.

1 Objectives of the Project

The objectives of the “AVISADOS: A Multi-Agent System for Advanced Visual Surveillance” project are:

1. Development of a new prototype of intelligent, distributed and dynamic multi-agent system for the surveillance task.
2. Development and implementation of a system to help in decision making, starting from a situated multimodal interface that incorporates the information and knowledge of the situation to be monitored (virtual sensors) to the data of fixed and moving cameras.
3. Development of models of humans and objects as an aid to robust tracking, previous to the task of scene interpretation.

*This article is dedicated to the memory of Professor José Mira Mira, a great researcher and a close friend; but who sadly passed away on August 13, 2008. Professor Mira was the starting coordinator of the project.

[†]Project coordinator; principal researcher, TIN2007-67586-C02-02. Email: caballer@dsi.uclm.es.

[‡]Principal researcher, TIN2007-67586-C02-01. Email: rmtomas@dia.uned.es.

4. Modeling, formalization, implementation and evaluation of an intermediate language between the geometric description of objects of interest and the proper semantic level of the interpretation of the activity in the scene.
5. Development of an advanced interface that increases the capacity and effectiveness of the communication of the human operator with the rest of the system. For it a support system to monitoring and decision making will be developed.
6. Development of a tool for modeling multi-agent architectures composed of a set of virtual sensors dedicated to collaborative surveillance with capacity of supervised and non-supervised learning.

The aims of the project correspond to the modeling and formalization of the tasks associated to each objective and their integration. The chronogram of Figure 1 describes the temporal sequencing of the tasks associated to subprojects UNED (T_{UNED}^1 to T_{UNED}^6) and UCLM (T_{UCLM}^1 to T_{UCLM}^5) denominated:

- UNED subproject: “Development of generic sensors and intermediate languages for the description of scenarios in Advanced Visual Monitoring tasks”
- UCLM subproject: “Scene modeling by multi-agent systems and decision support by mixed reality techniques in Advanced Visual Surveillance”

2 Level of success reached in the project

2.1 T_{UNED}^1 and T_{UCLM}^1

Tasks T_{UNED}^1 and T_{UCLM}^1 were completed during the last year 2009. Both tasks entailed the same purpose, a better segmentation of the elements of interest in surveillance environments. In this sense, T_{UNED}^1 task has introduced techniques of supervised, non-supervised and collaborative machine learning to fit the values of the parameters of the project’s prototypes. It is worth while mentioning the work on learning a probability map for detection of skin pixels in RGB color space [10]. The idea is to use this probability map to detect human presence in video sequences and apply it to video surveillance domain. Similarly, a learning system based on a statistical approach that allows to initialize the background model associated with a video sequence has been generated [3]. This model increases the performance of the segmentation method based on background subtraction as described in [4].

On the other hand, the UCLM subproject has continued using accumulative computation (AC) [44], [30] and lateral inhibition (LI) [22], [27], [45] to enhance the dynamic selective visual attention (DSVA) model [54], [55] with the inclusion of color, infrared (IR) and stereoscopy [25], [29], [47]. In relation to IR segmentation, let us highlight that an efficient human detection algorithm has been developed and improved [7]. The camera may be static [6], [16] or dynamic (mounted on a mobile robot) [9], as the algorithm can be adjusted to fulfill the operation mode. Also, the AC and LI methods have been adapted for the processing of RGB and HLS color images [17]. There has also been a great effort in obtaining real-time performance in motion detection through using field programmable gate array (FPGA) devices [14], [21]. Some typical application of segmentation by AC and LI has been traffic monitoring [23], [28], [46] and road-sign identification [48].

TASKS	FIRST YEAR	SECOND YEAR	THIRD YEAR
T_{UNED}^1 : Development of a set of hybrid methods of supervised, non-supervised and collaborative learning for the improvement of the tasks of monitoring and diagnosis			
T_{UCLM}^1 : Improvement of the dynamic selective visual attention method for the segmentation and tracking in video sequences			
T_{UCLM}^2 : Advanced multi-sensorial surveillance systems modelled as multi-agent systems			
T_{UNED}^2 : Development of virtual and multimodal sensors for the creation of a dynamic and located representation of the scene around interest coordinates			
T_{UCLM}^3 : Application of mixed reality techniques to support humans in decision making			
T_{UNED}^3 : Creation of the ontology of actions and/or activities of humans and other concurrent moving objects in specific scenarios of interest in advanced visual surveillance			
T_{UNED}^4 : Creation of a language of scene description for the the mutual feedback between the levels of image processing and scene understanding			
T_{UNED}^5 / T_{UCLM}^4 : Contribution to the creation of a tool for the generation of advanced multi-sensorial surveillance environments			
T_{UNED}^6 / T_{UCLM}^5 : Evaluation of the tool and the prototypes in tasks of real scenarios surveillance			

Figure 1: Project chronogram

In a work common to both subprojects, a human model has been developed and applied to segment human silhouettes. By learning a set of rules, different parts of the human (e.g. face, legs, arms, hands) may be identified, as well as objects carried by the humans. This system uses a genetic algorithm to automatically learn the optimal values of a set of parameters, enabling to customize the performance of a segmentation method applied to the detection of moving objects in video sequences. The learning system developed [50] is a supervised one. In fact, the definition of the evaluation function, associated with the genetic algorithm, is based on information known a priori for each of the frames belonging to the sequences used as training sequences.

