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Research Article

PUMA Internet Task Logging Using the IDAC-1

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Abstract

This project uses an IDAC-1 board to sample the joint angle position of the PUMA 76 1 robot and log the results on a computer. The robot is at the task location and the logging computer is located in a different one. The task the robot is performing is based on a Pseudo Stereo Vision System (PSVS). Internet is the transport media. The protocol used in this project is UDP/IP. The actual angle is taken straight from the PUMA controller. High-resolution potentiometers are connected on each robot joint and are buffered and sampled as potential difference on an A/D converter integrated on the IDAC-1. The logging computer through the Internet acting as client asks for the angle set, the IDAC-1 responds as server with the 10-bit resolution sampling of the joint position. The whole task is logged in a file on the logging computer. This application can give the ability to the Internet user to monitor and log the robot tasks anywhere in the Word Wide Web (www).

Keywords: Microcontroller, Embedded Internet, Task logging, Robotics, Embedded Application.

1. Introduction

Internet is today's medium of communication. Anybody can access data and information anywhere in the world. Through these information data highways the digitised web pages are travelling from the web server to anybody "surfing" in the Internet.

The idea to utilize this data bandwidth is not a novel idea, even the first users managed to connect distant computers and transfer valuable measurement data. Daponte et al in [1] have developed a real-time measurement and control system applied on an industrial installation over Internet. Although this application was developed for educational purposes in the laboratory it proved that a real-time system could be materialised over the Internet. The protocol used is the ReSerVation Protocol (RSVP).

In the measurement and control field other relevant distributed architectures over Internet were proposed [2],[3],[4]. All these solutions result effective when no strict delay bounds are present. The proposed architectures in their communication part are based on the traditional TCP/IP protocol, which assures data delivering but doesn't guarantee deadlines.

The routine the robot is performing is based on a Pseudo Stereo Vision System (PSVS) [5],[6].

This paper proposes a method of collecting data and monitors the joint positions through Internet using the UDP protocol. The data flow is secured by repeated acquisitions when a time out is occurred.

Ethernet-Internet in General

In Fig.1, the general structure of Ethernet and protocols over IP is shown. It can be seen that Ethernet is the physical layer. In this project the transport is the UDP protocol. The data handling protocol is using simple commands and will be described below.

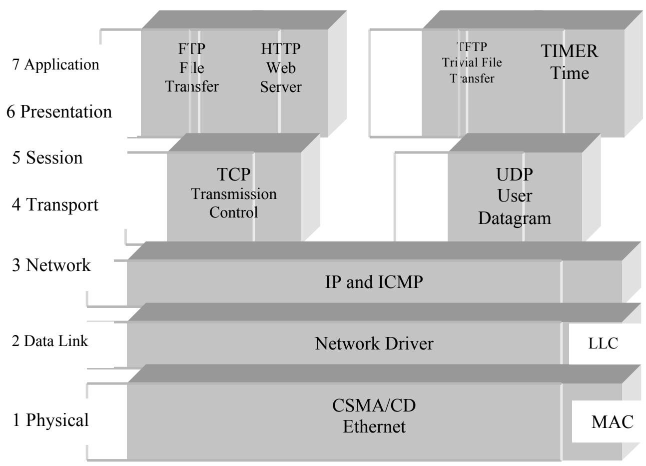

Fig. 1. Physical Layers in Ethernet-TCP/IP

IDAC-1 card can transfer data either on layer 3 (IP – ICMP) or on the physical layer (Ethernet). Ethernet is the actual data connection medium (physical layer) of two or more computers on a Local Area Network (LAN). The topology can be either an open loop topology (using coaxial cable and BNC connectors) or a star (using the UTP cable). It complies with the IEEE CSMA/CD standard. It has also error correction for safe data transport. All the commercial

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network cards plunged in the PCs are using this standard to communicate.

Based on this physical layer (Ethernet) many protocols have been developed in order to facilitate the computer communication. These protocols include the very well known NETBEUI, IPX/SPX, TCP/IP and many more. TCP/IP is same protocol used by the modem to connect the user through a telephone line to the Internet.
Internet is actually a huge number of computers linked together with different type of physical layers (Ethernet, telephone lines, fiber optics, e.t.c.) but using the same communication protocol the TCP/IP (Transfer Control Protocol over Internet Protocol).

The formation Internet has today is based on the basic principle: the IP address. Every computer linked to the Internet has a unique address of the type xxx.xxx.xxx.xxx where xxx is a number from 0 to 255. According to these rules IDAC-1 board has an IP address (195.130.94.43) and is able to communicate with any other computer linked to Internet.

