# TEP-108. RTCAR: Robotics and Technology of Computers for Rehabilitation Lab.[1]

The RTCAR group is working in Robotic, Embedded Architecture Systems for Real-Time and Computer Networks since 1984. Since 1990 this group is working also in assistive technologies for people with disabilities. Concerning Robotics, the RTCAR group has carried out several Research projects with the Spanish Plan of Advanced Production Technologies (and with the Robotic and Advanced Automation before that). To highlight some of them: "Universal Robot Controlled by Microprocessor" (1984/87), "Flexible Cell Multi-Robot with Sensorial Capacity" (1987/90), "Multi-Robot System with Coordination by Shared Exclusive Zones" (1993/96), etc.

In the 90s, the research of the group was focused in part in bus adaptation (and networks) for all computing system layers (hardware and software). This field gave as result several PhD thesis and research works (master thesis) of several members. They studied and researched in the bus adaptation field (bridges and emulation) long before the PCI bus made the topic popular with the release of PCI-ISA bridges. During those years, RTCAR dedicated most efforts to the study, design and implementation of these kinds of interfaces. On the other hand, since its beginning, the group has designed, developed and used more than 15 types of PCBs for ISA/PCI buses (some of them used by important companies like Navantia).

The RTCAR group has a considerable experience in hardware design and implementation. For instance, in a research line related to AER based spiking neuro-inspired systems, four projects funded by Spanish research programs (VICTOR, SAMANTA,SAMANTA2 and VULCANO) and another one by an European program (CAVIAR) included the design of a set of interfaces (based on FPGAs) for testing and debugging bio-inspired systems; an artificial vision system based on Real-Time convolutions; a general-purpose infrastructure for supporting bio-inspired, multilayer systems; and the connectivity elements between the AER modules and the digital systems of a robotic platform used for sensing and visual processing with a set-up of a hand-arm anthropomorphic robot. This research line had also another continuation in period 2012 to 2014 with the BIOSENSE project. The BIOSENSE project intends to build a bioinspired sensing-processing-actuating robotic platform based on modular AER technology. In that platform, the visual-motor coordination among several cameras for 3D vision, auditive cochleas and motor actuation on a high number of motors (more than 10) should be virtually instantaneous, with delays in the order of mili seconds or even lower. This platform will allow us to face problems of auditive and 3D visual sensing, sensory fusion, processing and decision taking, as well as motor actuation, still unsolved in the field of survaillance and robotics.

Since 1990, the group has been focused also in the field of Computerized Help of People with Disabilities. Thus in 1991 and 1995 two agreements were signed to design and develop "Technical Aids for the Mobility and Communication of Physically Disabled people" between the Andalusian Institute of Social Services and the University of Seville. In these agreements among other things several prototypes were developed for embedded control systems for wheel-chairs that culminated in the IASS-US SIRIUS Wheelchair. The group has also participated in several projects in the framework of the Spanish Integrated Projects in Rehabilitation Technology (PITER project of the Interministery Commission of Science and Technology, CICYT) in collaboration with other institutions. These projects ("Tetranauta I: Intelligent Control Unit for Standard Electric Wheelchair", "Tetranauta II" and "Tetranauta III") culminated with the implementation of an Intelligent Control Unit for standard electric wheelchair with functions of path following very useful for users of large buildings (like the National Hospital of Paralytics of Toledo used in the trials) or at home. As a recognition of this design, Tetranauta was considered one of the most relevant smart electric wheelchairs in the world, as shown in a review appeared in April 2005 in the prestigious journal "IEEE Control Systems Magazine". Finally, regarding to technical aids the group has collaborated

1 RTCAR web page: http://rtc.us.es

in two projects designing voice based interfaces (projects EFESTO and FLEX). The group has also been active in the field of universal accessibility (participating in the EU Cost 219bis and Cost219ter actions) and has been responsible for two projects related to the assesment and improvement the University of Seville web portal accessibility. In this area it has also worked in the accessibility of eLearning systems. The research group has participated in the EU project CARDIAC (ref.248582, ICT-2009.7.2 Accessible and Assistive ICT). It aims to create a platform that can bring together the various stakeholders in the area of accessible and assistive ICT with a view of identifying R&D gaps and emerging trends and generating a research agenda roadmap.

Currently it is participating in the EU project Game Up (http://www.gameupproject.eu). Game Up project apply technologies that have been shown to be effective to modify behaviours and motivate: persuasive technologies, serious games and social computing. These technologies will be used to promote mobility by encouraging elderly persons to be more physical active and motivating them to move more by increasing their self-efficacy.

