

The Web-controlled mobile Communication Robot – Ego Secundus

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Abstract—The R&D project Ego Secundus (ES) is a practical and usable implementation of telepresence for a new type of interpersonal and remote communication. Known technologies are exploited and optimized, while existing deficits are remedied by adding supplemental components. It envisions the creation of a system that enables global use by the lay person over the Internet with standard IT technologies. Ego secundus acts as a user’s “second ego” which is a spacially remote representative of the user in the real world.

Index Terms—Telerobotics, Video Conference, Remote Control, Telepresence.

I. INTRODUCTION

In the context of developments in Internet technology and the use of new media such as digital video/audio, multimedia, virtual scenes and spaces, and 3D worlds, new forms of communication are also being developed between the participating users. These include voice over IP, instant messaging, video conferencing over the Internet, and communication in virtual spaces by means of avatars. In all of these new communication forms the user’s mobility is always limited within the confines of the user’s immediate environment (videoconferencing by cell phone), or mobile communication is only possible in virtual spaces (user as avatar in a virtual world).

There are isolated known solutions for mobile videoconferencing in conjunction with telerobots such as the RAGE system of Berkeley Labs (USA) [1]. However a disadvantage of such solutions is that special technologies and systems are required for user access and video/audio transmission. Therefore RAGE is unsuitable for broadbased utilization by the general Internet user. Furthermore, these systems are inaccessible in public networks.

In the area of media art various telematic installations utilizing remote transmission and control over communication networks (including the Internet) were implemented, beginning at the end of 1980, for the purpose of interaction with the philosophical/artistic dimensions of telepresence. Examples include the “AL” [2] and “Ornitorrinco” [3] projects. However, these installations are also unsuitable for use by general Internet users, either due to the special technology required or their unavailability (or limited availability for short periods) for public use on the Internet.

II. “EGO SECUNDUS (ES)” PROJECT

The objective of the R&D project *Ego Secundus* is to achieve a practical and usable implementation of telepresence for a new type of interpersonal and spacially

remote communication. Known technologies are exploited and optimized, while existing deficits are remedied by adding supplemental components. It envisions the creation of a system that enables global use by the lay person over the Internet with standard IT technologies. Such a solution providing a form of communication capable of wide-ranging and cost-effective application are currently unknown to the author from prior art.

Ego secundus (ES) acts as a user’s “second ego” which is a spacially remote representative of the user in the real world. It involves implementation of the following technologies:

- Narrow-band access over the Internet by any user with a web browser. The user does not require any special software or hardware other than a conventional PC with web cam and headset.
- Utilization of an open and mobile robot platform as the basic design module of the ES with elementary sensor capabilities for safety in motion.
- Motion control of the ES itself and control of the web-cams located on it is accomplished over the Internet.
- Bidirectional video and audio transmission between the user and a display/audio system on the ES for communication with other persons in the vicinity of the ES.

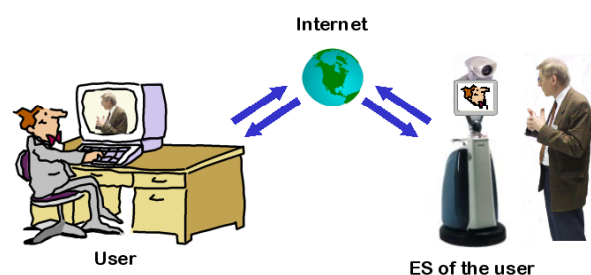


Figure 1. Communication with Ego Secundus (ES)

In its quiescent state the ES behaves passively. Not until a user logs on over the Internet does the ES obtain an identity (“second ego” of the user: ego secundus). It can then act within its local environment, and a video image of the current user (actual identity) also appears on the ES display (Fig. 1).

The ES itself does not possess any machine intelligence (except for some safety functions), and it only acquires this intelligence from its particular host (user). The user can observe the ES’s environment via controllable web-cams and can move the ES itself within this environment.