2.2 T_{UCLM}^2

The aim of task T_{UCLM}^2 is to model advanced multisensory surveillance systems using the multi-agent system (MAS) paradigm [77]. INGENIAS methodology [62], [63] was initially considered for modeling the project [41]. However, after a detailed study of INGENIAS, a new agent methodology - named VigilAgent - focused on surveillance environment generation is being developed. The new methodology integrates Prometheus [60] and INGENIAS methodologies, and ICARO-T agent development framework [34]. The methodologies are combined

into VigilAgent using model driven engineering techniques (MDE) [68]. VigilAgent includes all steps from the capture of requirements to the deployment of an agent-based surveillance application. In addition, another approach denominated DeciMas [69] has presented an agent-based interdisciplinary framework for decision making in complex systems (based in Protégé and Prometheus methodologies).

VigilAgent methodology has offered so far the following results: (a) a survey on multi-agent systems in intelligent, multisensory and distributed surveillance systems [35]; (b) an integrative methodology for developing multi-agent systems using Prometheus, INGENIAS and ICARO-T technologies [40], [19], [39]; (c) modeling of an agent-based robotic application to detect and follow human [38]; (d) using ICARO-T framework to implement and simulate the collaboration among mobile robots in a common surveillance task [37]; and, (e) a new conceptual framework [53], [36] including several levels (physical, symbol and knowledge). On the other hand, the DeciMas framework has led to the following publications: (a) a proposal for an agent-based decision support system [72], [73], [74]; and, (b) the implementation of a case study for a complex system [70], [71], [75].

2.3 T_{UNED}^2 and T_{UCLM}^3

The shared objective of these tasks is to improve the decision capacity of the human operator by offering additional information to the traditional surveillance visualization systems. So, visual surveillance is complemented with other types of sensors, able to provide additional and redundant information for a more efficient decision making. The UNED subproject (T_{UNED}^2) has facilitated sensorial integration through designing a model of situated generic sensors. This enables modifying or supplementing the measured data with time and situation information from the camera (the robot) [52]. The task establishes spatio-temporal measure correlations of different sensors to integrate them and to create multisensory information, richer in semantics. Proposals for modeling the external environment of the robot through multisensory fusion have been developed [2]. A new concept called “advanced center of area” that allows for smoother, faster, and more efficient and robust navigation [1], [12] has been addressed. Currently, machine vision is being integrated into the model, using a pan-tilt color camera located on the robot [11]. Also for video surveillance, a prototype that integrates activity level events from different sensors, and prioritizes its search as a function of triggered alarm level and its associated cost [65], [66] has been developed. Additionally, in the representation of the environment of a robot, mechanisms for reactive navigation using sensory representation methods based in the center of area, both in the theoretical [13] as in the practical aspect [1], have been proposed.

Now, the aim of task T_{UCLM}^3 is to apply mixed reality techniques to provide support to a human operator in the decision making process. The aim is to improve the human ability for decision making, thanks to an enhanced and advanced human-computer interaction. Indeed, many tracking applications only perform well in constrained environment, with low dynamic backgrounds and objects highly scattered on the image. In our approach, object detection techniques have been developed in order to locate and extract objects of interest from multi-spectrum real-world images. Then, these objects are shown in a virtual world developed through augmented reality techniques used to model a 3D representation of the monitored environment [33], [57].

2.4 T_{UNED}^3 and T_{UNED}^4

Task T_{UNED}^3 has as objective the identification of knowledge sources and the their conceptual modeling from the descriptions of the human expert, separating the knowledge in two layers and having in the horizon the intention to formalize the models by reusing libraries of methods and ontologies. Moreover, in task T_{UNED}^4 , a model for the mutual feedback between the levels of image processing and scene understanding has been proposed and developed. A study [61] has been conducted on human activities at different levels of description, and ontologies have been described for each level. Different scenes are being characterized starting from these ontologies and spatio-temporal multisensory signals [42]. Also some data mining mechanisms are being explored for finding recurrent patterns in different scenarios.

The primary goal for achieving the identification of most human activities is to improve human tracking [59]. It seems clear to address the problem by distinguishing the best models based on the distance to the man and the degree of refinement in the description of the desired scene. A human model has been developed for block-based real-time monitoring of a set of events and states, related to the analysis of the activity performed by a human in an image sequence. In [32] the model uses static patterns, and in [76] dynamic patterns are used. Lastly, the approach has been applied to model problems of video surveillance [31]. Also, some work oriented to recognizing individuals in controlled environments has been introduced. A system for recognition of individuals belonging to one group over individuals outside the group has been described [58]. The proposed approach does not identify individuals, but simply classifies them, this way reducing the computational load and learning time. New descriptors of the image allowing analysis of the scenes have also been studied [67].

A great effort has been done to get a mutual complementarity in the layers of image processing and scene understanding [64], [56]. The blobs obtained at the image sequence processing level enable understanding what is happening in the scene. And, comprehension of the current actions present in the scene improves the segmentation process. Thus, inconsistencies can be found and solved in the layer of activities, or new operators can be used to solve them. From the activities layer some visual aspects are focused and vision operators are efficiently used [4]. These strategies allow solving problems in monitoring and identification from the level of activities [51].