This project deals with the task logging of a robot to distant location using the Internet. PUMA 761 robot has internally installed high-resolution potentiometers on each joint. The robot controller using the potentiometers creates a potential difference 0 – 5Volts. These potential differences are buffered sampled by an A/D installed on an embedded Internet board (Photo 2).

2. IDAC-1 General Description

IDAC-1 is a board manufactured by Lamda Labs Inc. and is the materialization of a Data Acquisition and Control through the Internet. It has on board a PIC16F877 microcontroller, which acts as the data controller as well as the data acquisition. It comprises five (5) analog channels, eight (8) digital I/O and an 8-bit counter. The PUMA robot is a 6 Degrees of Freedom (DOF) manipulator and to monitor the robot tasks 6 analog channels are needed. Thus, Lamda Labs modified a IDAC-1 board to be able to sample six (6) analog channels. The analog voltages from the PUMA controller are buffered using the AD 670 instrumentation amplifier. The output is directed to IDAC input analog channels.

The digital I/O can be programmed on the fly either as input or output. The Internet user can read the status of the digital inputs and change as desired the digital outputs. In the present project none of the available digital I/O are used, but in a future application they can be used to control/monitor the status of the robot, to give audio-visual signals that the robot task is being logged by an Internet user e.t.c.

IDAC-1 Hardware Description
Photo 1 shows the IDAC-1 board. IDAC-1 comprises: a) The Microchip PIC16F877 microcontroller loaded with the communications and data sampling embedded software, b) the Realtek TL8019AS acting as the Ethernet controller and transceiver to the network and c) the appropriate connectors to the network, the analog and digital inputs and to the RS232 for the parameter programming.

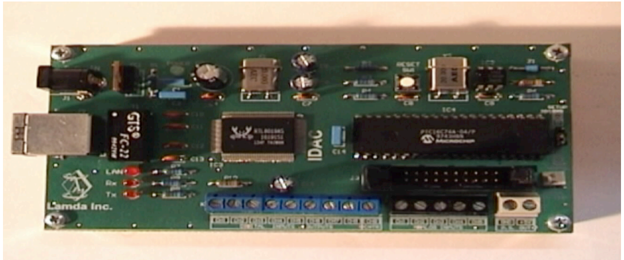

Photo 1. IDAC-1 board

The Microchip PIC16F877 microcontroller was selected as the central processing unit because: a) it has the memory size (4Kbytes) demanded by this application and b) has on chip an A/D of 10 bit resolution.

The Realtek TL8019AS chip is one of the most used transceiver chips in the market and is used in most of the existing PC Ethernet LAN cards.

IDAC-1 Software Description
The block diagram of the embedded software is shown in Figure 2. The microcontroller after the initialisation, it runs a self-checking routine. At the next step checks the on board jumper if the user wishes to enter the set-up routine. If so the parameters are entered through the RS232 port and set on the board. If not the RJ45 port is check for an incoming package. If so, the package is decoded and checked if there is a command. The commands the IDAC-1 can execute are: a) Set-up the Digital I/O, b) Read the Digital I/O status c) Read the six (6) Analog channels and d) Read the contents of the 8bit counter. After this the UDP protocol package has to be prepared. The package is transferred to RealTek and sent to RJ45 Ethernet port.
At any time the user can issue a command and receive the answer through Internet.

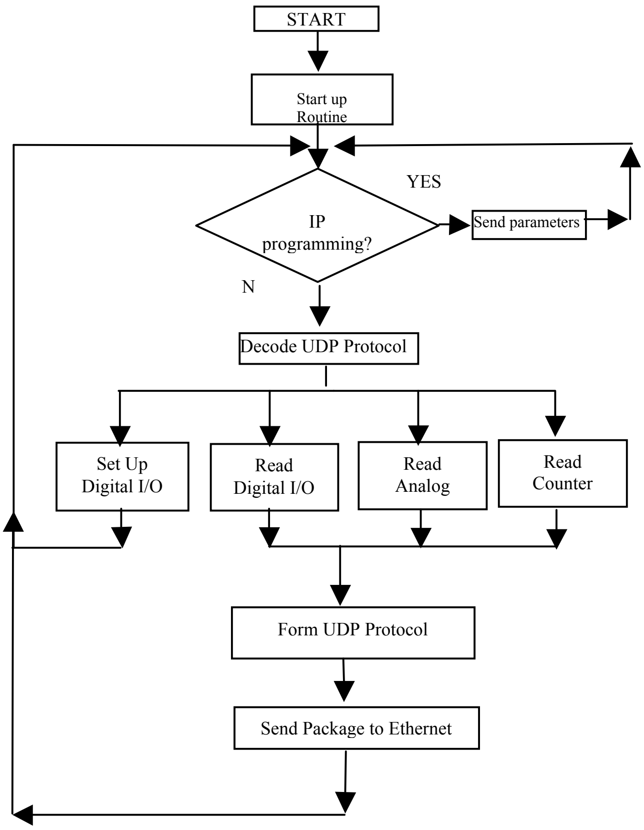

Fig. 2. Embedded Software Block Diagram.