RTCAR has also been involved in the study and development of heterogeneous local area and wireless networks and in the access to services and mobile devices. Several projects have been carried out in this line: HETERORRED, DOMOSILLA and AmbienNet. HETERORRED (TIC2001-1868-C03-02) formalized the design of bridges between wireless networks to other buses: wire based (CAN or DX), power- line based or infrared based. The final objective is the application and integration of heterogeneous functional subsystems through their corresponding bridges. In DOMOSILLA (TIC2000-0087-P4-01), RTCAR leaded a study, evaluation and design of an interconnection system between Local Area Network of a Wheel-chair (DX bus) and a Domotic network (the EHS network) was designed and developed. The main idea of this project was to allow a wheelchair user to operate the different devices connected to a Domotic EHS network at their home with the controller integrated in their wheelchairs used initially to drive the chair. In this project, the group designed a compatible DX bus device to capture the chair controller orders and transmit them through a RF link to a EHS controller. AmbienNet (TIN2006-15617-C03-03) project aims to demonstrate the viability of navigation systems to assist users with and without disabilities supported by intelligent environments. A multi-cell indoors people localization system and a network of sensors and intelligent wheelchairs (acting like autonomous mobile platforms) has been developed. Project P06-TIC-02298, supported by the Junta de Andalucía, complements the AmbienNet project by focusing on the navigation of wheelchairs using a wireless network of external sensors. Thorugh the Agreement with Telefonica (Contrato 68/83: 0399/0228), RTCAR has been recently involved in the design of Persuasive Systems to promote exercising through the use of virtual environments. The system, named “Virtual Valley” and based on the Oracle’s Wonderland technology, has been recently selected as one of the outstanding developments based on this technology in the Open Wonderland blog: http://blogs.openwonderland.org/2010/11/23/virtual-valley-e-health-application/.

Finally, it is worth to mention that the RTCAR group is a member of : EDeAN - European Design for All e-Accessibility Network (www.edean.org); the spanish « Red Nacional de Centros de Excelencia en Diseño para Todos »; the « Red Española de eCiencia » (supercomputing group); and the « Red iberoamericana RETADIM -Red Telemática de Tecnologías de Apoyo a Discapacitados y Mayores » (www.retadim.org).

Some of the papers that have been published by the members of the research team during the recent years are:


- Perez-Peña F, Morgado-Estevez A, Linares-Barranco A, Jimenez-Fernandez A, Gomez-Rodriguez F, Jimenez-Moreno G, Lopez-Coronado J. Neuro-Inspired Spike-Based Motion: From Dynamic Vision Sensor to Robot Motor Open-Loop Control through Spike-VITE. Sensors. 2013; 13(11):15805-15832.
- Pablo Iñigo-Blasco, Fernando Diaz-del-Rio, Ma Carmen Romero-Ternero, Daniel Cagigas-Muñiz, Saturnino Vicente-Diaz, Robotics software frameworks for multi-agent robotic systems development, Robotics and Autonomous Systems, Volume 60, Issue 6, June 2012, Pages 803-821, ISSN 0921-8890.