2.5 T_{UNED}^5 and T_{UCLM}^4

Tasks T_{UNED}^5 and T_{UCLM}^4 are in charge of creating a tool incorporating all prototypes. This is still an ongoing common task. The system has been designed as a modular architecture, able to integrate all modules developed by UNED and UCLM teams. The creation of this tool requires a continuous collaboration and coordination. Subgroup UNED is dedicating itself to integrating (i) software to process the output of the multimodal virtual sensors; (ii) software of scene description; (iii) software of scene understanding; (iv) software of situation diagnosis; and, (v) software of pre-alarm and alarm generation, whilst subgroup UCLM is in charge of elaborating (vi) software of sensor introduction; (vii) software of image processing; and, (viii) software of multi-agent systems modeling. Finally, there is a common part, namely, (ix) parametrization of the software, (x) software of control, (xi) design of the man-machine interface, and, (xii) performing simple tests.

The developed prototype has to allow the interoperation among the different modules. The main problem of this task is the combination of heterogeneous technologies used in the partial prototypes. Where possible, different modules are integrated as dynamic libraries, and in other cases, a communications system is in charge of passing the parameters and messages among the modules. A test bench has been developed to test the final prototype. Also, a package of tools [51] has been created to edit the knowledge included in the activities level. The package is based on evolution monitoring and inference on every spatio-temporal aspect. Finally, the Cybersim simulator is being adapted to simulate various types of robots and monitor robot activities in real-time. The simulator is being developed under GPL and a working version can be downloaded from <http://www.ia.uned.es/personal/jmcuadra/software.html>. The simulator will be integrated within the test bench in order to process every simulated action (both visual and non-visual).

2.6 T_{UNED}^6 and T_{UCLM}^5

During the next six months, the teams will put into operation several scenarios in order to evaluate the tool as well as the proper developed environment. During the end of the project the validity of the proposed methodological approach will be verified, forming tasks, methods and entities for the domain of surveillance in two concrete scenarios, namely, monitoring of the interior of a building and monitoring of the perimeter area of a building.

3 Result indicators

3.1 Result indicators for the UCLM subproject

3.1.1 Student formation

- PhD Dissertations:
 - J.P. Molina Massó. “Development of three-dimensional user interfaces. A proposal for a methodological environment for development” (February 2008).
 - A.S. García Jiménez: “New interaction techniques close to collaborative virtual environments” (January 2010).
 - M.V. Sokolova: “DeciMaS: An Agent-based Interdisciplinary Framework for Decision Making in Complex Systems” (March 2010).
 - J.M. Gascuña Noheda: “VigilAgent: Agent-based technologies to model and implement intelligent surveillance systems” (April 2010).
- Ongoing PhD Thesis:
 - J.J. Valencia Jiménez: “Speaker recognition systems in surveillance using software agents”.
 - E. Lazcorreta Puigmartí: “Web data mining by multi-agent system for user customization”.
 - J.C. Castillo Montoya: “Visual data fusion for improving safety and security”.
- Research Master Students:
 - L.G. Rojas Albarracín: “Human behavior patterns from pose studies”. 2009.
 - C.A. Carbajal Varela: “Skeletonisation techniques for determining humans”. 2009.
- Research Scholarship holders and Contracted:
 - A.S. García Jiménez. Scholarship holder of the Junta de Comunidades de Castilla-La Mancha, 2005-2008.
 - M.V. Sokolova. Scholarship holder of the Ministerio de Asuntos Exteriores, Years 2006-2007.
 - J.M. Gascuña Noheda. Scholarship holder of the Junta de Comunidades de Castilla-La Mancha, 2007-2010.
 - J. Carlos Castillo Montoya. Contracted of the Junta de Comunidades de Castilla-La Mancha, 2009-2011.
 - J. Serrano Cuerda. Contracted of the Junta de Comunidades de Castilla-La Mancha, 2009-2011.

3.1.2 Patent

- Antonio Fernández Caballero, Javier Martínez Cantos, José Luis Rubio (2009). Surveillance system and method by thermal camera (09380122.3). Exploited by MoviRobotics SL.

3.1.3 Technology transfer

- “MMI Display Analysis Tool”. EUROCOPTER España S.A., 172,000 euros (2007-2009). See [8], [20].
- “Robot MR10: Intelligent surveillance systems based in thermal camera”. MoviRobotics SL, 23,000 euros (2008-2009).
- AVANZA I+D “Integral management of warehouses” (TSI-020400-2009-101). Métodos y Tecnologías (MTP), 54,000 euros (2009-2010).
- HITO “MultimodalSensors: Research on multimodal, usable and accessible user interfaces for multisensory surveillance environments”. SECISA Seguridad S.A., 51,000 euros (2010).
- HITO “Automatic inspection methods in tunnels”. MoviRobotics S.L., 54,000 euros (2010).

