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# Remote Monitoring and Control of an Electric Powered Wheelchair in an Assisted Living Environment

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**Abstract:** Ambient Intelligence can be defined as an evolution from the conventional automation systems, which are a set of computers, sensors and actuators that ubiquitously and pervasively have the purpose of facilitate the execution of daily tasks. One very important derivation from Ambient Intelligence are the Assisted Living Environments that are complex systems designed to help people interacting with other devices. The impact of such systems in everyday life is more easily observed when talking about users with disabilities. That is the case of the project described in this paper. Modifications were made to an electric-powered wheelchair in order to enable its remote control by using mobile devices. Those modifications have focused on the wheelchair control system and aimed to emulate it in software so that Smartphones and Tablets could control the wheelchair. Details of the developed system, with emphasis on the telematics control will be given along the paper.



*Keywords: Tele-Medicine and e-Health, Intelligent Homes and Ambient Intelligence, Ambient Assisted Living, Automatic Electric-Powered Wheelchair, Telematics Control and Monitoring.*

## 1. INTRODUCTION

One of the most important assistive technology equipment created to increase the mobility of people with motor disabilities is the electric-powered wheelchair, (Electrical Wheelchair or EPW). Depending on the disabilities, potential users may choose among a large number of available models. In some cases, the user is strong enough to command movement trough joysticks or similar devices, in extreme cases it is necessary to make use of solutions that consider biological signal to control the movement of the EPW. In all cases it is assumed that a customization of the EPW is needed, normally it means, among other details, the selection of the right sensor for human-machine interfaces and custom regulation of driving parameters.

In fact, there are reports about how difficult it is to drive a EPWs, many users faced many problems to learn how to control them, while others just cannot use them properly [Fehr2000] [Simpson2008]. Some other diseases affect the patients' condition along time reducing their motor ability. In these cases the patients may lose their driving skills leading to a necessary change of the EPWs control interface. In any cases, driving tests with potential users are necessary.

That is why, for a long time from now, many academic studies addressed the design of EPW driving simulators [Erren2007] [Pithon2009]. The first simulators made use of 2D representations for driving electric-powered wheelchairs [Lefkowicz1992] [Swan1994]. Recently the simulators are developed in 3D. Among the most successful tools, there are the Wheelsim [Rnt2008, Lifetool2008] and Accessim [Ceremh2011].

Ambient Intelligence (AmI) can be defined as an evolution from the conventional automation systems, which ubiquitously and pervasively have the purpose of facilitate the execution of daily tasks [Remagnino2005] [Romero2008]. These new systems hold a high degree of automation processes and products, and mix different technologies, which exist individually today, in an inhabited integrated environment [Garate2005] [Harwing2002]. The final objective is to provide automatized systems capable of providing comfort, entertainment, nursing elderly and ill inhabitants, environment security, resource economy (energy, water), and other functionalities that will adapt to the need of the human being in these environments [Verhaegh2006] [Litz2007] [Sanchez2008].

To implement the concept of Ambient Intelligence it's necessary to involve a great quantity of technologies and areas of knowledge related to electronics and software development [vanHouten2008]. These were first researched by the Philips Company in their R&D labs in Holland [Ist2001]. In order to obtain the desired characteristics of Ambient Intelligence the knowhow of technologies like new materials, micro-electromechanical systems, sensor technology, wireless communication, adaptive software, embedded systems, software agents, and the like, are needed [Mukherjee2006].

The current technological scene has allowed for even smaller equipment to have more processing and communication power, and with that new applications can be proposed. Sensors and actuators can be connected in wireless networks with little cost, making it possible to obtain a great amount of data to a specific ambient or process, and act upon them


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[Pauwels2007]. And all of this should occur without direct user intervention.

However, in order for an Ambient Intelligence scenario to become reality, only data collection is not enough. It's necessary to imbue the system with computational intelligence so it can process data on its own in order to infer in the context of them and still take into consideration the perspective of the human user [Becker2006]. With that it's possible to make the ambient reactive and adaptable to the needs of the users.

