CHAPTER X

AUGMENTED REALITY AND SOCIAL INTERACTION PLATFORM THROUGH MULTIROBOT DESIGN

J. G. VICTORES, S. MORANTE, M. GONZÁLEZ-FIERRO and C. BALAGUER

Robotics Lab, Universidad Carlos III de Madrid jcgvicto@ing.uc3m.es

Gaming environments have proved to be very popular and easily accessible social interaction platforms in a nowadays highly technological and sometimes isolated world. Parallel to this, robotics has tried over the years to provide educational tools to reach closer to younger generations. With this aim in mind, this paper presents the fusion between massively highly distributed video-games and real interaction with actual physical robot platforms, both commercial and amateur ones. The resulting development is a network distributed game called Robot Devastation, which calls for amateurs and professional roboticists to collaborate, play and develop software, hardware and algorithms crossing the bridge between the virtual and real world, making use of cutting-edge technologies like augmented reality and cloud computing.

1 Introduction

The motivation behind this project is the same that led the foundation and management of the ASROB[1] Robotics Society of the Universidad Carlos III de Madrid. These objectives are essentially the following (González-Fierro, 2010):

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[1] ASROB Website: http://asrob.uc3m.es

- To bring robotics closer to society, especially the engineering graduate and undergraduate students from Universidad Carlos III de Madrid.
- To promote educational robotics as a *Do It Yourself* (DIY) activity, which allows the students to put the knowledge learned in formal classes into practice.
- To establish a community of robotics-interested people to collaborate with each other among the lines of research of interest for the society.

Currently, ASROB has more than 270 official members involved, professors, graduates and undergraduates from many Universities of Spain. It has 6 main projects. The UAV project aims to develop and control an autonomous quadcopter. It main purpose is to perform surveillance routines for prevention of natural disasters, inspection and maintenance of infrastructures, citizen safety and assistance in emergency situations. The main task of the ECRO project (acronym for Earth Civil RObot) is to build and control an autonomous mobile robot to perform tasks in the same line of the former project. The Open Source 3D Printer project has created a big community of self made 3D printers. The main purpose is to perform cheap and fast design prototyping. The RPC project (Personal Robots for Competitions) and Mini-humanoid robot project aim to create and control mobile and small humanoid robots for student championships like CEABOT challenge (Jardón, 2008).

The last project, Robot Devastation, is a MMOG (Massively Multiplayer Online Game) mixing real robots and augmented reality with social interaction. Video-games have been identified as unifying across social barriers, promoting individual characteristics, and allowing researchers to measure performance in tasks while being fun and stimulating for participants (Griffiths, 2002). Durkin discovered several measures - including family closeness, activity involvement, positive school engagement, positive mental health, substance use, self-concept, friendship network, and disobedience to parents - in which game players performed better than peers who never played computer games (Durkin, 2002).

However, tutors and teachers must take a positive and active role in ensuring that computer games can be incorporated in education effectively, especially for students' social skills development (Latif, 2009).

The concept and game presents a competitive environment in all the multidisciplinary aspects of robotics, intended for maximizing the enjoyment experienced by the players. Vorderer provided empirical evidence for the role of competition in the playing process and the impact of competitiveness for selective exposure to computer games (Vorderer, 2003). It is important to notice that there is no fixed structure in the game. Robot Devastation has been devised as a social platform where players interact to connect to campaigns and organize tournaments to compete with each other, all based on mutually (or community) agreed rules.

Robot Devastation is the future of online games, a step forward in the industry of entertainment. The player will be able to interact not only with other players via Internet but with the real environment by controlling real robots.

This chapter is ordered as follows. Section 2 explains the robot platform development. Section 3 describes the game software architecture. Section 4 addresses the current development of the project, and finally section 5 summarizes the conclusions.

2 Robotic Platforms

The game is intended to be ubiquitous and platform-independent. However, several robots are being used as proof-of concept platforms, and a small mobile robot is being developed as a plug-and-play device for the application. The following is a description of these devices, in order of growing complexity of development and control.

