Acquisition Data Card Simulator for Industrial Informatics Projects

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Abstract — *One of the objectives of the Industrial Informatics subject at second course of Technical Industrial Engineers in Electronic, is to instruct the student in the development of Industrial Informatics projects, integrating the knowledge acquired from different subjects of the course. This work is performed in the framework of an educational Project at Escuela Técnica Superior de Ingeniería del Diseño in Universidad Politécnica de Valencia (Spain). During the project the student will use the following tools: a personal computer, the Borland C++ Builder programming environment and an ADLink PCI-9112 acquisition data card. The acquisition data card is the element that not always is available in University laboratories or at student homes, for this reasons a didactic simulator called SimSeny has been developed. Simseny allows to develop the computer application without the need of that expensive card. This paper describes the contribution of the developed simulator and its help to facilitate the project design as well as the obtained results after its use by the students.*

Index Terms — *Industrial computer, Innovation in higher teaching education, online laboratories.*

INTRODUCTION

Several educational experiences are being carried out in the Industrial Informatics discipline of 2nd course of Industrial Technical Engineers degree in Industrial Electronics branch of the Escuela Técnica Superior de Ingeniería del Diseño of the Universidad Politécnica de Valencia. The objectives of these experiences are to guarantee general basic knowledge as well as to foment abilities like work in group, endow practical aspects of the course and teach adaptation techniques to new challenges, etc.

This subject is involved inside an Educational Innovation Project (EIP) of the Universidad Politécnica de Valencia called EUROPA [1]. The main objective is to improve integrally the university education. This project affects all the mandatory subjects of the Industrial Electronics branch.

The EIP methodology is based on the active learning theory [2, 3, 4] where students are engaged in more activities than just listening. They are involved in dialog, debate, writing, and problem solving, as well as higher-order thinking, e.g., analysis, synthesis, evaluation. Likewise, the cooperative learning theory [3, 4, 5] defined as the instructional use of small groups so that students work together to maximize their own and each other's learning has been applied.

In the Industrial Informatics subject, one of the challenges proposed to the students is the development of an Industrial computer system using a personal computer (PC), the programming environment Borland C++ Builder for Windows and an acquisition data card model ADLink PCI-9112 [6]. A process prototype including the necessary sensors and actuators should be controlled by the application developed.

A project of this magnitude requires laboratories qualified for the proposed application development. And this represents an enormous cost that is excessive for a mandatory and massive subject. However, most of the computer classrooms and students homes have great part of the necessary infrastructure that is not more than the personal computer. They only need the acquisition data card and the devices connected to this card.

The experience in this subject has shown that the most difficult thing to obtain the best results with this approach is the availability of the acquisition data card. Therefore, we have thought if it is possible to develop the application without having the acquisition data card.

The answer is affirmative, it has been enough with developing a simulator that allows the development of the application without necessity of this card. The acquisition data card only will be indispensable in the final stage of the project, because it is necessary to carry out tests with real sensors and actuators. The main advantages of this approach are that students can make part of the application development in their house or in computer science classrooms and that the laboratory cost (material and maintenance) has been reduced.

In section 2, a methodology based on the development of miniprojects is described. Section 3 is dedicated to the simulator that has been developed. In section 4 an example of practical use is presented. To sum up the conclusions and the future evolution of the simulator are outlined in section 5.

MINIPROJECTS BASED METHODOLOGY

A fundamental part of the subject is the development of miniprojects by teamwork [7]. The miniprojects consists on simplified real problems that the students should solve by teams. The proposed problems have not been described neither solved in class. The miniprojects aim at making an effort in the practical aspects, fomenting abilities such as the work in group, capacity of adaptation to new challenges, etc.

Each teamwork should develop a control system of a process composed of analog and digital circuitry. The system is based on a PC equipped with an acquisition data card. Some of the miniprojects developed by students can be appreciated in the figure 1.

The miniproject evaluation [8] is common to the subjects involved in the Educational Innovation Project and it represents a part of the final score of each one of them. The teamworks present the miniprojects to a jury of the lecturers of all the subjects and it is necessary to prepare a report of each of the implied subjects.