From a technical perspective the ES combines various principles and methods from the areas of avatars, robots, teleoperation, video conferencing and Internet and transforms them into a new and future-oriented communication form.

A. Component Structure of ES

The central engineering component of the ES is the MG-400 mobile robot platform from Neobotix (Stuttgart) equipped with supplemental hardware and software. The actual “intelligent” robot functions of the MG-400 (e.g. autonomous movement over prescribed paths, autonomous obstacle detection) are not currently utilized in the ES, since the user has full control over the Internet. Nevertheless, future work will involve coupling the intrinsic intelligence of the MG-400 platform with individual Internet control by the user (Telepresence), in order to enrich the user’s navigational capabilities with the

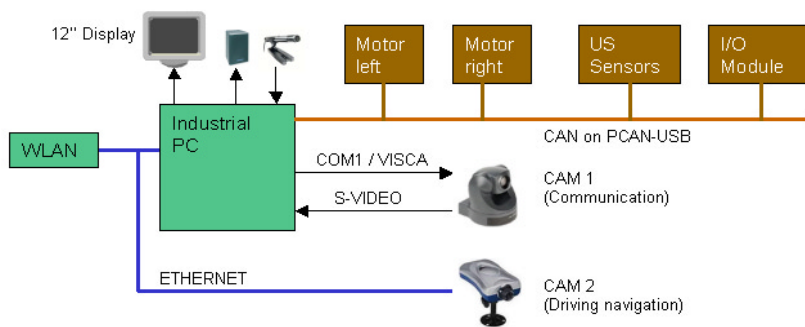


Figure 2. Basic engineered structure of the ES

available “intelligence” of the ES.

The basic engineered structure of the ES device is shown in Fig. 2. In addition to the hardware already available in the MG-400 the following components have also been integrated in the system:

- Controllable web-cam for communication purposes (CAM 1),
- Stationary web-cam for ES navigation (CAM 2),
- 12” display to show the particular user,
- Audio system with special microphone and separate loudspeakers.

CAM 1, together with the audio system, is used to implement a bidirectional video/audio communication channel. CAM 2 with its unidirectional wide-angle video channel is used for ES driving navigation. The ES is connected to the Internet by a script-controlled WLAN Router.

The center of the ES control is a powerful industrial PC (IPC). All hardware modules of the control peripherals (drive modules, ultrasonic sensors, digital inputs and outputs) are connected to the IPC via the CAN bus and a CAN-PCCARD as master. The PTZ control (PTZ pan, tilt, zoom) of the communication camera CAM1 is realized via a serial interface

by means of the VISCA protocol provided by Sony for this camera type. As CAM1 only has one S-VIDEO output (there being no further space for a video card in the IPC however), connection of the video signal from CAM1 to the IPC is via an external S-VIDEO/USB converter. As a network camera, CAM2 is directly connected to the internal TCP/IP network of the ES.

B. Movement Control of ES

From the software perspective the ES utilizes the TCP/IP command-based Neobotix Platform Control for the MG-400 and supplements it with the following components for drive control over the Internet (Fig. 3):

- Client/Server module for control and visualization of the ES over the Internet (ES Control),
- Client/Server module for safety of ES movements in a public space (ES Safety).

Both modules are implemented in Java and are platform-independent. On the Client side the ES Control Server is accessed by a special Java applet (ES Control Applet). The ES Control Applet operates on-demand and when the Live Connect mechanism is used event-driven, i.e. momentary process data from the ES are displayed on the user web page in real time.

The ES Control Applet realizes a web-based command interface with two

operating modes:

- Synchronous operation: A response from the ES Control Server is awaited after sending a command (telegram).
- Asynchronous operation: Incoming commands are automatically detected and can undergo a direct event-oriented processing in the ES Control Applet.