2.1 Icha-bot

The Icha-bot (see Fig. 1) is the small, minimalistic, mobile robot being developed for Robot Devastation. It is composed by:

- An Arduino FIO board, which is an officially supported 3.3 V Arduino board which additionally includes an on-board LiPo battery charger.
- A WiFly RN 171 module, which is a WiFi Arduino shield that can be mounted directly on the board's Xbee connector and communicate with the board via 3.3 V serial protocol sharing its wireless communications.
- Two Pulse Width Modulation (PWM) controlled micro-servos which have been modified for continuous movement. The PWM is

generated on the board, and the power is taken directly from the battery.

- Two wheels and a back support piece. The wheels and support piece are 3d-printable, and have been designed in OpenSCAD to be parametric and adapt to different motors.
- A 850 mAh LiPo battery.

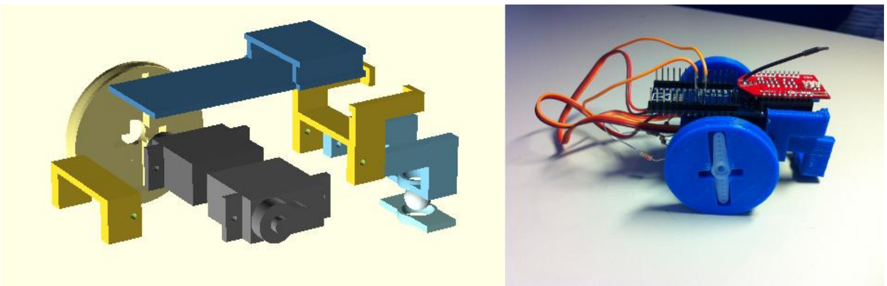

Fig. 1. Icha-bot

2.2 ECRO

The ECRO (acronym for Earth Civil RObot) is a mobile robot composed by several devices, including a laptop and electronics, all mounted on a wheeled base of aluminum (see Fig. 2).

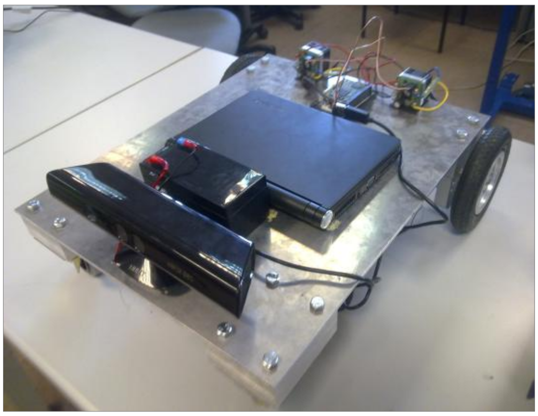

Fig. 2. ECRO

Many devices can be attached to the robot. The ECRO developers change these devices depending on the task or work being developed. For this project, the robot uses the following devices:

- Two electric wheels with 12 V DC motors and 15 cm rubber tires.
- A Lenovo Netbook running over an Ubuntu (a Debian-based GNU/Linux distribution) Operating System. The Netbook provides wireless capabilities to the rest of the system.
- Two HB-25 drivers, that allow controlling the motors as non-linear velocity-controlled servos (by PWM signals) at a 25 A peak current.
- A Skymega board. The Skymega board is an Arduino-compatible evolution of Open Source hardware Skypic board (González-Gómez, 2005). On the ECRO, it serves as meeting point between the Netbook (using a 5V TTL FTDI cable) and the motor drivers (providing their PWM signals).
- A Kinect motion-sensing input device, used as and RGB webcam and as a depth image camera.

All these items are mounted on the base, and are physically connected to each other. Fig. 3 depicts a diagram of these connections.