Regarding the Industrial Informatics subject, the students develop the miniproject with the following tools: a personal computer, the programming environment Borland C++ Builder 1.0 for Windows and an acquisition data card model ADLink PCI-9112.

The experience in this disciple has shown that the unavailability of the acquisition data card is the biggest handicap to obtain the best results with this focus. To avoid this dependency on the hardware card, a simulator of the acquisition card has been developed. Therefore, the development of the application is not locked because of the necessity of this card neither of external circuitry.

THE "SIMSENY" SIMULATOR

A PCI-9112 acquisition data card of the company ADLink is used so that the computer carries out data acquisition and process control. This card includes digital inputs and outputs, analog inputs and outputs, and counters.

The acquisition data card is an expensive device and a few number of units are available for the miniproject realization. However, the rest of the computer infrastructure required is available in most of the laboratories and student's homes.

Consequently, the simulator has been developed to achieve the following objectives:

- Facilitate the development of great part of the application at home or in any computer classroom.
- Reserve the acquisition data cards only for the miniproject final stage realization. Therefore, the card damage due to inadequate or careless use will be minimized.
- Try to reduce the total laboratory cost (material and maintenance).

SimSeny is an acquisition data systems simulator that allows to develop and test applications that carry out data acquisition without necessity of having installed the required hardware.

The first premise considered in the simulator design is that its application should be the most transparent possible to the student and to be the sufficiently generic to apply it to different acquisition data systems. This way, the simulator tries to imitate the acquisition data card at the electronic signals level that are available through its connectors.

In this manner, it is possible to prove a program that uses an acquisition data card without having to install the card and without having to mount any type of devices or circuits in the card connectors. Later on the control program can be tested on a computer equipped with the acquisition data card, connecting to the card inputs and outputs the devices to control.

The figure 2 shows the simulator "SimSeny" [9] in operation, where the user can see the simulated physical signals that the card generates. The simulator can be obtained in the following internet address: http://www.disca.upv.es/aperles/simseny. An important feature is that the simulator can be executed in the same computer that runs the control application or in any

other computer interconnected to the network, being able to make a remote application control. In this case the TCP/IP protocol will be installed in the two computers.

The simulated signals are:
- Digital outputs: by means of color circles are represented 16 digital outputs. The green or red color of the circle represents a logical level "0" or "1" respectively in the corresponding digital output.
- Analogical outputs: tensions between -15 and 15 volts in analogic outputs are represented by means of two objects that are similar to analogical meters.
- Digital inputs: clicking with the mouse in one of the 16 circles that represent digital inputs, the logical level of the corresponding input is commuted.
- Analogical inputs: by means of displacement bars it is possible to introduce a variable tension in 16 analog inputs.

A general overview of the components that intervene in the computer application can be observed in figure 3. The application that the students should develop interact with the card drivers through a dynamic link library (DLL). This library accesses directly the acquisition data registers.

The simulator has been introduced in the application as can be seen in the figure 4. All the calls to the card library functions are captured and can be redirected to the simulator or can continue using the card. The acquired information is converted to a format that is independent of the used card and it is sent through a local or remote (TCP/IP) communication links to the simulator interface.

The elements that compose the simulator are:
- A specific head file (for the used programming language) that overloads the functions that make use of the card and allows redirect these functions to the simulator, converting the card control information to an independent format.
- A Dynamic Link Library (DLL) independent of the acquisition data card that is only loaded when the use of the simulator is required. This library allows the control application interaction with the simulator user interface. The use of a DLL in order to connect with the simulator, makes this tool applicable in programming environments such as Visual C++, C++ Builder, Visual Basic, Delphi, LabView/LabWindows, HP VEE, etc.
- A signals visor that allows to show the card physical outputs and to introduce physical values in the inputs.

To be able to use the simulator it is enough to include a header file just as it is shown next.

```
#include "9112.h"
#include "simseny9112.h"
...
```

From that moment the execution of the application developed by the student shows a window to choose the simulator or the card.

