C3
A SHORT CURRICULUM OF THE ROBOTICS AND TECHNOLOGY OF COMPUTER LAB.

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RESUMEN

Nuestro grupo de investigación está liderado por el profesor Civit. Somos un grupo multidisciplinar de 23 investigadores que realizan su labor docente e investigadora en la Escuela Politécnica Superior y en Escuela de Ingeniería Informática. Las principales líneas de investigaciones son: a) Robótica industrial y móvil. b) Procesamiento neuro-inspirado basado en pulsos electrónicos. c) Sistemas empotrados y de tiempo real. d) Arquitecturas paralelas y de procesamiento masivo. e) Tecnología de la información aplicada a la discapacidad, rehabilitación y a las personas mayores. f) Usabilidad y accesibilidad Web.

En este artículo se reseña la historia del grupo y se resumen las principales publicaciones y proyectos que ha conseguido en los últimos años.

Palabras clave: Robótica, Procesamiento neuro-inspirado, Sistemas empotrados, Arquitecturas paralelas, Tecnología para la rehabilitación. Usabilidad y accesibilidad Web.

ABSTRACT

Our research Lab is directed by Prof. Anton Civit. It is an interdisciplinary group of 23 researchers that carry out their teaching and researching labor at the Escuela Politécnica Superior (Higher Polytechnic School) and the Escuela de Ingeniería Informática (Computer Engineering School). The main research fields are: a) Industrial and mobile Robotics, b) Neuro-inspired processing using electronic spikes, c) Embedded and real-time systems, d) Parallel and massive processing computer architecture, d) Information Technologies for rehabilitation, handicapped and elder people, e) Web accessibility and usability

In this paper, the Lab history is presented and its main publications and research projects over the last few years are summarized.

Keywords: *Robotics, Neuro-inspired processing, Embedded systems, Parallel architecture, Rehabilitation Technologies, Web accessibility and usability*

INTRODUCTION

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, several projects funded by Spanish research programs (VICTOR, SAMANTA, SAMANTA2, VULCANO, BIOSENSE) 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.

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 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 assessment 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 behaviors and motivation: 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. Through 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 summarized in the next section. This papers can be referenced through the RTC Lab web page [1].

SUMMARY OF MOST RECENT PAPERS

In this section a selected set of the most recent papers published by the members of the research team are summarized.

A Tradeoff Analysis of a Cloud-based robot navigation assistant using stereo image processing

Abstract: The use of Cloud Computing for computation offloading in the robotics area has become a field of interest today. The aim of this work is to demonstrate the viability of cloud offloading in a low level and intensive computing task: a vision-based navigation assistance of a service mobile robot. In order to do so, a prototype, running over a ROS-based mobile robot (Erratic by Videre Design LLC), is presented. The information extracted from on-board stereo cameras will be used by a private cloud platform consisting of 5 bare-metal nodes with AMD Phenom 965 x4 CPU, with the cloud middleware Openstack Havana. The actual task is the shared control of the robot teleoperation, that is, the smooth filtering of the teleoperated commands with the detected obstacles to prevent collisions. All the possible offloading models for this case are presented and analyzed. Several performance results using different communication technologies and offloading models are explained as well. In addition to this, a real navigation case in a domestic circuit was done. The tests demonstrate that offloading computation to the Cloud improves the performance and navigation results with respect to the case where all processing is done by the robot.

Full text:

http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=7052418. IEEE Transactions on Automation Science and Engineering (T-ASE): Special Issue on Cloud Robotics and Automation, vol. pp, no. 99, p. 1-11.