3.1.4 Other related research projects

- “Adaptive location-based services in dynamic cooperating objects environments”. Proposal submitted to ICT Call 5 (FP7-ICT-2009-5).
- “Model-driven engineering for the development of surveillance multisensor systems”. Junta de Comunidades de Castilla-La Mancha, PII2I09-0069-0994 (2009-2011).
- “Multisensor information fusion in real-time for advanced surveillance”. Junta de Comunidades de Castilla-La Mancha PII2I09-0071-3947 (2009-2010).
- “Collaborative mobile platforms based in advanced computer vision”. Ministerio de Ciencia e Innovación UNCM08-1E-030 (2010-2012).
- “A multi-agent system for the intelligent control of fixed and moving PTZ cameras in wireless networks”. Junta de Comunidades de Castilla-La Mancha PBI06-099 (2007-2009).
- “New techniques of interaction: Virtual reality and computer vision”. Ministerio de Ciencia e Innovación UNCM05-23-050 (2006-2009).

3.1.5 Publications

Journal Papers:

Journal Title	Reference	Status	Impact F.
Expert Systems with Applications	[23],[25],[29],[70]	Published	2.596
Computer Vision and Image Understanding	[16],[38]	Submitted	
Applied Soft Computing	[48]	Published	2.220
Sensors	[59]	Published	1.909
Fuzzy Sets and Systems	[21]	Published	1.870
The Knowledge Engineering Review	[18]	Published	1.833
Pattern Recognition Letters	[35]	Accepted	1.588
Image and Vision Computing	[26], [47]	Published	1.559
Machine Vision and Applications	[45]	Published	1.496
Engineering Applications of Artificial Intelligence	[20]	Submitted	1.485
Neurocomputing	[14]	Published	1.397
	[50],[24],[54]	Published	1.234
Robotics and Autonomous Systems	[44]	Submitted	
	[5]	Published	1.214
	[7]	Submitted	
Expert Systems	[36]	Submitted	0.717

Conference Papers:

Conference Proceedings	Reference
Lecture Notes in Computer Science	[6], [8], [9], [22], [27], [28], [30], [39], [40], [41], [46], [53], [55], [56], [72], [73], [74], [75], [77]
Communications in Computer and Information Science	[19]
Advances in Practical Applications of Agents and Multiagent Systems	[37]
Information Technologies in Environmental Engineering II	[71]

Master Thesis:

- P. García Martínez (2009). Cooperation among AmigoBot mobile robots in surveillance tasks.
- G. Toldos Serrano (2009). Model-driven techniques for supporting Prometheus methodology in agent-oriented software development.
- J. Molina López (2008). Implementation of autonomous navigation algorithms for the Pioneer 3AT mobile robot.
- J.M. Rodríguez Sánchez (2008). Conceptual description of moving objects in video sequences.
- J. Serrano Cuerda (2007). Segmentation of B/W and color video sequences based in accumulative computation using ActiveMIL.
- A.T. Hernández Malagón (2007). Video processing and alarm generation in multicamera surveillance environments using ActiveMIL.
- S. Romero López (2007). Video monitoring and multiarea alarm management system with remote access.
- R.C. Ruiz Villena (2007). Autonomous navigation of the Pioneer 3-AT robot.
- F. Virginia Popoviciu (2007). Programming of industrial robots through graphical simulation.

3.1.6 Research Collaborations

- A. Fernández Caballero has been on scientific stages at “Université catholique de Louvain” (4 months during year 2009) and at “Kursk Technical University” (3 months during year 2008)
- J.M. Gascuña Noheda has been on a scientific stage at “Universidad Complutense de Madrid” (3 months during year 2009)
- The research group belongs to the European network EUCogII (2nd European Network for the Advancement of Artificial Cognitive Systems, Interaction and Robotics).
- The research group belongs to the Thematic Network in Natural/Artificial Computation Technologies (RTNAC).

3.1.7 Other Activities

- A. Fernández Caballero is an Associate Editor of the prestigious journal “Pattern Recognition Letters” since February, 2009.
- A. Fernández Caballero and María Teresa López Bonal are lecturers of postgraduate courses, first in the program of “Doctorate in Advanced Computer Science Technologies” (with Mention of Quality from ANECA Ref. MCD2006-00423) and at the moment in the “University Master in Advanced Computer Science Technologies” (with Official Verification from ANECA Ref. MO2006-00197).
- A. Fernández Caballero is a member of the Organizing Committee of “The Twenty Third International Conference on Industrial, Engineering & other Applications of Applied Intelligent Systems, IEA-AIE 2010”.

3.2 Result indicators for the UNED subproject

3.2.1 Student formation

- PhD Dissertations:
 - D. Martínez Gómez. “Dynamic architecture for surface visual inspection in real-time”. UNED. 2007.
 - J. Des Diz. “A support system for ophthalmology diagnosis”. ETSII. UNED. 2007.
- Ongoing PhD Thesis:
 - J. Martínez Cantos. Scene description languages in video surveillance task. ETSII. UNED.

- J.M. Cuadra Troncoso. Creating multimodal virtual sensors for monitoring and diagnosis in advanced visual surveillance environments. ETSII. UNED.
- H. Gómez. High-level interpretation of video sequences using ontologies. ETSII, UNED.
- J. Torres Estrada. Ontologies and data models: Methodology to integrate and translate queries. ETSII. UNED.

- **Research Master Students:**

Members of the project, and therefore the associated research issues, have special importance in the research master "Advanced Artificial Intelligence", that is taught in the Department of Artificial Intelligence in the graduate program "Artificial Intelligence and Systems", which aims to train students towards the preparation of doctoral theses in this field, symbolic methods and bio-inspired, learning, evolutionary computation, vision artificial and perceptual robotics and autonomous. This provides training for students from the project results and the participation of many of them, particularly since the Masters thesis, in the research itself.