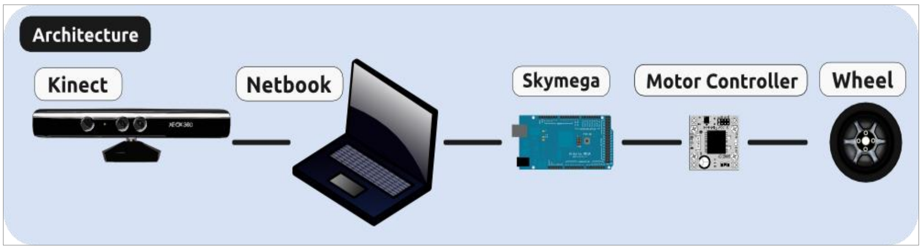

Fig. 3. ECRO connections

The mechanical configuration of ECRO can be seen in Fig. 4. There are two frontal electric wheels and two posterior caster wheels. The electric wheels cannot turn around, so robot movements are based on the Differential Wheels configuration: applying different velocities to each wheel will allow the vehicle to rotate.

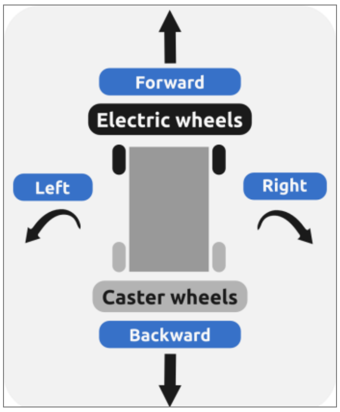

Fig. 4. ECRO movement

Previous to developing game-like technologies, the authors tested web interfaces with ECRO and other robots (Victores, 2011). An HTML web page was provided with buttons to send orders to the wheels' motors. The web interface allowed the possibility of controlling the robot with any electronic device with Internet browsing capabilities.

The visual design was programmed in HTML and JavaScript language, the HTML server was programmed in Python, using the CherryPy library to serve the actual web content, and YARP to send the commands corresponding to the pressed buttons to the actual robot. The different tools were organized in tabs as seen in Fig. 5, including direct motor commands sender, speech recognition, and joypad.

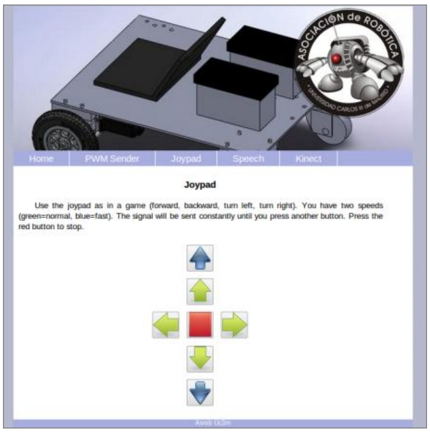

Fig. 5. ECRO Web Interface Joypad Tab

For teleoperation scenarios such as those found in Robot Devastation, additional devices have been used on the end-user's side to provide feedback, closing the loop with the human. This concept is achieved by including, to our devices, a wireless joypad with rumbling capabilities. The range camera and the joypad are linked for the player to “feel” events that are physically happening in a remote location, i.e., when the Kinect device detects the distance from the robot to a wall is too small or even “touching”, the player notices the event and feels the “vibrations” of the joypad. Fig. 6 depicts a diagram of this closed loop behavior.

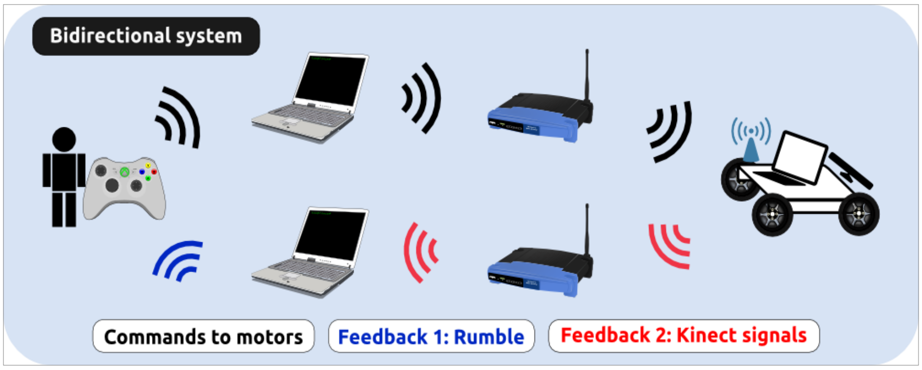

Fig. 6. ECRO communications for rumble feedback

Several teleoperation examples of ECRO can be seen in online videos[2].