Neuro-Inspired Spike-Based Motion: From Dynamic Vision Sensor to Robot Motor Open-Loop Control through Spike-VITE

Fernando Perez-Peña,*, Arturo Morgado-Estevez, Alejandro Linares-Barranco , Angel Jimenez-Fernandez, Francisco Gomez-Rodriguez,Gabriel Jimenez-Moreno and Juan Lopez-Coronado

Abstract: In this paper we present a complete spike-based architecture: from a Dynamic Vision Sensor (retina) to a stereo head robotic platform. The aim of this research is to reproduce intended movements performed by humans taking into account as many features as possible from the biological point of view. This paper fills the gap between current spike silicon sensors and robotic actuators by applying a spike processing strategy to the data flows in real time. The architecture is divided into layers: the retina, visual information processing, the trajectory generator layer which uses a neuroinspired algorithm (SVITE) that can be replicated into as many times as DoF the robot has; and finally the actuation layer to supply the spikes to the robot (using PFM). All the layers do their tasks in a spike-processing mode, and they communicate each other through the neuro-inspired AER protocol. The open-loop controller is implemented on FPGA using AER interfaces developed by RTC Lab. Experimental results reveal the viability of this spike-based controller. Two main advantages are: low hardware resources (2% of a Xilinx Spartan 6) and power requirements (3.4 W) to control a robot with a high number of DoF (up to 100 for a Xilinx Spartan 6). It also evidences the suitable use of AER as a communication protocol between processing and actuation.

Full text: Sensors 2013, 13(11), 15805-15832

www.mdpi.com/1424-8220/13/11/15805

A Compact Forearm Crutch Based on Force Sensors for Aided Gait: Reliability and Validity

Gema Chamorro-Moriana,*, José Luis Sevillano and Carmen Ridao-Fernández.

Abstract: Frequently, patients who suffer injuries in some lower member require forearm crutches inorder to partially unload weight-bearing. These lesions cause pain in lower limb unloading and theirprogression should be controlled objectively to avoid significant errors in accuracy and, consequently,complications and after effects in lesions. The design of a new and feasible tool that allows us tocontrol and improve the accuracy of loads exerted on crutches during aided gait is necessary, soas to unburden the lower limbs. In this paper, we describe such a system based on a force sensor,which we have named the GCH System 2.0. Furthermore, we determine the validity and reliabilityof measurements obtained using this tool via a comparison with the validated AMTI (AdvancedMechanical Technology, Inc., Watertown, MA, USA) OR6-7-2000 Platform. An intra-class correlationcoefficient demonstrated excellent agreement between the AMTI Platform and the GCH System.A regression line to determine the predictive ability of the GCH system towards the AMTI Platformwas found, which obtained a precision of 99.3%. A detailed statistical analysis is presented for all themeasurements and also segregated for several requested loads on the crutches (10%, 25% and 50% ofbody weight). Our results show that our system, designed for assessing loads exerted by patients onforearm crutches during assisted gait, provides valid and reliable measurements of loads.

Full text: Sensors 2016, 16(6), 925

A game-based approach to the teaching of object-oriented programming languages

José María Rodríguez Corral, Antón Civit Balcells , Arturo Morgado Estévez , Gabriel Jiménez Moreno , María José Ferreiro Ramos.

Abstract: Students often have difficulties when trying to understand the concepts of object-oriented programming (OOP). This paper presents a contribution to the teaching of OOP languages through a game-oriented approach based on the interaction with tangible user interfaces (TUIs). The use of a specific type of commercial distributed TUI (Sifteo cubes), in which several small physical devices have sensing, wireless communication and user-directed output capabilities, is applied to the teaching of the C# programming language, since the operation of these devices can be controlled by user programs written in C#. For our experiment, we selected a sample of students with a sufficient knowledge about procedural programming, which was divided into two groups: The first one had a standard introductory C# course, whereas the second one had an experimental C# course that included, in addition to the contents of the previous one, two demonstration programs that illustrated some OOP basic concepts using the TUI features. Finally, both groups completed two tests: a multiple-choice exam for evaluating the acquisition of basic OOP concepts and a C# programming exercise. The analysis of the results from the tests indicates that the group of students that attended the course including the TUI demos showed a higher interest level (i.e. they felt more motivated) during the course exposition than the one that attended the standard introductory C# course. Furthermore, the students from the experimental group achieved an overall better mark. Therefore, we can conclude that the technological contribution of Sifteo cubes – used as a distributed TUI by which OOP basic concepts are represented in a tangible and a visible way – to the teaching of the C# language has a positive influence on the learning of this language and such basic concepts