- **Master Thesis**

- Optimization of aviation turbine efficiency with thermodynamics genetic algorithms. Author: J.M. Chaquet Uldemolins. Supervisor: E.J. Carmona Suárez. 2010.
- Initialization of a background model oriented to moving objects segmentation in video sequences. Author: J.M. Carmona. Director: E.J. Carmona Suárez. 2010.
- Detection of human presence in video sequences based in skin pixel search. Author: L. Collados. Director: E.J. Carmona Suárez. 2009.
- Automatic tuning of the weights of the fitness function of a genetic algorithm with supervised learning. Author: J.M. Molina Casado. Supervisor: E.J. Carmona Suárez. In preparation.
- Classification of individuals through facial recognition. Author: A. Moreno Fernández de Leceta. Supervisor: M. Rincón Zamorano. 2008.
- Analysis of dynamic scenes by Bayesian nets based in the BB6-HM model. Author: M. Tolós Rigueiro. Supervisor: M. Rincón Zamorano. 2008.
- Intelligent recognition of drowsiness using HMMs. Author: P. García Sanchís. Supervisor: Mariano Rincón Zamorano. In preparation.

- **Research Scholarship holders and Contracted:**

- Angel Rivas Casado, David Ortégón Tesías, José Juan Alócén Martínez and Manuel Martín Ortíz have been contracted to participate in the implementation of the prototypes.

3.2.2 Technology transfer

- Contract Art. 83 LOU. "Feasibility study for detecting Alzheimer through resonances". Principal researcher: Mariano Rincón Zamorano. Contracting company: DEIMOS SPACE S.L. 2008.
- Contract Art. 83 LOU. "Development of an intelligent video system". Principal researcher: Mariano Rincón Zamorano. Contracting company: Tecnoidea. 2009.

3.2.3 Other related research projects

- AVANZA I+D, Official announcement 1/2009. "Image processing tools for early detection of Alzheimer and other dementias". Coordinated by DEIMOS SPACE, S.L. and other five universities are also involved. Total Amount: 619,337 Euros. UNED participation, Supervisor: Mariano Rincón Zamorano. Assigned amount: 38,136 euros. 2009.

3.2.4 Publications

Journal Papers:

Journal Title	Reference	Status	Impact F.
Neurocomputing	[24], [54], [61], [12], [64]	Published	1.234
	[44], [31]	Submitted	1.234
Robotics and Autonomous Systems	[7]	Submitted	1.214
Engineering Applications of Artificial Intelligence	[14]	Published	1.397
Expert Systems	[36], [65]	Submitted	0.717

Conference Papers:

Conference Proceedings	Reference
Lecture Notes in Computer Science CAEPIA-TIIA (CLAI)	[17], [53], [55], [56], [49], [32], [67], [58], [43], [51], [1], [13] [66]

3.2.5 Research Collaborations

We are collaborating with Dr. Ángel Sánchez and Dr J.J. Pantrigo of the Universidad Rey Juan Carlos in representation spaces in neuroscience and computation. In particular in visual tracking is based on a synergic combination of strategies coming from particle filters and population-based metaheuristics. We are starting a collaboration with the POLAR group of INRIA and students of our group have already started research stays in facilities run by François Bremond. Currently we are collaborating with the School of Electronics and Communications at the Universidad Técnica Particular de Loja (Ecuador) so that it can expand its assistance to students in our master's degree thesis and can perform with our group. Both the relationship and with the UTPL and POLAR undoubtedly lead to a greater internationalization, participation and distribution of project and new projects for doctoral theses.

We are working with research groups at the University of Castilla-La Mancha, University of Zaragoza, Center for Biomedical Technology of the Polytechnic University of Madrid and the Neuroscience Unit at the Public University of Navarra in the project progresses: image processing tools for early detection of Alzheimer and other dementias.

Mariano Rincón Zamorano was granted a scholarship by the NILS Mobility Project for a stay of 6 months with Dr. Atle Bjørnerud, Rikshospitalet University Hospital, Norway, to study new techniques of brain image registration.

3.2.6 Other Activities

- Activities for the organization of the international conference IWINAC-2009, June, Santiago de Compostela. Ministerio de Ciencia e Innovación. TIN2008-02513-E. 2009.