EXAMPLE OF PRACTICAL USE

To use the SimSeny, the simulator should be executed in the first place and next the program that uses the acquisition data card, so that when this last one is executed, the execution of the initialization card function unchains the mechanism to opt to use the simulator or the acquisition card.

In the first place the dialogue of the figure 5a will appear; if the option of simulating is chosen, then the dialogue of the figure 5b appears and it allows to choose if the simulator and the control application will be executed in the same computer ("Local" option) or if the simulator will be in a different machine ("Remote" option) being necessary in this case to specify the IP address of the computer in which the simulator is being executed.

As example, the use of the simulator with a liquids deposit control program (program written for the acquisition data card AD-Link PCI-9112) it is shown. For this case, once elect the simulating option, the local connection option will be chosen. Next, the multiple card features can be proven observing their effect in the visor.

This control program supposes the sensors inputs and actuators outputs showed in table 1.

To modify the value of the analogical and digital input sensors is possible from the simulator interface, in function of these values the control program will activate the bomb or the output valve. Figure 6 shows the control program and simulator aspect in operation.

CONCLUSIONS

The practical and innovative approach that is given to the subject causes the problem of unavailability of very expensive acquisition data cards. The simulator presented in this paper allows to overcome part of the economic problems. On the other hand, its transparency to the application software makes its use easy and doesn't represent any additional effort.

The simulator has been used during several academic courses making possible to carry out an evaluation and improvement of its operation and use.

It has been verified that approximately 40% of the students use the simulator to make their developments. In the case of those that only have to perform the miniproject of the Industrial Informatics subject the tendency is usually to use the simulator instead of connecting an external hardware when carrying out the final defense of the project.

The obtained results encourage us to continue in this line and to introduce enhancements such as sensors and actuators simulation and virtual prototypes that substitute the original ones that are used in the subject.

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FIGURES AND TABLES

TABLE I
CONTROL APPLICATION INPUTS AND OUTPUTS

Signal	I/O	Type	Connection	Description
Over-heating	Input	Digital	DI0	TTL compatible, overheating = 5 V, normal = 0V
Overflow	Input	Digital	DI1	TTL compatible, overflow = 5 V, no overflow = 0V
Temperature	Input	Analog	AD0	0º to 100º C, tension range: −5 to +5 volts
Level	Input	Analog	AD1	0 to 8000 liters, tension range: −5 to +5 volts
Valve	Output	Digital	DO0	TTL compatible, open = 5 V, close = 0V
Bomb	Output	Digital	DO1	TTL compatible, ON = 5 V, OFF = 0V
Heater	Output	Digital	DO2	TTL compatible, ON = 5 V, OFF = 0V