3. Experimental Set-Up

As mentioned above the potential differences presenting the position angles of robot joints are buffered using six(6) instrumentation amplifiers AD640. The voltages are driven to the IDAC-1 board. The buffering – sampling layout is shown in photo 2. The robot controller is shown in photo 3. Using the instrumentation amplifiers as buffers was the only way of sampling the position angles of the robot joints without any implication to the robot movements.

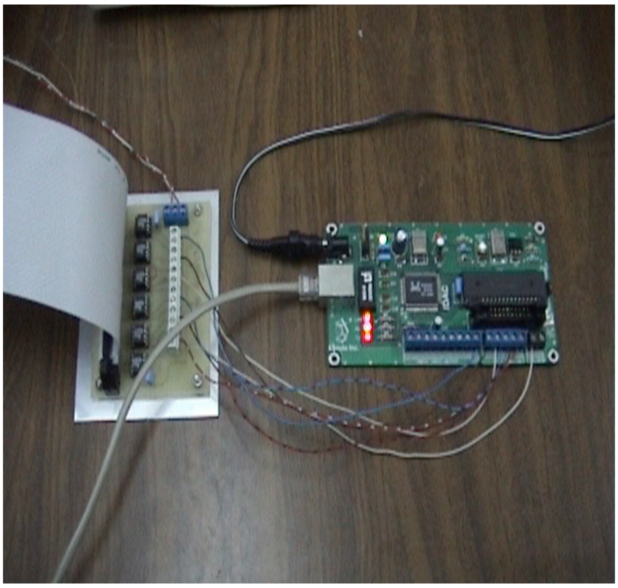

Photo 2. Buffering and Sampling layout

Photo 3. Robot controller

Inside of the robot controller a ribbon cable is installed to collect the potential differences and is driven to the buffering board. The buffering board provides the voltages to the IDAC-1 board.

A PC connected to Internet on a distant location was used as the logging computer. The program running on it is issuing read analog input commands to IDAC-1 is getting the answers. Those readings are translated to angles, based on a calibration routine followed at the start of the project. The resulted angles are saved on a file.

4. Experimental Results

The set-up was tested during a routine based on a Pseudo Stereo Vision System (PSVS) (Photo 4). The method finding the robot path on a plane surface uses a single camera, mounted on the end-effector of the robot manipulator as a sensor.

Photo 4. PUMA 761 performing a task based on PSVS.

The robot path points are calculated using an image of a static scene of the environment of the manipulator, where a desired track was appeared. The calculation of the final path points is the result of the combination of two well known methods for camera calibration and for hand/eye – robot/world calibration. A software application written in C, using the previous two methods and simple image processing procedures is used to calculate the desired robot path points based on the image captured by the camera. The desired robot path points can be found with high accuracy. The method was used to simulate a gantry system with a robotic manipulator.

The graphics users interface collecting the task data is presented in Figure 3.

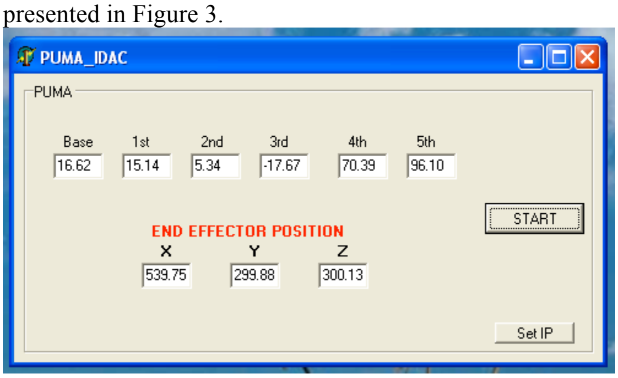

Fig. 3. Users interface

At the same time IDAC-1 was sampling the joint positions and passed through the Internet to the logging computer. To find the minimum data traffic on the network, a late night time was selected (after 23:00).

The time response was quite satisfying at it was rated to few hundred milliseconds (from 254 to 329msec). This time of course is not adequate for fast or fine robot tasks. Nevertheless, if the aim is to monitor the robot task and not accurately log every one of its movements, this timing is more than appropriate.

5. Conclusions

This paper described a task logging system of a PUMA robot. The joint angles was continuously sampled and logged through Internet, using the IDAC-1 board. This on-line through Internet logging is the best way to monitor any robot's tasks from anywhere in the world. The monitoring will provide data to a remote computer and in cases of task error the procedure could be terminated.

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