A Neuro-Inspired Spike-Based PID Motor Controller for Multi-Motor Robots with Low Cost FPGAs

Angel Jimenez-Fernandez , Gabriel Jimenez-Moreno, Alejandro Linares-Barranco, Manuel J. Dominguez-Morales, Rafael Paz-Vicente and Anton Civit-Balcells

Abstract: In this paper we present a neuro-inspired spike-based close-loop controller written in VHDL and implemented for FPGAs. This controller has been focused on controlling a DC motor speed, but only using spikes for information representation, processing and DC motor driving. It could be applied to other motors with proper driver adaptation. This controller architecture represents one of the latest layers in

a Spiking Neural Network (SNN), which implements a bridge between robotics actuators and spike-based processing layers and sensors. The presented control system fuses actuation and sensors information as spikes streams, processing these spikes in hard real-time, implementing a massively parallel information processing system, through specialized spike-based circuits. This spike-based close-loop controller has been implemented into an AER platform, designed in our labs, that allows direct control of DC motors: the AER-Robot. Experimental results evidence the viability of the implementation of spike-based controllers, and hardware synthesis denotes low hardware requirements that allow replicating this controller in a high number of parallel controllers working together to allow a real-time robot control

Full text: Sensors 2012, 12(4), 3831-3856

Mobile robot motion planning based on Cloud Computing stereo vision processing

Abstract: Nowadays, the limitations of robot embedded hardware (which cannot be upgraded easily) make difficult to perform computationally complex tasks such as those of high level artificial vision. However, instead of disposing these "outdated" embedded systems, Cloud technologies for computation offloading can be used. In this paper we present and analyze an example of computation offloading in the context of artificial vision: point cloud extraction for stereo images. A prototype prepared for exploiting the cloud's unique capabilities (such as elasticity) has been developed, and the inherent issues that appears are explained and addressed

Full text: Conference ISR ROBOTIK 2014

The Shared Control Dynamic Window Approach for Non-Holonomic Semi-Autonomous Robots

Abstract: A shared control method, called Shared Control Dynamic Window Approach is presented. It is inspired in the Dynamic Window Approach (DWA) for autonomous mobile robots. It takes user commands by means of the control interface and provide the most suitable and kinodinamically feasible trajectory that guarantees obstacle avoidance. It provides navigation assistance to drive vehicles in unstructured environments and other scenarios where dynamic constraints play an important role. In order to keep an intuitive control for the user, the intrusiveness of the method varies gradually and proportionally with the danger of collision. Preliminary experiments with users driving vehicles in a simulated world validate the method. Its implementation is public under General Public License.

Full text: Conference ISR ROBOTIK 2014

Neuro-Inspired Spike-Based Motion: From Dynamic Vision Sensor to Robot Motor Open-Loop Control through Spike-VITE

Abstract: In this paper we present a complete spike-based architecture: from a Dynamic Vision Sensor (retina) to a stereo head robotic platform. The aim of this research is to reproduce intended movements performed by humans taking into account as many features as possible from the biological point of view. This paper fills the gap between current spike silicon sensors and robotic actuators by applying a spike processing strategy to the data flows in real time. The architecture is divided into layers: the retina, visual information processing, the trajectory generator layer which uses a neuroinspired algorithm (SVITE) that can be replicated into as many times as DoF the robot has; and finally the actuation layer to supply the spikes to the robot (using PFM). All the layers do their tasks in a spike-processing mode, and they communicate each other through the neuro-inspired AER protocol. The open-loop controller is implemented on FPGA using AER interfaces developed by RTC Lab. Experimental results reveal the viability of this spike-based controller. Two main advantages are: low hardware resources (2% of a Xilinx Spartan 6) and power requirements (3.4 W) to control a robot with a high number of DoF (up to 100 for a Xilinx Spartan 6). It also evidences the suitable use of AER as a communication protocol between processing and actuation.