FIGURE. 1
EXAMPLES OF MINI-PROJECTS CARRIED OUT BY THE STUDENTS.
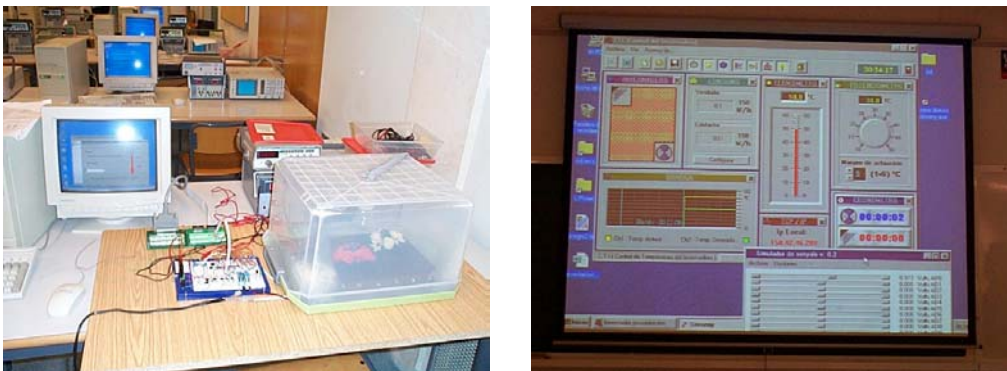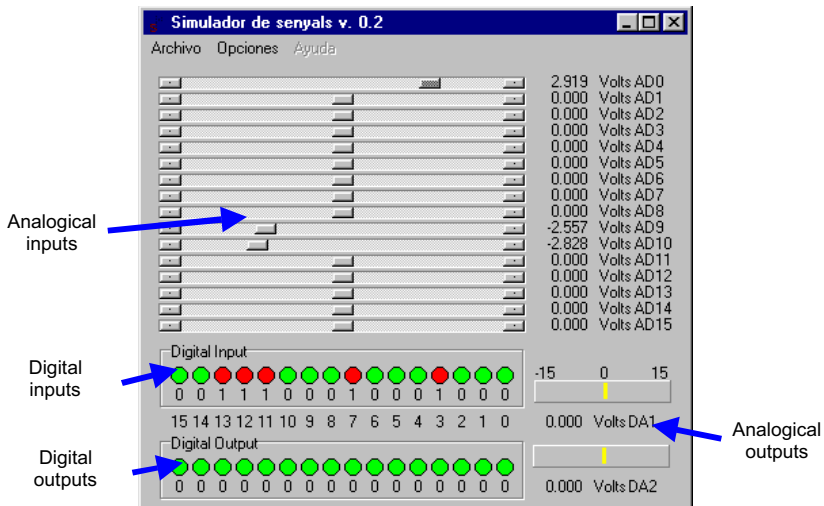

FIGURE. 2
"SIMSENY" GRAPHICAL INTERFACE.

FIGURE. 3
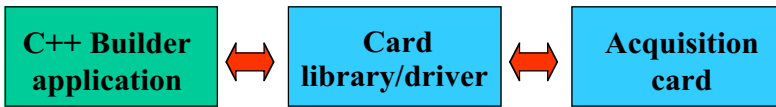RELATIONSHIP AMONG APPLICATION AND ACQUISITION CARD .

FIGURE. 4
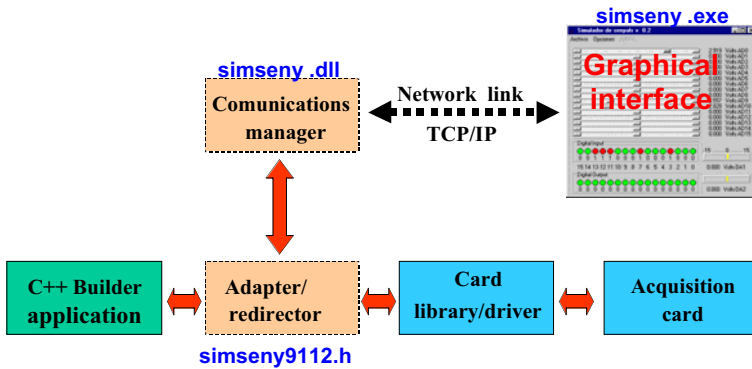RELATIONSHIP AMONG THE APPLICATION AND THE SIMULATOR "SIMSENY".

FIGURE. 5
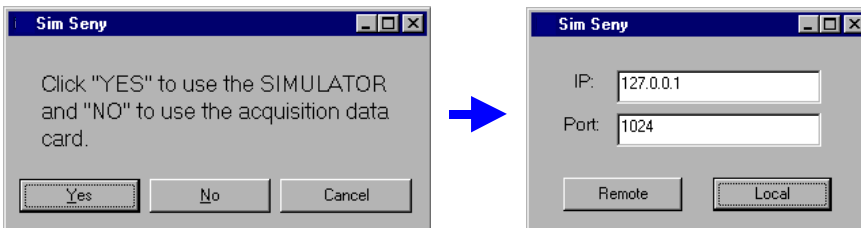(A) DIALOG TO CHOOSE BETWEEN THE SIMULATOR OR THE ACQUISITION CARD. (B) SIMULATOR LOCALIZATION.

FIGURE. 6
DEPOSIT CONTROL APPLICATION USING THE SIMULATOR.