References

- [1] Álvarez-Sánchez, J. R., de la Paz-López, F., Cuadra-Troncoso, J.M. & Rosado, J.I. (2009). Partial center of area method used for reactive autonomous robot navigation. Lecture Notes in Computer Science, 5602, 408-418.
- [2] Alvarez, J.R, Mira, J., de la Paz, F. & Cuadra-Troncoso, J.M. (2007). The centre of area method as a basic mechanism for representation and navigation. Robotics and Autonomous Systems, 55(12) 860-869.
- [3] Carmona, J.M. (2010). Initialization of a background model oriented to moving objects segmentation in video sequences. Master Thesis dissertation. UNED.
- [4] Carmona, E., Rincón, M., Bachiller, M., Martínez-Cantos, J., Martínez-Tomás, R. & Mira, J. (2009). On the effect of feedback in multilevel representation spaces for visual surveillance tasks. Neurocomputing, 72(4-6), 916-927.
- [5] Casals, A. & Fernández-Caballero, A. (2007). Robotics and Autonomous Systems in the 50th Anniversary of Artificial Intelligence. Robotics and Autonomous Systems, 55(12), 837-839.
- [6] Castillo, J.C., Serrano-Cuerda, J. & Fernández-Caballero, A. (2010). Robust people segmentation by static infrared surveillance camera. In press, Lecture Notes in Computer Science.
- [7] Castillo, J.C., Serrano-Cuerda, J., Fernández-Caballero, A. & Alvarez, J.R. (2010). Optical flow estimation or image differencing: Moving object detection from infrared camera on mobile robot. Submitted, Robotics and Autonomous Systems.
- [8] Castillo, J.C., López, M.T. & Fernández-Caballero, A. (2009). Vision-based text segmentation system for generic display units. Lecture Notes in Computer Science, 5602, 334-343.
- [9] Castillo, J.C., Serrano-Cuerda, J., Fernández-Caballero, A. & López, M.T. (2009). Segmenting humans from mobile thermal infrared imagery. Lecture Notes in Computer Science, 5602, 225-234.
- [10] Collados, J. (2009). Detection of human presence in video sequences based in skin pixel search. Master Thesis dissertation. UNED.
- [11] Cuadra-Troncoso, J.M. (2010) Creating multimodal virtual sensors for monitoring and diagnosis in advanced visual surveillance environments. PhD Thesis dissertation. ETSII. UNED.
- [12] Cuadra-Troncoso, J.M., Álvarez-Sánchez, J.R. & de la Paz-López, F. (2009). Discretized ISO-learning neural network for obstacle avoidance in reactive robot controllers. Neurocomputing, 72, 861-870.
- [13] de la Paz-López, F., Álvarez-Sánchez, J.R., Rosado-Sánchez, J.I. & Cuadra-Troncoso, J.M. (2009). Mathematical foundations of the center of area method for robot navigation. Lecture Notes in Computer Science, 5602, 419-428.
- [14] Delgado, A.E., López, M.T. & Fernández-Caballero, A. (2010). Real-time motion detection by lateral inhibition in accumulative computation. Engineering Applications of Artificial Intelligence, 23(1), 129-139.
- [15] Fernández-Caballero, A., Gámez, J.A., Córdón, O. & Hoffmann, F. (2010). The impact of soft computing for the progress of artificial intelligence. In press, Applied Soft Computing.