2.3 UAV

The UAV (Unmanned Aerial Vehicle, depicted in Fig. 7) started as part of the air civil robots research line of the ASROB Robotics Society. Its main structure is symmetrical with four propellers, a topology commonly known as that of a quadcopter or quadrorotor. Its original, closed-source electronics (belonging to an X600D) has been replaced by an open architecture composed by a Roboard (an embedded x86-compatible PC with PWM outputs) connected to:

- Four 30A GemFan ESCs (Electronic Speed Controllers) that allow control of the four brushless tri-phasic motors similar to that of a velocity-controlled servo as with ECRO.

[2] Online video of ECRO teleoperation examples: http://youtu.be/_9e7dF-dl7I

- A Minoru stereo webcam, for 3D vision.
- A barometric sensor, for measuring altitude.
- A 6-axis inclinometer/accelerator/gyroscope with an additional GPS module.
- A Belkin 802.11g USB module to provide wireless communications. Its extremely common chipset allows extra networking possibilities.

Fig. 7. UAV

The UAV currently flies attached to cables from beneath that act as security lines[3].

3 Software Architecture

The main concept is based on creating a mixed reality environment where all physical agents (real people) and non-physical agents (NPCs, Non-Playing Characters) can interact in the game using physical actors (real robots) or non-physical actors (simulated robots).

At the low level, each device communicates with its master through the protocols mentioned in the above section. However, at the high level, all communications are performed over TCP/IP.

The need for a lightweight and flexible underlying communication platform is implicit in the whole game concept, which implies there should be no maximum number of robots connected, and connections may be many-

[3] Online video of UAV flight: http://youtu.be/5CMGP65uGEk

to-many. To enable a publisher/subscriber paradigm over a variety of architectures (the use of embedded systems means that some platforms will be computationally very limited) using a range different programming languages, the main components have been integrated using YARP (Fitzpatrick, 2008) as the communications platform.

The main difficulty is allowing all of the players to connect to the services offered by the platform, such as the shared score board to keep track of how others are doing, or the game manager to set up new tournaments or campaigns.

3.1 Gameplay Modalities

There are several possible modalities of gameplay. Tournaments and campaigns are organized by local Game Masters, which launch the Robot Devastation Game Master Server (GMS) on their PC. In tournaments, players connect to the local GMS and compete to achieve the highest scores in a limited time. Campaigns involve that the players that connect must achieve specific objectives fixed by the local Game Master, such as recovering a set of banners protected by other players.

Tournaments and campaigns are mainly intended for beginners. Advanced players connect to the Perma-session, which is a permanent death match session mounted on a global server. Fig. 8 depicts these concepts.

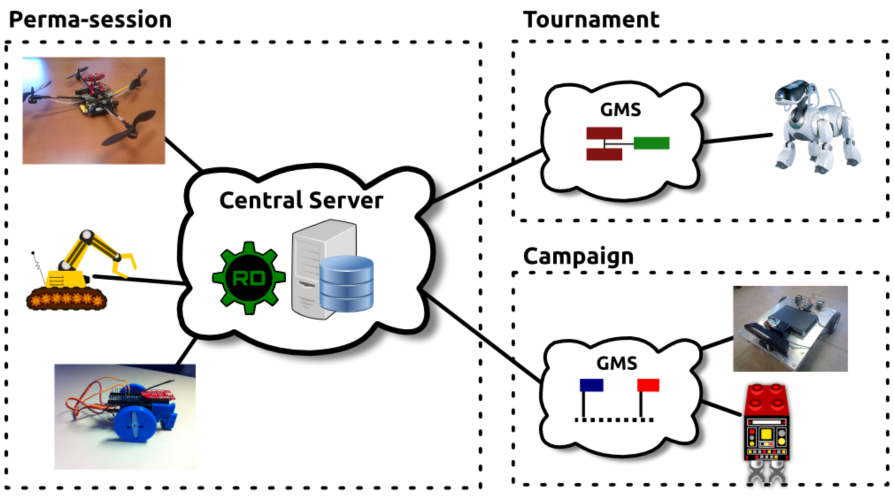

Fig. 8. Robot Devastation core concepts

Each game server stores geolocalization data (coordinates, altitude, orientation) and player scores to enable gameplay.

