A Bluetooth Solution For Manipulating An Object Manipulator Within An X-Ray Tomograph

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***Abstract* — In this paper, a Bluetooth application for controlling an X-Ray Tomograph with a PDA is presented. The new system presents a solution that replaces the old manual keyboard which was not precise and lacked many functionalities. The application is based on a Bluetooth server/client network architecture and was developed in order to give more flexibility to the user than that offered before. It uses the new and advanced capabilities that modern computing offer such as short-range wireless communication to control the movements of the Tomograph's object-manipulator.**

***Index Terms* — Wireless communication, Bluetooth, PDA, X-Ray tomograph, Server/client.**

I. Introduction

The *fxs* 160.50 is an X-ray Tomograph from Fein-focus with an objet manipulator that can be operated in 5 different directions, together with the movements of the CCD detector which operates in another direction. These movements used to be governed via a manual keyboard that was unable to perform complex and accurate movements. Some improvements on the original system were performed [1], made it controlled via a PC and gave some good results. In this work, an even improved solution is added to the modified system that enables it to be wirelessly controlled via a PDA (Personal Digital Assistant). The new solution uses Bluetooth wireless communication protocol (2.4 GHz) to communicate with the modified PC based system [1] in order to send orders to the original system. The implementation of this solution was performed using LABView.

II. THE FXS 160.50

The *fxs* 160.50 is a microfocus X-ray system used in research and industry to produce images of internal structures of samples of no more than 30 lbs in weight. In Non Destructive Testing for example, it is used to control cracks, corrosion and wearout inside a pipeline without the need to destroy it. The sample to be viewed is positioned inside the Tomograph on an object-manipulator that can perform 5 different movements (rotation, tilt, vertical translation on the Z axis, horizontal translation on the X axis and horizontal translation on the Y axis). These movements were formerly controled via a manual keyboard. There were many inconveniences linked with that as the movements were not accurate enough because they were manually controlled via pushbuttons and joysticks. Also, sequential and complex movements were not possible because of the lack of a programming console. For these reasons, the control method of the object-manipulator was modified to deal with the mentioned inconveniences. The modifications included replacing the old manual keyboard by a PC based system that can communicate with the control unit of the object-manipulator inside the Tomograph via an interface board in series with an intermediary circuit. The implementation of the modified system was a success, and from its first use gave some remarquable results especially in terms of precision and sequetial programming [1].

Manipulating X-rays can be dangerous. This is due their nature and the high energy they carry. A long interaction of a human being with X-rays can be harmfull to its body and even causes dangerous diseases such as cancer [2]. In order to avoid long exposures to X-rays by the machine operator, hence reducing the possibility to catch serious ilnesses, and to add more flexibility to the modified X-ray system, a new wireless solution based on the well known Bluetooth communication technology in which the human operator can manoeuvre the machine wirelessly from a distance up to 10 meters, is proposed. This solution is explained in the next section.

III. THE WIRELESS SOLUTION

The new wireless solution is based on a Bluetooth Server/ Client architechture in which a PDA is used as a client to send information inside files to a PC server via a Bluetooth communication protocol. The server treats the received information, and sends appropriate orders to the Tomograph's Control Unit through the DAQ board and intermediary citcuit. When received, the orders are translated into movments to be carried out by the object manipulator and CCD camera (Figure 1).

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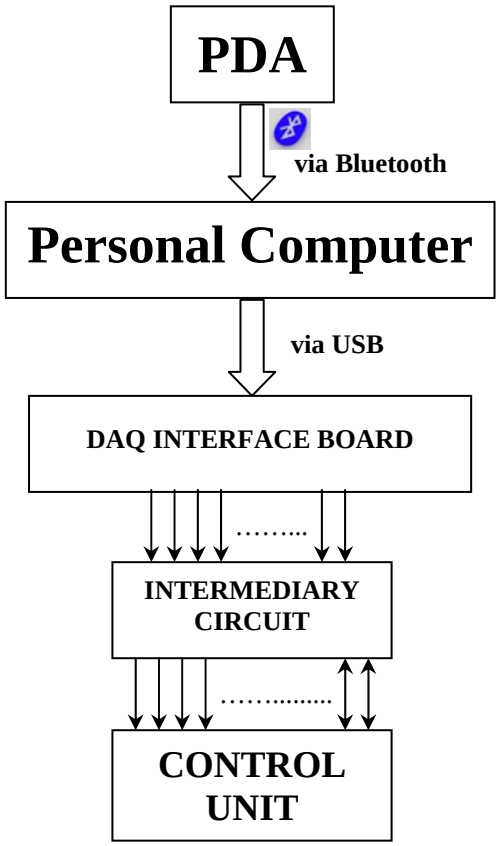

Figure 1. Architecture of the new solution

The above architecture is composed of the following:

A. THE PDA

A personal digital assistant (PDA) is a handheld device designed to facilitate organizational ability from a mobile platform. While the original PDAs were somewhat limited to keeping address, phone, calendar, and task lists, today's PDA can function as a cellular phone, fax, provide Internet connectivity, and much more. There are many different types of PDAs, but most models work with either Palmtop software or a special version of Microsoft Windows called *Windows Mobile*. All models can interface with a laptop or desktop system, though optional accessories may be required. Synchronization between computer and PDA is one of the most popular features of this digital device.

A Bluetooth® PDA incorporates Bluetooth technology and the ability to network the device wirelessly with other personal electronics.

Bluetooth technology creates a personal area network (PAN) that Bluetooth-enabled devices in the immediate vicinity can join to become interoperable. Bluetooth is especially useful for PDAs because of the need to synchronize. Without a Bluetooth PDA, synchronization normally requires a USB cable to link the PDA to the computer.