http://www.mdpi.com/1424-8220/13/11/15805

Stereo Matching: From the Basis to Neuromorphic Engineering

M. Domínguez-Morales, A. Jiménez-Fernández, R. Paz-Vicente, A. Linares-Barranco and G. Jiménez-Moreno.

Abstract: Image processing in digital computer systems usually considers the visual information as a sequence of frames. These frames are from cameras that capture reality for a short period of time. They are renewed and transmitted at a rate between 25 and 30 frames per second (typical real-time scenario).

Digital video processing has to process each frame in order to obtain a filter result or detect a feature on the input. Classical machine vision started using a single camera (A. Rosenfeld, 1969) as a system sensor in order to perform a treatment for each of the frames obtained by that camera. This method provided a controlled environment but it lacks certain aspects from human vision, such as 3D vision, distance calculation, trajectories, etc.

This work will focus on a relatively new approach to a digital system implementation: this work will introduce the reader to the world of Neuromorphic Engineering as a new paradigm for codifying, process and transmit data.

Finally, the aim of this work is to show a first approach of a stereo vision system using the principles of Neuromorphic Engineering and applying them to solve one important problem in a stereo vision system: the matching process.

Full text: Computer and Information Science » Computer Graphics » "Current Advancements in Stereo Vision", book edited by Asim Bhatti, ISBN 978-953-51-0660-9, Published: July 11, 2012

http://www.intechopen.com/books/current-advancements-in-stereo-vision/stereo-matching-from-the-basis-to-neuromorphic-engineering

Robotics software frameworks for multi-agent robotic systems development

Abstract: Robotics is an area of research in which the paradigm of Multi-Agent Systems (MAS) can prove to be highly useful. Multi-Agent Systems come in the form of cooperative robots in a team, sensor networks based on mobile robots, and robots in Intelligent Environments, to name but a few. However, the development of Multi-Agent Robotic Systems (MARS) still presents major challenges. Over the past decade, a high number of Robotics Software Frameworks (RSFs) have appeared which propose some solutions to the most recurrent problems in robotics. Some of these frameworks, such as ROS, YARP, OROCOS, ORCA, Open-RTM, and Open-RDK, possess certain characteristics and provide the basic infrastructure necessary for the development of MARS. The contribution of this work is the identification of such characteristics as well as the analysis of these frameworks in comparison with the general-purpose Multi-Agent System Frameworks (MASFs), such as JADE and Mobile-C.

Full Text: Robotics and Autonomous Systems. Volume 60, Issue 6, June 2012, Pages 803–821

http://www.sciencedirect.com/science/article/pii/S0921889012000322

GameUp Project on Swiss National TV

Swiss National TV reported last Thursday, 8. May 2014 in their science dedicated television programme "Einstein" on GameUp. You will find the video on the following link:

http://www.srf.ch/player/tv/einstein/video/sturz-risiko-senioren-wappnen-sich-mit-computer-spielen?id=0fba7b39-bd31-48df-a905-b4cf305c282a

CONCLUSION

The RTC Lab is an interdisciplinary group of researchers that carry out their teaching and researching labor at different research fields like Industrial and mobile Robotics, Neuro-inspired processing using electronic spikes, Embedded and real-time systems, Parallel and massive processing computer architecture, Information Technologies

for rehabilitation, handicapped and elder people, Web accessibility and usability, etc. During the last years, it has been consolidated of one of the most productive and best funded of the University of Seville.

REFERENCES

1. RTC Lab. Robotics and Technology of Computer Lab (Web, accessed June 2016). http://www.rtc.us.es/category/publication/papers/