3.2 Augmented Reality Interface

Regarding game interfaces, and taking advantage of wide distribution of smartphones, there are two types of interfaces: smartphone and traditional computer or console versions.

Smartphone Interface

The main line of research of the development of the smartphone interface is dual-sided due to the state of the market at the time of writing: development for Android and for iOS Operating Systems. The basic functionality of the systems is the same: the player must point the camera towards the robot or towards whatever part of the world where he or she counts on seeing some action. Here, as seen in Fig. 9, the player sees all the Robot Devastation action depicted on screen in the form of augmented reality.

Fig. 9. Robot Devastation smartphone interface concept

This includes a representation of all of the simulated robots involved in the session (tournament, campaign, or Perma-session), markers on the real robots, and other game-play fictional phenomena such as laser rays, controllers and indicators. One of the main technical difficulties is representing these objects in the correct place. Our current decision is to use AR markers on the robots, and use the mobile device's inclinometer sensors to approximate how the laser rays should be sent and represented.

Computer Interface

The main difference with the previously seen interfaces is that there must be a camera on the robot. This enables the player to see the world from the robot's perspective, and is immersed into this world as he is visualized as inside a cockpit, as depicted in Fig. 10.

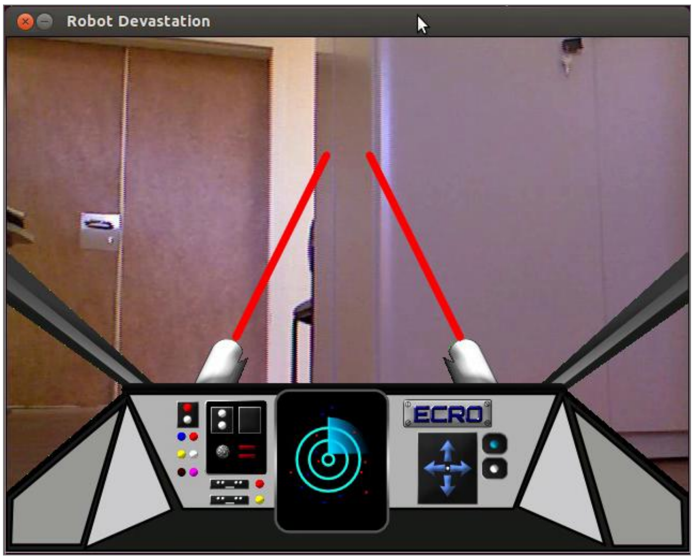

Fig. 10. Robot Devastation gameplay screenshot

4 Current Implementation and Future Developments

Robot Devastation for PC version 0.0 was released in July 2012. A test of this alpha version implementation controlling the ECRO can be seen online[4].

There is no official release date for Robot Devastation for Android or iOS versions yet, but partial developments corresponding to the use of AndAR,

[4] Online video of Robot Devastation gameplay: http://youtu.be/2RJayuBKR6Q

Android's ARToolkit (Billinghurst, 2001) based augmented reality package can be found on the repository.

5 Conclusions

The Robot Devastation project is a new generation of MMOG (Massively Multiplayer Online Game). Its main novelty is the combination of players with real robots and simulated robots through a context of geolocalized augmented reality.

The project is being developed inside the ASROB community, a group of graduate and undergraduate students interested in robotics, electronics and computer science. The project has two working lines.

On one hand, an educational and academic approach. The development of this project implies the acquisition, learning and development of scientific knowledge in the areas of robotics, artificial intelligence, control and electronics. Furthermore, it has a social reach: a robot that can avoid all kinds of adversities in order to reach a target in a game implies the development of technology that can directly be used for rescue tasks or bomb deactivation.

On the other hand, it has an strong component of entertainment. The game establishes what the authors believe to be the future of gaming, bridging the gap between the current virtual world and physical real platforms. The game will create a community of professionals and amateurs that plays, interacts and develops software, hardware and algorithms.

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