In addition to a computer, a Bluetooth PDA can also connect to any other Bluetooth-enabled device, including a printer, cell phone, digital camera or digital music player. The only requirement is that the devices support the same Bluetooth standard. Fortunately, it's easy to add Bluetooth connectivity to a device or computer by using a USB Bluetooth adapter. Current operating systems have built-in drivers for Bluetooth support, and drivers are also widely available online.

Adding Bluetooth capability to computers, laptops and printers can be used for many purposes in addition to supporting a Bluetooth PDA. For example, using Bluetooth networking one can wirelessly send print jobs from a laptop to a printer. Bluetooth also allows one to easily trade files between a desktop and laptop without need of setting up a formal network using operating system protocols – a task that can be challenging to anyone who isn't network savy.

In our architecture, the PDA is used to send order files via a Bluetooth connection to the PC which treats this information and sends orders in its turn to the DAQ board. The program that enables communication between the PDA and the PC was written in LabVIEW®.

B. THE PC

The PC receives orders from the PDA in a file. This file, sent by the PDA via Bluetooth communication is treated in the PC within a program written in Visual Basic. The information carried within the file includes speed control, direction of movement and emergency stop. These orders are sent to the Tomograph's Control Unit via a DAQ board in series with an intermediary circuit [1].

C. THE DAQ BOARD

To allow the PC to send orders (speed and direction of movements) to the Tomograph's Control Unit, a DAQ interface board together with an intermediary circuit designed to imitate the operations of the switches and joysticks of the manual keyboard is used (figure 1).

The DAQ interface board used is a 24 bit digital input/output USB board (PMD 1024-LS from Measurement Computing). The PC communicates with the card using a USB (A to B) cable. The 24 digital I/O are organised in three ports (A, B and C) and can be programmed individually as Inputs or Outputs. The outputs of the digital ports are directly connected to the intermediary circuit via wires.

The movements to be controlled for the object manipulator and the CCD detector are operated following these axes:

(X -, X+): Movement to the (left, right) inside the tomograph

(Y -, Y+): Movement (down, up) inside the tomograph

(ZR -, ZR+): Movement to the (back, front) inside the tomograph

(ROT -, ROT+): Rotation to the (left, right) inside the tomograph

(TILT -, TILT+): Tilt to the (left, right) inside the tomograph

(ZII -, ZII+): Movement to the (back, front) inside the tomograph of the CCD detector.

D. THE INTERMEDIARY CIRCUIT

This circuit is used to imitate the operations performed by the switch buttons and joysticks of the manual keyboard [1].

For example, if we want to move the objet manipulator to

the right (X– movement), we must send the order from the PC to the DAQ card to output a digital +5V from bit 7 of port A (A7). As this bit is connected to the base of a transistor, this latter saturates sending the emitter voltage to the collector's (connected to +5V from the DAQ card). The emitter in turn is linked to the input of the relay, which when subjected to a digital +5V switches state allowing the current to flow from the common wire to the appropriate wire responsible for moving the object manipulator to the right in the control unit of the *fxs* 160.50. This procedure is similar for all movements and speed changes.

The programming language used to build the application software for communicating between the PC and the tomograph thorough the DAQ interface card is Visual Basic 6 (VB6). While the software package used to establish a Bluetooth communication between the PDA and the PC is LabVIEW. These are explained in the next section.

IV. APPLICATION SOFTWARE

This application software for this solution is devided into two categories: One responsible for the Bluetooth communication, and one for the USB communication. The Bluetooth communication is established between the PDA and the PC, while the USB communication is established between the PC and the Tomograph's Control Unit.

A. The Bluetooth communication application software

The Bluetooth wireless communication between the PDA and the PC is established based on a Server/ Client architecture using the well known development environment LabVIEW. LabVIEW (short for Laboratory Virtual Instrumentation Engineering Workbench) is a platform and development environment for a visual programming language from National Instruments [3]. It is commonly used in data acquisition, industrial measurement and control and instrument control.

In our case, LabVIEW was used to build a server/client application based on Bluetooth connectivity in which a client program resident in the PDA is used to send orders in a binary file to a server program in the PC. The client program allows the user to perform all the operations that were previously available on the old system. These include: Speed control, object manipulator's movements following 5 different degrees of freedom and start/emergency stop operation. The server program receives the binary file that contains the appropriate orders fot the Control Unit and saves it to a specific location on the hard drive of the PC. Another program (running simultaniously) continuously consults the received file to perform the necessary operations. This task is performed by the USB communication application software.

B. The USB communication application software

The USB communication application software is the same as described in [1], with a small modification. The modification includes a PC/PDA control option with which, the user can choose between controling the movements of the object manipulator either from the PC or from the PDA. If the PC control option is chosen, the application acts exactly as that of [1]. However, if the PDA control option is chosen, the application in this case reads a binary file from a certain location on the hard drive, performs some tests on the contents of the file and then sends the appropriate orders to the Control Unit. The file to be read is the one sent by the PDA via the Bluetooth connection using the LabVIEW application as described above.

V. CONCLUSION

In this paper, a Bluettoth communication solution for controlling the movements of an object manipulator in an X-Ray tomograph was presented. The new solution uses Bluetooth connectivity (2.4 GHz) to offer wireless capabilities to the already modified and improved system. The advantages gained by using this system are numerous. To mention, the movements can now be performed without having to be exposed to X-rays for long periods, which reduces the chances of catching malicious diseases. It also allows more flexibility and interoperability between the old and the new system.

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