- Juan Luis Font, Pablo Iñigo, Manuel Dominguez, Jose Luis Sevillano, Claudio Amaya. Analysis of source code metrics from ns-2 and ns-3 network simulators. Simulation Modelling Practice and Theory 19 (2011) 1330–1346
- A. Marco, R. Casas, J.L. Sevillano, V.Coarasa, A. Asensio and M.S. Obaidat. “Synchronization of Multi-hop Wireless Sensor Networks at the Application layer”. IEEE Wireless Communications. 18 (2011) 82-88.
- D. Cascado, S. Romero, S. Hors, A. Brasero, L. Fernández-Luque, J. L. Sevillano. Virtual Worlds to enhance Ambient-Assisted Living. 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society. Pages: 212-215. Buenos Aires, Argentina. August-Sept. 2010
- Daniel Cascado, Jose Luis Sevillano, Luis Fernandez-Luque, Karl Johan Grøttum, Lars Kristian Vognild, Tatjana M. Burkow. Standards and implementation of pervasive computing applications. In Pervasive Computing and Networking, Mohammad S. Obaidat, Mieso Denko, and Isaac Woungang (Eds.), John Wiley & Sons, Ltd., UK., In Press (2011).
- J. Barbancho, D. Cascado, J. L. Sevillano, C. León, A. Linares y F.J. Molina. Cooperation in Wireless Ad-Hoc and Sensor Networks. In *Cooperative Networking* (Eds. M.S. Obaidat and S. Misra). In press.
- J. Abascal, A. Lafuente, A. Marco, J.M. Falcó, R. Casas, J.L. Sevillano, D. Cascado and C. Luján. “An architecture for assisted navigation in intelligent environments”. Int. J. Communication Networks and Distributed Systems, Vol. 4, No. 1 pp. 49-69, 2010
- Diaz del Rio, F, Sevillano, J.L, Vicente, S, Jiménez, G, Civit, A. Chrono-Scheduling: a Simplified Dynamic Scheduling Algorithm for Timing Predictable Processors. JOURNAL OF CIRCUITS, SYSTEMS AND COMPUTERS, vol 18, pp. 387-406, 2009.
- F. Díaz-del-Río, D. Cagigas, J. L. Sevillano, S. Vicente, D. Cascado. Error Adaptive Tracking for Backstepping Controllers: Application to Mobile Robots. 40th International Symposium on Robotics (ISR 2009). Pages: 303-308. Barcelona, Marzo 2009
- R.Serrano, T.Serrano, A.Acosta, C,Serrano, J.A.Pérez, L.Camuñas, B.Linares, A.Linares, G.Jiménez, A.Civit. On Real-Time AER 2D Convolutions Hardware for Neuromorphic Spike Based Cortical Processing. IEEE TRANSACTIONS ON NEURAL NETWORKS, vol. 19, pp. 1196- 1219, 2008.
- Linares-Barranco, M. Oster, D. Cascado, G. Jiménez, A. Civit and B. Linares-Barranco. Inter-spike-intervals analysis of AER Poisson-like generator hardware. Neurocomputing, Vol. 70, Issues 16-18, October 2007, Pages 2692-2700.
- Linares Barranco, G. Jimenez, B. Linares Barranco, A. Civit: On Algorithmic Rate-Coded Aer Generation. IEEE Transactions on Neural Networks . Vol. 17. Núm. 3. 2006. Pag. 771-788.
- J.L. Sevillano, D. Cascado, F. Diaz Del Rio, S. Vicente, G. Jimenez, A. Civit-Balcells. "Soft Real-Time Communications over Bluetooth under Interferences from ISM Devices". International Journal of Communication Systems. Vol. 19-10, pp. 1103- 1116. December 2006.

# Training capacity

RTCAR group is currently composed of 16 faculty members from the Computer Architecture Department (ATC) of the University of Seville and 2 PhD students with fellowships (supported by the University of Sevilla and Junta de Andalucia, respectively). 11 out of the 16 faculty members have a PhD. These faculty members (among them 1 "Catedrático de Universidad" and 5 "Profesores Titulares") teach, among other subjects, in the University of Seville's "Industrial Informatics" PhD program, in the Master on "Software Engineering and Technology", the Master on "Computer and Network Tecnology", as well as in the Endesa-University of Seville's Master on "Management of Information and Communication Technology". In recent years, 5 PhD theses and 14 Master theses (Advanced Studies Diplomas) have been defended in the ATC Department, all of them being supervised by RTCAR members. Also, tens of End-of-Study projects in Computer Science and Engineering have been supervised by RTCAR members, including 2 FIDETIA (Foundation for the Research and Development of the Information Technologies in Andalusia) awards (2008 and 2009) and the 2º National Award for End-of-Study projects by Sun Microsystems (2009). Additionally, two of the RTCAR members serve as Academic Mentors of the Student Chapters at the University of Sevilla of the IEEE (www.ieee.org) and the SCS (www.scs.org) (Gabriel Jiménez and Daniel Cascado, respectively).

In last six years RTCAR group has included 12 research scholarship fellows, funded by EU projects and by several companies (Telefonica S.A., MP Ascensores, etc.). Also, several research scholarship fellows have been sent particularly to our group (from institutions like the "Institut Universitaire de Technologie de Montpellier", the "Institut für Neuroinformatik (INI)" of Zurich, etc.) to work on their Master thesis projects and have been trained under the supervision of RTCAR members. There are also strong collaborations with other international teams and institutions like Tromsø Telemedicine Laboratory and Norut (Northern Research Institute) in Norway (Research Director Lars K. Vognild), Monmouth University (Prof. M.S. Obaidat), SCS- The Society of Modeling and Simulation International (José Luis Sevillano currently serves as Vice-President for Membership, which includes the responsibility on all the Student Chapters all over the world), etc. Also, members of the RTCAR group have also served in relevant roles (Program Chair, co-Chair, Publications Chair, TPC member, etc.) in international conferences like ACS/IEEE AICCSA, SPECTS, IEEE ICC, IEEE Globecom, etc. All this experience justifies the training and educational capacity of our research group, and it also justifies its international renown.

Finally, the RTCAR group wants to stress the relations that it has with several companies in the industrial environment through agreements and projects. These have allowed that part of the doctoral scholar and research fellows formed and trained in our laboratories have acquired the adequate profile for being integrated in the work-teams of these companies.