- [16] Fernández-Caballero, A., Castillo, J.C., Serrano-Cuerda, J. & Maldonado-Bascón, S. (2010). Real-time human segmentation in infrared videos. Submitted, Expert Systems with Applications.
- [17] Fernández-Caballero, A., Castillo, J.C., Serrano-Cuerda, J. & Maldonado-Bascón, S. (2010). Evaluation of colour video segmentation by lateral inhibition in accumulative computation. Submitted, Pattern Recognition Letters.
- [18] Fernández-Caballero, A. (2009). Contribution of fuzziness and uncertainty to modern artificial intelligence. *Fuzzy Sets and Systems*, 160(2), page 129.
- [19] Fernández-Caballero, A. & Gascueña, J.M. (2009). Developing multi-agent systems through integrating Prometheus, INGENIAS and ICARO-T. *Communications in Computer and Information Science*, 67, 219-232.
- [20] Fernández-Caballero, A., López, M.T. & Castillo, J.C. (2009). Display text segmentation after learning best-fitted OCR binarization parameters. Submitted, Machine Vision and Applications.
- [21] Fernández-Caballero, A., López, M.T., Castillo, J.C. & Maldonado-Bascón, S. (2009). Real-time accumulative computation motion detectors. *Sensors*, 9(12), 10044-10065.
- [22] Fernández-Caballero, A., López, M.T., Fernández, M.A. & López-Valles, J.M. (2009). Revisiting algorithmic lateral inhibition and accumulative computation. *Lecture Notes in Computer Science*, 5601, 57-66.
- [23] Fernández-Caballero, A., Gómez, F.J. & López-López, J. (2008). Road-traffic monitoring by knowledge-driven static and dynamic image analysis. *Expert Systems with Applications*, 35(3), 701-719.
- [24] Fernández-Caballero, A., Mira, J. & Deco, G. (2008). 50 years of Artificial Intelligence: A neuronal approach. *Neurocomputing*, 71(4-6), 667-669.
- [25] Fernández-Caballero, A., López, M.T. & Saiz-Valverde, S. (2008). Dynamic Stereoscopic Selective Visual Attention (DSSVA): Integrating motion and shape with depth in video segmentation. *Expert Systems with Applications*, 34(2), 1394-1402.
- [26] Fernández-Caballero, A., Sanfeliú, A. & Shirai, Y. (2008). Pattern recognition in interdisciplinary perception and intelligence. *Pattern Recognition Letters*, 29(8), 1021-1023.
- [27] Fernández-Caballero, A., Fernández, M.A., López, M.T. & Gómez, F.J. (2007). Step-by-step description of lateral interaction in accumulative computation. *Lecture Notes in Computer Science*, 4692, 518-525.
- [28] Fernández-Caballero, A., Gómez, F.J. & López-López, J. (2007). Knowledge-based road traffic monitoring. *Lecture Notes in Computer Science*, 4528, 182-191.
- [29] Fernández-Caballero, A., López, M.T., Mira, J., Delgado, A.E., López-Valles, J.M. & Fernández, M.A. (2007). Modelling the stereovision-correspondence-analysis task by lateral inhibition in accumulative computation problem-solving method. *Expert Systems with Applications*, 33(4), 955-967.
- [30] Fernández-Caballero, A., Pérez-Jiménez, R., Fernández, M.A. & López, M.T. (2007). Comparison of accumulative computation with traditional optical flow. *Lecture Notes in Computer Science*, 4692, 447-454.
- [31] Folgado, E., Rincón, M., Carmona, E.J. & Bachiller, M. (2009). A block-based model for monitoring of human activity in surveillance applications. Submitted, Neurocomputing.
- [32] Folgado E., Rincón-Zamorano, M., Bachiller-Mayoral, M. & Carmona, E.J. (2009). A block-based human model for visual surveillance. *Lecture Notes in Computer Science*(5602) 208-215.
- [33] García Jiménez, A.S. (2010). New interaction techniques close to collaborative virtual environments. PhD Thesis dissertation. UCLM.
- [34] Garijo, F.J., Polo, F., Spina, D. & Rodriguez, C. (2008). ICARO-T. Manual de uso de los componentes.
- [35] Gascueña, J.M. & Fernández-Caballero, A. (2010). On the use of agent technology in intelligent, multi-sensory and distributed surveillance. In press, *The Knowledge Engineering Review*.
- [36] Gascueña, J.M., Fernández-Caballero, A., Delgado, A.E. & Martínez-Tomás, R. (2010). Knowledge modelling through computational agents: Application to surveillance systems. Submitted, Expert Systems.
- [37] Gascueña, J.M., Fernández-Caballero, A. & Garijo, F.J. (2010). Developing multi-agent systems through integrating Prometheus, INGENIAS and ICARO-T. In press, *Advances in Practical Applications of Agents and Multiagent Systems: 8th International Conference, Advances in Intelligent and Soft Computing Series*.
- [38] Gascueña, J.M. & Fernández-Caballero, A. (2009). Agent-oriented modelling and development of a person-following mobile robot. Submitted, Expert Systems with Applications.
- [39] Gascueña, J.M. & Fernández-Caballero, A. (2009). Agent-based modelling of a mobile robot to detect and follow humans. *Lecture Notes in Computer Science*, 5559, 80-89.
- [40] Gascueña, J.M. & Fernández-Caballero, A. (2008). Prometheus and INGENIAS agent methodologies: A complementary approach. *Lecture Notes in Computer Science*, 5386, 131-144.
- [41] Gascueña, J.M. & Fernández-Caballero, A. (2007). The INGENIAS methodology for advanced surveillance systems modelling. *Lecture Notes in Computer Science*, 4528, 541-550.
- [42] Gómez, H. (2010). High-level interpretation of video sequences using ontologies. PhD Thesis dissertation. UNED.
- [43] Insausti, R., Rincón-Zamorano, M., González-Moreno, C., Artacho-Pérula, E., Díez-Peña, A. & García-Saiz, T. (2009). Neurobiological significance of automatic segmentation: application to the early diagnosis of alzheimer. *Lecture Notes in Computer Science*, 5602, 134-141.
- [44] López, M.T., Fernández-Caballero, A., Fernández, M.A. & Carmona, E.J. (2010). History of algorithmic lateral inhibition and accumulative computation in computer vision. Submitted, Neurocomputing.
- [45] López, M.T., Fernández-Caballero, A., Fernández, M.A., Mira, J. & Delgado, A.E. (2007). Dynamic visual attention model in image sequences. *Image and Vision Computing*, 25(5), 597-613.
- [46] López, M.T., Fernández-Caballero, A., Fernández, M.A., Mira, J. & Delgado, A.E. (2007). Algorithmic lateral inhibition formal model for real-time motion detection. *Lecture Notes in Computer Science*, 4739, 638-645.

