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3D virtual world remote laboratory to assist in designing advanced user defined DAQ systems based on FlexRIO and EPICS

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HIGHLIGHTS

- Assist in the design of FPGA-based data acquisition systems using EPICS and FlexRIO.
- Virtual Reality technologies are highly effective at creating rich training scenarios.
- Virtual actions simulate the behavior of a real system to enhance the training process.
- Virtual actions can make real changes remotely in the physical ITER's Fast Controller.

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ABSTRACT

iRIO-3DLab is a platform devised to assist developers in the design and implementation of intelligent and reconfigurable FPGA-based data acquisition systems using EPICS and FlexRIO technologies. Although these architectures are very powerful in defining the behavior of DAQ systems, this advantage comes at the price of greater difficulty in understanding how the system works, and how it should be configured and built according to the hardware available and the processing demanded by the requirements of the diagnostics. In this regard, Virtual Reality technologies are highly effective at creating rich training scenarios due to their ability to provide immersive training experiences and collaborative environments. The designed remote laboratory is based on a 3D virtual world developed in Opensim, which is accessible through a standard free 3D viewer. Using a client-server architecture, the virtual world connects with a service running in a Linux-based computer executing EPICS. Through their avatars, users interact with virtual replicas of this equipment as they would in real-life situations. Some actions can be used to simulate the behavior of a real system to enhance the training process, while others can be used to make real changes remotely in the physical system.

1. Introduction

The iRIO-3DLab platform has been designed to facilitate the learning process for personnel responsible for the design of intelligent data acquisition systems implemented on devices based on PXIe technology. A good example of this kind of systems has been established by ITER CODAC with the definition of its Fast Controllers. They use embedded technology, and are implemented on industrial controllers running Red Hat Enterprise Linux (RHEL) and EPICS [1]. These controllers are characterized by the need for very high sampling rates and highly demanding real-time control loops that require the ability to run pre-processing algorithms on the acquisition hardware itself. UPM and CIEMAT have developed a methodology and a series of prototypes based on the use of reconfigurable and intelligent data acquisition systems designed using FlexRIO, FPGA-based acquisition devices [2]. This technology is based on an FPGA mounted on a PXIe format card and an adapter module including the interface and/or digitalization functions.

The proposed architecture unquestionably provides an optimal solution to the dynamic configuration needs of the acquisition system tailored to the specific requirements of each application. However, the integration of this type of technology into a distributed acquisition system such as EPICS presents several challenges, as these cards do not have fixed resources and depend on the adapter module to which they are connected. Consequently, the Input Output Controller (IOC) also needs to be reconfigured [3]. To

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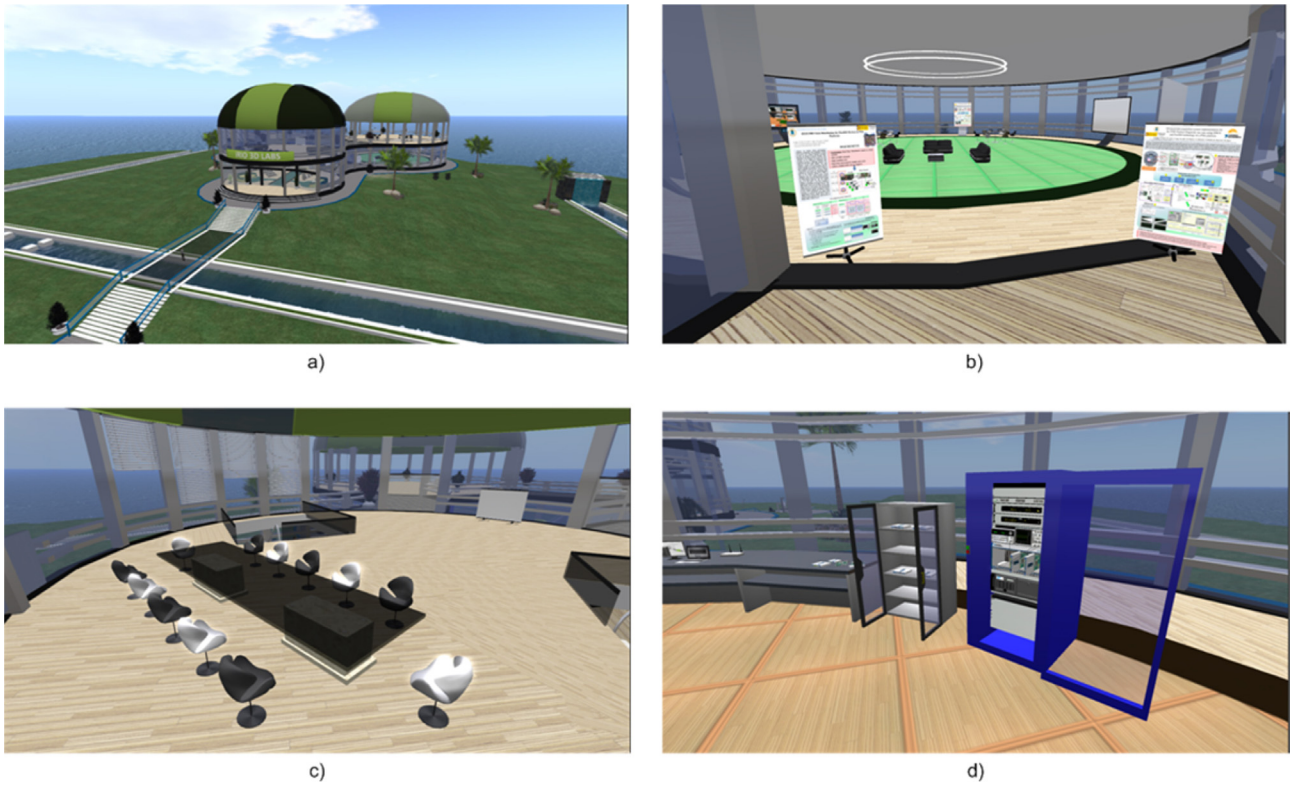