After loading the ES Control Applet onto the user website (= control console of the ES), the requisite commands can be transferred to the ES by JavaScript functions. The commands can be classified into the following three categories:

- Movement commands: The client sends to the server in synchronous operating mode.

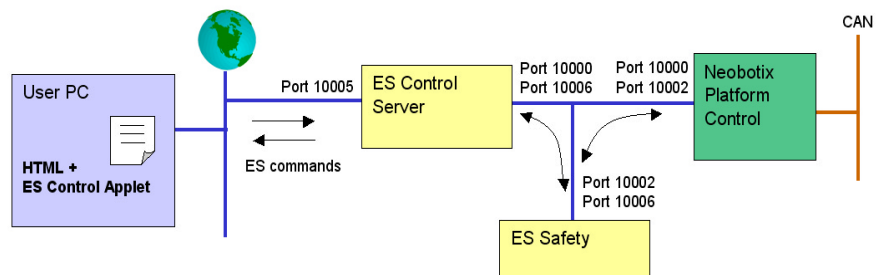


Figure 3. Additional modules for the drive control of the ES over the Internet

- *Status information:* The server sends asynchronously to the client (e.g. information on the movement state of the ES) or the client requests this information from the server.
- *Configuration commands:* The client sends synchronously to the server for setting the behavior of the platform control.

The *ES Control Server* interprets commands received from the ES Control Applet of the user web page (Port 10005) and from the ES Safety software (Port 10006); it coordinates data exchange between these applications and controls the MG-400 platform by passing commands to Platform Control (Port 10000). The ES Control Server thereby serves as the link between Platform Control, the user web page with the ES Control Applet and ES Safety software.

The ES Control Server and the ES Control Applet exchange a defined string (“ping pong”) periodically to enhance the safety of the robot platform. If one of the connected units does not receive a reply within a specified time after sending, the connection is considered faulty and is disconnected. The ES then stops immediately, and it prepares for connection with a new Client.

The *ES Safety* module provides the safety functions needed for remote control of the Ego Secundus with collision-free operation. For this purpose the module requests the hardware status from Platform Control several times per second, and it evaluates the measured values of ultrasonic sensors contained in this status data.

Seven US sensors (US ultrasonic) are located on the front of the ES and three such sensors are on the rear of the ES for measuring distance. These sensors detect obstacles around the ES (0.2 ... 1.0 m), display these on the website and enable an automatic stop of the ES. In particular during movement of the ES, the reliability of the sensor measuring results is, however, considerably affected by external acoustic influences (own motor sounds, sound reflections in the ES environment). These sensors are currently only used as an “activation” block, i.e. a movement of the ES can only be started if there are no obstacles in the ES environment. A laser scanner is to be used in future for obstacle recognition while the ES is moving.

Two clients are implemented in the safety software. The connections to Platform Control (Port 10002) and to the ES Control Server (Port 10006) are routed through these clients. communication with Platform Control is executed by exchanging byte sequences. Strings are passed to Platform Control.

Parameters of the two modules ES Control and ES Safety are configured accordingly on both server and client sides.

C. Video/Audio communication between user and ES

The video/audio communication between the user and ES (or with persons in the environment of the ES) is only realized using Internet Explorer. The user does not require any additional software for this. All requisite components are loaded into the user's web browser from the internet.

Communication is via three components (Fig. 4) at the server end:

- *ES Video/Audio Server:* Makes the video/audio

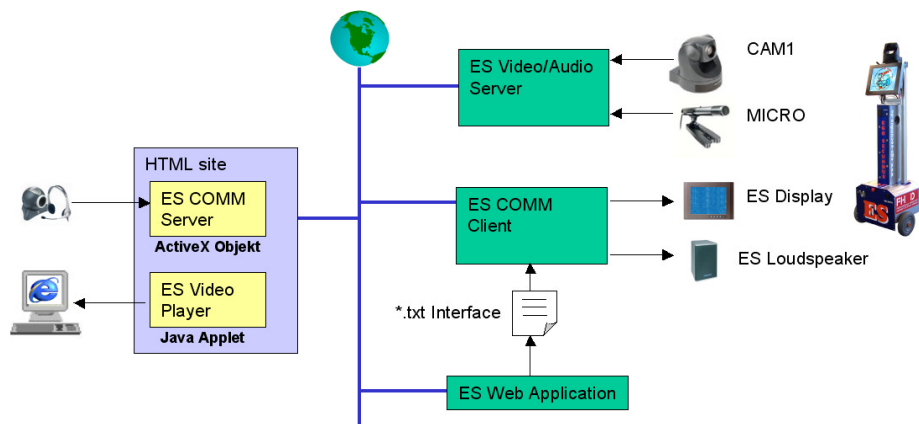


Figure 4. Video/Audio communication between user and ES

stream of CAM1 and MICRO available in the web using the unicast process. The video stream is represented in a Java applet player at the client end.

- *ES COMM Client:* Realizes the presentation of a user in the ES corresponding to the selected operating mode (without/with video, without/with audio) and works as a video client for representing the user in the ES display as well as an audio client for receiving the speech signals from the user.
- *ES Web Application:* The ES COMM client is informed about which user has logged in with which operating mode via this web application. An interface file is used for this, which is written by the web application after a user logs in and read by the ES COMM client cyclically every 2 seconds. If no user is logged in, the ES logo is shown on the ES display.

The client-end recording and distribution of the video stream by the user at the ES is via a video/audio streaming server (ES COMM server), which is also loaded onto the user PC by the ES web-server as an ActiveX object. An ActiveX object is necessary in such a case, as only this may also access the communication peripherals (video, audio) in the user PC. Such access to the PC peripherals is not possible for Java applets due to security reasons. The ActiveX object works for audio simultaneously as client and receives the speech signals from a person in the environment of the ES.

D. Web-Based Navigation and User Interface

ES driving navigation is primarily accomplished by means of a fast-reacting wide-angle network camera (CAM 2) and supplemental navigation information that is

overlaid on the camera's video image. A first variant of the ES user interface (control console) in the user's browser is shown in Fig. 5.

In addition to navigation information, the control console also displays the driving speed, battery charge state and a position counter. Depending on the operating mode, the user might also see his/her own video image in the browser for verification, just as it appears in the ES display. The user can also output messages to the ES display by entering text in the browser.

The user can control the ES by activating the control keys with the mouse. If the mouse has a mouse wheel, the

