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A client–server architecture for the remote sensing and control of a drilling robot

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Abstract

Remote sensing, implemented through virtual instrumentation, is a very important technology for industrial measurements. Moreover, the architecture and methods involved are effective for the teaching and dissemination of measurement technologies. A proper design may yield to cost-effectiveness, reliability and flexibility.

Despite that, some traditional domains, like the drilling equipment production, are reluctant to the innovations and in particular are not confident in the electronic reliability.

Therefore in this paper we first briefly discuss the architecture and the main properties of distributed systems for remote sensing and control. Then we refer of a research concerning an entirely remote measurement and control system, for an innovative drilling robot, able to move along a micro-tunnel and drill the landfill to insert drainage pipes, in order to definitively remediate them. Due to the working hazardous conditions, all the operations should be executed with a fully remote control and monitoring.

The designed drilling machine has been built and tested at the workshop, moreover the machine successfully drilled a 15 m draining pipe in the final test on site.

Keywords: Remote sensing and control; Distributed measurement system; Virtual instrument; Measurement in robotics

1. Introduction

The virtual instrument (VI) and mixed-reality lay-outs have become a common practice not only in many industrial applications but also in the teaching and dissemination of measurement technologies [1–8]. Their cost-effectiveness, reliability and flexibility are the most attractive properties allowing a development of both the fields of application and the VIs themselves, by exploiting autonomic communications and distributed diagnosis options.

Despite that, some traditional domains, like the drilling equipments production, are reluctant to the innovations and in particular are not confident in the electronic reliability. This research figures out a entirely remote measurement and control for an innovative drilling machine, taking particular care of the key aspects of reliability, fault-free and human perception of the remote machine.

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The new communication technologies open different horizons to the distributed measurement systems: where a man could not stay or where no physical connection is allowed between the process under control and the world outside, there the solution could be found in the remote measurement and control with a communication network, like wire or wireless local area networks.

A prototype machine has been built, instrumented and controlled with an on-board processor able to communicate via TCP/IP connections: an ASCII string based data transmission has been created in order to leave free the developing language and the operating system for the human machine interface (HMI). The straight-forwardness of the conceived command, control and monitoring architecture minimized the debugging time needed to assemble the machine with the on board measuring system and the HMI.

The application originated from the current distributed measurement and control system is the first step, in this field, towards the migration from the electromechanical world to the VIs or, notably, the mixed-reality one.

2. Virtual instrument

2.1. Overview

The virtual instrument shows architectural components similar to those of a traditional instrument, but with a radically different implementation: many hardware parts of the traditional instrumentation are software implemented in the VI. Nowadays VIs hardware parts are relegated to the acquisition/generation interface with the reality, all other components are software implemented on a common PC, at least ruggedized for industrial or hazardous application conditions, with the appropriate drives needed to manage the hardware itself.

The software implementation allows the end-user supplying with an extreme flexibility and adaptability to the peculiar application; moreover, the last 20-year grow-up of both PCs technologies and software developments provides scientists and engineers with the tools to exactly build the measurement system which best fits to their applications or new ideas.

We can use the general definition of National Physical Laboratory [9]: "*a VI is a reusable measurement instrument created by adding hardware and/or software to a general-purpose computer, typically a PC, Mac or workstation, and which uses a computer screen to provide the visual interface to the instrument*". By making reference to this definition we can see how the VI makes possible not only the process management and data display, but also the process control and actuation; and, also, the hardware instrumentation management for data collection from sensors and signal generation to actuators. From this point of view the VI permits to gather all traditional instrument panels into a single virtual front panel displayed on monitor and customizable according to the operator/scientist needs. This is the great improvement: indeed, we can control a lot of instruments and we can handle in parallel complex experimental measurements with the simultaneous resort to pertinent instrumentation and respective measures. This is specially relevant for the multi-function drilling robot [10], concerned by this study.

2.2. Architecture

In every virtual instrument we can distinguish the following components: the front panel, that is the interface with the operator; the software, that is the backbone of the VI; the communication bus, that is the interface between the PC and the hardware; and the hardware instrumentation, see Fig. 1.

The VIs front panel is the interface of the computer-based instrument with the user: this is obviously highly affected by the continuous development of both computer science and PC-compo-

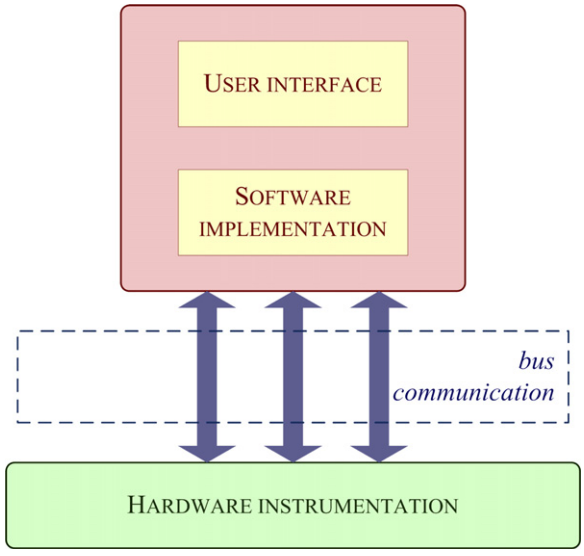

Fig. 1. Virtual-instrument block diagram.