Integrating an Entertainment Robot*

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Abstract: *In this paper we will present Eldi, a mobile robot that has been in operation at the Elder Museum of Science and Technology at Las Palmas de Gran Canaria since December 1999. This is an ongoing project that was organized in three different stages of which only the first one has been accomplished. The initial phase, termed "The Player", the second stage, actually under development, has been called "The Cicerone" and in the final phase, termed "The Vagabond", in which Eldi will be allowed to move erratically across the Museum. This paper will focus on the accomplished first stage to succinctly describe the physical robot and the environment and demos developed. Finally we will summarize some important lessons learnt.*

Keywords: mobile robotics, entertainment robotics, agent architectures

1 Introduction

Last years have revealed Education and Entertainment as promising, though demanding, new application scenarios for robotics with a great scientific, economic and social potential [5]. The interest raised by products like Sony's Aibo or the attention deserved by the media to projects as Sage [4], Rhino [3], Kismet [1] and, more recently, Minerva [2] demonstrate the fascination of the general public for these new fashion robotic "pets".

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In this paper we will present Eldi, a mobile robot that has been in operation at the Elder Museum of Science and Technology at Las Palmas de Gran Canaria since December 1999. This is an ongoing project that was organized in three different stages of which only the first one has been accomplished. The initial phase, termed "The Player", was devoted to design and build the physical robot, obtain a scalable and extensible software control architecture and put all this into operation in a number of shows and demos that should be offered to visitors. The second stage, actually under development, has been called "The Cicerone" and aimed at adding better navigational capabilities in the robot such as it can give tours through some of the Museum's halls. In a final phase, termed "The Vagabond", Eldi will be allowed to move erratically across the Museum during its "spare" time (i.e. while not required to give a tour, attend a show or recharge batteries) and it will be possible for a visitor to demand its attention and services through a multimodal interface (gesture, voice and a touch-screen).

Figure 1. Front and side views of Eldi

2 ELDI system anatomy

2.1 Hardware description

As stated above, the first phase of the project, carried out during 11 months, was devoted to build the robot and accomplish a first level of capabilities. Physically, the robot's body has two main components, see figure 1. The lower part integrates a commercial Nomadic's XR4000 mobile platform that gives the robot its basic mobility and sensor capabilities, hosted by a processor under Linux operating system. On top of this platform, it integrates a "torso" that hosts a second processor – TopRobot – under Microsoft Windows NT, several radio communication systems that offer a 802.11 wireless link with off-board systems and transmission of color video and sound from the robot, a touch-screen, loudspeakers and a two degree of freedom head.

The robot is equipped with an active vision system that comprises a pair of Sony EviG21 motorized color cameras housed in the head, a Directed Perception pan-tilt that articulates the neck, and a PCI frame grabber. Basically, the processor installed in the mobile platform controls the motion, localization, obstacle avoidance and power resources of the whole system, it runs under the Linux operating system. The second "upper" system, TopRobot, that runs under Microsoft Windows NT 4.0, controls the whole robot and develops all interactions with users through a number of devices that include the vision system. Communications with off board systems are routed through the Linux system.

2.2 Control Systems

Three main subsystems control the robot. In the upper body a 350 MHz Pentium II takes care of vision, communication, interaction and high-level robot control. In the base, a micro-controller network manages the power and sensor systems (ultrasonars, infrared, bumpers) at low level, and a 233 MMX Pentium under Linux is in charge of platform sensor control, obstacle avoidance, localization, and low level motion control.

Several external machines complete the system – PC's connected using a local area network with two segments being Eldi the network gateway –: The **GameController**, a dual Pentium 350Mhz under Microsoft Windows NT, The **BoardController**, a Pentium 300 under Microsoft Windows 98 and, the **ConacPC**, a Pentium 100 under Microsoft Windows 95.

Global control is achieved by means of CAV, a software architecture that provides a substrate for combining different machines in an asynchronous manner, which can exchange signals with parameters. This architecture is described in more detail later.

2.3 Sensors

In its upper body, the robot incorporates an active color vision system – SONY EVI-G21 and Imaging PCI frame grabber – mounted on a pan-tilt unit by Directed Perception for color detection and tracking – faces, robot games pieces –, and a 14" SVGA color touch-screen by ELO Touchsystems for direct interaction with visitors – information, screen games –. A laser beacon is also included as part of the location system – CONAC –.

In its lower body – an XR4000 from Nomadic Technologies –, there are microswitches for door opening detection and temperature probes for motor overheating control. The robot base has two rings with 24 sensor modules with ultrasonic sensors for long range obstacle detection, infrared sensors for short range obstacle detection and bumpers for contact detection, besides there are additional contact sensors on doors.

External sensors include a pair of color vision cameras mounted on the ceiling of the robot area to help players and robot localization, using a PCI Imaging frame grabber, a wireless microphone – TOA – for voice recognition, and laser detectors for location system.

2.4 Degrees of freedom

The robot head is mounted on a neck – PTU-Directed Perception – with 2 degrees of freedom – pan, tilt –. The robot eyes are constituted by two motorized cameras that contribute with 2 mechanical degrees of freedom – pan, tilt – and 2 optical degrees of freedom – zoom, focus –.

An holonomic system allows for the movement of the base with 4 wheels driven by 2 motors each one – wheel rotation and translation –.

2.5 Power Systems

A microcontroller based system is in charge of power distribution. The mobile platform has a main battery set with four 33 Amp·h batteries. The platform contains also an auxiliary battery set with four 18 Amp·h batteries in order to supply some extra power for those additional devices added to the mobile platform: The upper PC – TopRobot –, a speaker, the CONAC emitter and the video transmitter. Two DC-DC conversors and a devices power control board supply upper body systems from the battery sets.

2.6 Communication Systems

All the machines compose a two segments local network connected by means of Wireless network interface – Lucent Technologies Wireless IEEE 802.11 interface in 2.4 GHz DS – that uses the lower body as gateway. Internal robot communication systems include a 100 Mb/sec Fast Ethernet linking the robot's main processors – upper and lower body – and an Arcnet network for transmission of information between microcontrollers and the platform main processor. External systems are connected using a classic ethernet.

Audiovisual data are transmitted from the robot by means of a video-audio transmitter – Eagle 2.4 GHz PAL –.

3 Functional description: CAV in Eldi

A major breakthrough accomplished during this first phase has been the software architecture and associated methodology used to control the robot and off-board systems. The system that controls Eldi and the rest of the installation has been conceived as a set of agents that interact by means of discrete events. Eldi has been built using an extended version of CAV [7], a tool that enormously eases the definition and implementation of distributed systems modeled as discrete event systems. It was devised initially to facilitate the development process and reduce the integration effort involved in the design and implementation of active vision systems [9]. It permits to model a set of interacting control modules as a set of parallel/concurrent, asynchronous and weakly coupled agents interacting by means of events or signals, where in turn, each agent is modeled as a Port Automaton [10] [8]. CAV makes all agents, both on-board and off-board, share the same