Fig. 1. Facilities of iRIO-VirtualLab: (a) Laboratory Building, (b) Exposition Room, (c) Meeting Room, and (d) Technical Room.

configure the IOC the designer must be familiar with the operation of EPICS, the syntax of the IOC configuration files, and its relationship with the selected hardware configuration. In the current stage, in which the technologies that are to be used to design future diagnostics and control systems are being specified, there is a need for tools which enable users and developers to familiarize themselves with the proposed technologies. This is the case for the FlexRIO and EPICS technologies. These tools must also overcome the geographical dispersion of developers and enable them to access the real hardware making up the system.

iRIO-3DLab is a multi-user 3D Virtual World developed on OpenSimulator [4] aimed at providing advanced instrumentation systems users with an understanding of acquisition system architecture, as well as its procedures for assembly, connection, start-up, shut-down, etc. Additionally, it enables them to carry out a set of predefined tests to establish different configurations and test their effects on a real system in operation, as well as drive inputs and measure outputs remotely.

In this regard, the iRIO-3DLab platform has shown itself to be a very useful resource for accelerating the learning curve. Just like any virtual world, its strength lies in its ability to create an Immersive Learning Environment (ILE) with a high sense of realism that is accessible via the Internet [5]. A 3D virtual world is an environment in which users are virtualized by avatars through which they can interact with objects in the virtual world or each other using synchronous communication tools. These spaces considerably improve the capacity for spatial representation and manipulation procedures, and strengthen practical learning, which promotes greater involvement, collaboration and creativity [6]. It is therefore not surprising that this type of technology has already been used in the fusion field for teaching and training in the management of equipment and execution of procedures [7], as well as for testing instruments and material at the development stage in order to evaluate the suitability of their design prior to final manufacture [8].

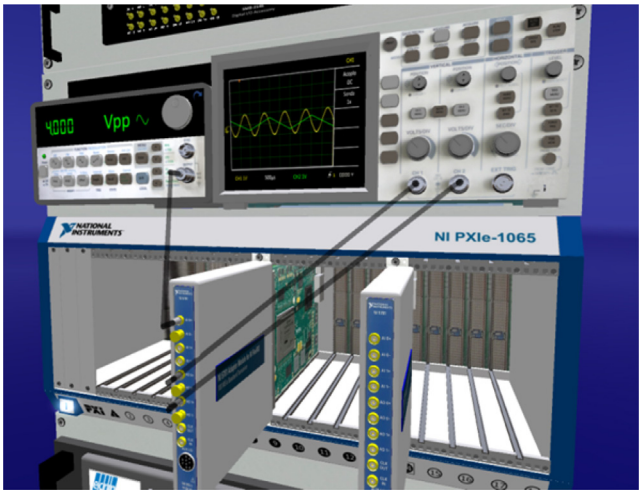

Fig. 2. Example of a virtual hardware configuration for a PXIe system using FlexRIO.

2. iRIO-3DLab operation and functionalities

The main component of iRIO-3DLab consists of the virtual world. As shown in Fig. 1 a), the virtual world comprises a building in which we can find several rooms assigned to different uses. In particular, as Fig. 1 b) shows, these include the exposition room were textual documentation and multimedia about the latest developments carried out on FlexRIO-based intelligent acquisition systems can be found. There is a meeting room, shown in Fig. 1 c), in which collaborative tasks can be conducted using available synchronous

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