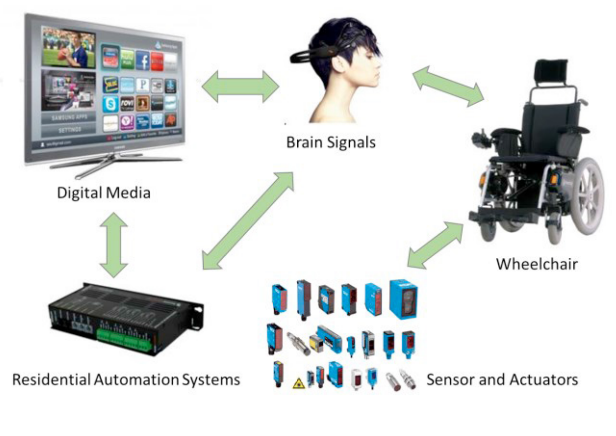


Fig. 1. Basic Architecture of the CRIAI Project.

The CRIAI project is inserted in this context, which is a joint research initiative focused on the proposal of an AmI system designed to help people with disabilities. Fig. 1 contains the main components of this project. Sensors and actuators were properly distributed in a set of rooms. They are controlled by a residential automation system that is also properly connected to the consumer electronic devices. Central point is an EPW that was modified to receive commands via BCI or other mobile devices. That is a very important point in the proposed architecture as it is desired that the EPW navigate autonomously in a known ambient.

The main objective of this paper is to describe the modifications made to the electric wheelchair during the CRIAI Project. The sole purpose of these changes was to enable remote control of the wheelchair by using mobile devices. The modifications have focused on the control system and aimed to emulate it in software so that Smartphones and Tablets could control the wheelchair.

## 2. CONTROL APPROACHES

The commercial EPW used in this work has two micro-controllers inside it: the interface microcontroller (I-MCU), which manages the buttons, the joystick and the LEDs that allow the user to interact with the EPW; and the power microcontroller (P-MCU), which has control of the motors and brakes, manages the battery and stores a few setup parameters. The two MCUs communicate with each other through CAN bus.

At a first glance, there are two different approaches to add another device to control the EPW: emulate the electrical signals of the mechanical joystick; or add another node to the internal CAN bus. The first option requires a digital-to-analog converter to generate two voltage levels, which represent the displacement of the joystick on the X and Y axes. The signals connect to the analog-to-digital converter of the I-MCU to replicate the behavior of the joystick. The second options requires CAN bus interface to send commands to the P-MCU directly, instead of going through the I-MCU, and must use the same definition of messages as the P-MCU and I-MCU.

Beyond the Wi-Fi connection, both approaches require additional hardware from the remote control microcontroller (RC-MCU): a CAN controller, which may be internal or external, and an external CAN transceiver, or a digital-to-analog converter, which may also be internal or external. Fig. 2 provides an overview of the whole system and how each device connects to the other.

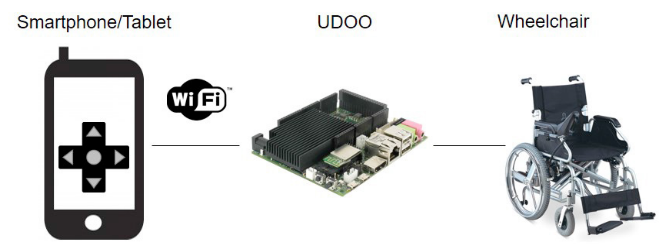


Fig. 2. Overview of devices that compose the system.

### 2.1 Joystick Emulation

The joystick emulation approach requires three steps to correctly connect the signals to the I-MCU and allow the RC-MCU to replace the joystick: identify the voltage levels generated by the joystick, design the connection between DAC and ADC, and define the equation that converts the joystick displacement to the value range of the DAC. The working principle of the joystick is shown in Fig. 3. The joystick can assume any position inside the circle formed by its mechanism. The voltage level of the outputs varies based on the position that is currently being held.

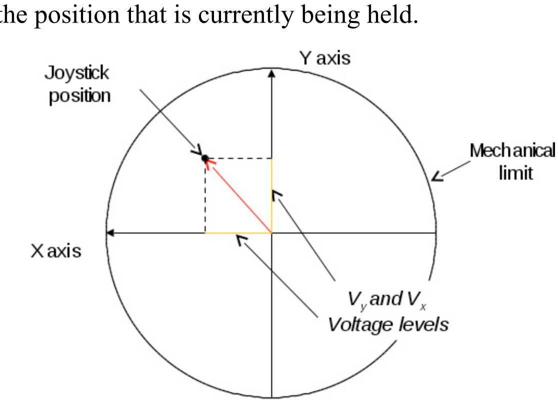


Fig. 3. Working principle of the joystick.

After measuring the voltage level at the joystick output, the values shown in table 1 were acquired for both X and Y axes.