- [47] López-Valles, J.M., Fernández, M.A. & Fernández-Caballero, A. (2007). Stereovision depth analysis by two-dimensional motion charge memories. *Pattern Recognition Letters*, 28(1), 20-30, Enero 2007.
- [48] Maldonado-Bascón, S., Acevedo-Rodríguez, J., Lafuente-Arroyo, S., Fernández-Caballero, A. & López-Ferreras, F. (2010). An optimization on pictogram identification for the road-sign recognition task using SVMs. *Computer Vision and Image Understanding*, 114, 373-383.
- [49] Martín-Gómez, D., Rincón-Zamorano M., García-Alegre M. C. & Guinea- Díaz, D. (2009). ARDIS: Knowledge-based Dynamic Architecture for Real-Time Surface Visual Inspection. *Lecture Notes in Computer Science*, 5601, 395-404.
- [50] Martínez-Cantos, J., Carmona, E.J., Fernández-Caballero, A. & López, M.T. (2008). Parametric improvement of lateral interaction in accumulative computation in motion-based segmentation. *Neurocomputing*, 71(4-6), 776-786.
- [51] Martínez-Tomás, R. & Rivas-Casado A. (2009). Knowledge and event-based system for video-surveillance tasks. *Lecture Notes in Computer Science*, 5601, 386-394.
- [52] Mira, J. & Delgado, A.E. (2009). Sensory representation spaces in neuroscience and computation. *Neurocomputing*, 72 (4-6), 793-805.
- [53] Mira, J., Delgado, A.E., Fernández-Caballero, A., Gascueña, J.M. & López, M.T. (2009). Computational agents to model knowledge - Theory, and practice in visual surveillance. *Lecture Notes in Computer Science*, 5601, 375-385.
- [54] Mira, J., Delgado, A.E., López, M.T., Fernández-Caballero, A. & Fernández, M.A. (2008). A conceptual frame with two neural mechanisms to model selective visual attention processes. *Neurocomputing*, 71(4-6), 704-720.
- [55] Mira, J., Delgado, A.E., Fernández-Caballero, A., López, M.T. & Fernández, M.A. (2007). The underlying formal model of algorithmic lateral inhibition. *Lecture Notes in Computer Science*, 4528, 119-129.
- [56] Mira, J., Martínez-Tomás, R., Rincón, M., Bachiller, M. & Fernández-Caballero, A. (2007). Towards a semi-automatic situation diagnosis system in surveillance tasks. *Lecture Notes in Computer Science*, 4528, 90-98.
- [57] Molina Massó, J.P. (2008). Development of three-dimensional user interfaces. A proposal for a methodological environment for development. PhD Thesis dissertation. UCLM.
- [58] Moreno-Fdz. de Leceta, A. & Rincón-Zamorano, M. (2009). Access control to security areas based on facial classification. *Lecture Notes in Computer Science*, 5602, 254-263.
- [59] Moreno-García, J., Rodríguez-Benitez, L., Fernández-Caballero, A. & López, M.T. (2010). Video sequence motion tracking by fuzzification techniques. *Applied Soft Computing*, 10(1), 318-331.
- [60] Padgham, L. & Winikoff, M. (2004). *Developing Intelligent Agent Systems: A Practical Guide*. John Wiley.
- [61] Pantrigo, J.J., Sánchez, A. & Mira, J. (2009). Representation spaces in a visual-based human action recognition system. *Neurocomputing*, 72(4-6), 901-915.
- [62] Pavón, J., Gómez-Sanz, J.J., Fernández-Caballero, A. & Valencia-Jiménez, J.J. (2007). Development of intelligent multi-sensor surveillance systems with agents. *Robotics and Autonomous Systems*, 55(12), 892-903.
- [63] Pavón, J., Gómez-Sanz, J.J. & Fuentes, R. (2005). The INGENIAS methodology and tools. *Agent-Oriented Methodologies*, chapter IX, 236-276.
- [64] Rincón, M., Bachiller, M., Martínez-Cantos, J., Martínez-Tomás, R. & Mira J. (2009). On the effect of feedback in multilevel representation spaces for visual surveillance tasks. *Neurocomputing*, 72(4-6), 916-927.
- [65] Rivas-Casado, A., Martínez-Tomás, R. & Fernández-Caballero, A. (2010) Multiagent system for event recognition and composition. Submitted, *Expert Systems*.
- [66] Rivas-Casado, A. & Martínez-Tomás, R. (2009) Metodología de composición de eventos basada en reglas. Workshop on Computational Logics and Artificial Intelligence (CLAI) in CAEPIA-TIHA.
- [67] Sánchez-Cesteros, O. & Rincón-Zamorano, M. (2009). Image equilibrium: A Global image property for human-centered image analysis. *Lecture Notes in Computer Science*, 5602, 216-224.
- [68] Schmidt, D.C (2006). Guest Editor's Introduction: Model-Driven Engineering. *Computer*, 39(2), 25-31.
- [69] Sokolova, M.V. (2010). DeciMaS: An Agent-based Interdisciplinary Framework for Decision Making in Complex Systems. PhD Thesis dissertation. UCLM.
- [70] Sokolova, M.V. & Fernández-Caballero, A. (2009). Modeling and implementing an agent-based environmental health impact decision support system. *Expert Systems with Applications*, 36(2), Part 2, 2603-2614.
- [71] Sokolova, M.V. & Fernández-Caballero, A. (2009). Multi-agent-based system technologies in environmental issues. *Information Technologies in Environmental Engineering II*, 549-562.
- [72] Sokolova, M.V. & Fernández-Caballero, A. (2008). Agent-based decision making through intelligent knowledge discovery. *Lecture Notes in Computer Science*, 5179, 709-715.
- [73] Sokolova, M.V. & Fernández-Caballero, A. (2008). Facilitating MAS complete life cycle through the Protégé-Prometheus approach. *Lecture Notes in Computer Science*, 4953, 73-82.
- [74] Sokolova, M.V. & Fernández-Caballero, A. (2007). A meta-ontological framework for multi-agent systems design. *Lecture Notes in Computer Science*, 4528, 521-530.
- [75] Sokolova, M.V. & Fernández-Caballero, A. (2007). An agent-based decision support system for ecological-medical situation analysis. *Lecture Notes in Computer Science*, 4528, 511-520.
- [76] Tolós, M. (2008). Analysis of dynamic scenes by Bayesian nets based in the BB6-HM model. Master Thesis dissertation. UNED.
- [77] Valencia-Jiménez, J.J. & Fernández-Caballero, A. (2008). Holonic multi-agent system model for fuzzy automatic speech / speaker recognition. *Lecture Notes in Computer Science*, 4953, 63-72.