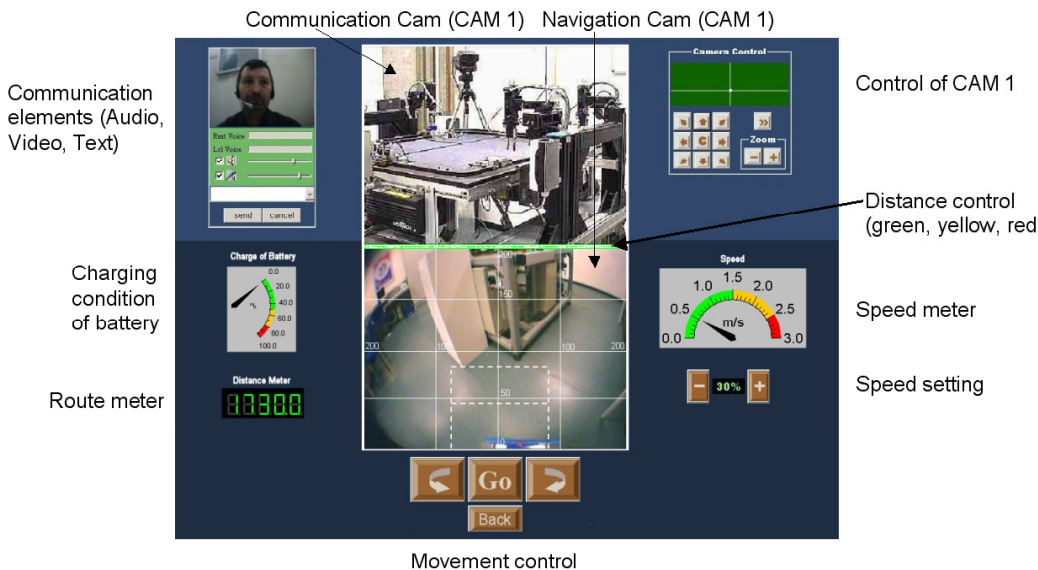


Figure 5. Control console of the ES in the web-browser

movement speed can be set using this at the same time. Work is currently being carried out on a mouse-controlled joystick. In principle, however, a hardware joystick can also be used for the ES control [4].

The communication camera CAM 1 is essentially only used for communication between the user and persons in the ES's environment. This camera has high optical quality (Sony EVI D70) and is movable (Pan, Tilt, Zoom) in the stop state of the ES.

E. Operation and Applications

To use the ES an interested party must register at the ES web portal <http://www.ego-secundus.de> and choose one of the following operating modes when logging onto the ES:

- *Observer without communication:* As an observer without communication the ES can only see and hear its environment on a mobile basis. The user's identity is shown in the ES display in the form of a visitor's card with full address.
- *Communication with text:* In communication with text, additional text-based user information may be output in the ES display. The user's full identity is displayed.
- *Communication with video and text:* In communication with video and text the user is also shown in streaming video in the ES display, and the user's e-mail address is shown in the ES display to identify the user.

- *Communication with video and audio:* In communication with video and audio the ES user can also communicate by audio. In this case the user's e-mail address is also displayed to identify the user.

All web pages (ES web portal) required for use of the ES, including the control console shown in Fig. 4, are distributed and saved on a server of the Düsseldorf Telelabor (<http://www.telelabor.de>) according to the principle of Lean Web Automation [5]. On the ES itself there are only the ES Control Applet and the video streaming applet, which, after establishing a connection

with the user's web browser, are loaded on this Client and produce the necessary connection to the ES via HTTP and TCP/IP. This results in a maintenance-friendly system, because whenever changes are made in the ES web structure, this does not require any intervention in the ES itself.

ES applications include communication and presentation tasks at trade shows, exhibitions and similar events. For

example, a person at a remote location might use ES to visit a trade show and enter the exhibit booths just like a real visitor, talk to booth personnel and accurately view presentations at the exhibit booth (Fig. 6).

The ES can also be used for observation and inspection tasks. A user might visit a museum as an ES over the Internet and view the exhibits in detail, or the ES might be used to perform inspection tasks in the industrial field (e.g. in environments that are hazardous for humans). Moreover, ES could be used to enable handicapped persons to participate and interact in global social, cultural and sporting events in a realistic way.

III. CONCLUSIONS

The Ego Secundus development has produced a telepresence-based and mobile communication system that can be controlled by any user over the Internet. The video/audio channel integrated in the ES for communication guarantees sufficiently good quality starting at a transmission bandwidth of 150 kBit/s. Motion control is executed in a stable and safe manner and permits ES driving speeds of approx. 6 km/h. The following work steps are planned for 2006/07:

- Expansion of navigation information by incorporating a dynamic 3D model of the ES,
- Improvement of algorithms for safety monitoring as well as the use of an additional laser scanner,

- Optimization of resource utilization (power, CPU performance),
- UMTS interfacing of ES to the Internet.

Beginning in November 2006 interested parties may register to use ES at <http://www.ego-secundus.de>. Users



Figure 6. Ego Secundus in action in the University of Applied Sciences Duesseldorf in January 2006

will be informed by e-mail of the times at which ES will be enabled on the Internet for test purposes. Plans call for regular operation and 24 hour availability of ES on the Internet beginning in 2007.

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