HANDLE

Developmental pathway towards autonomy and dexterity in robot in-hand manipulation

Data Acquisition Devices Synchronization

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Acronyms

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1 Data Acquisition Architecture

Due to the high number of devices and the possibility of simultaneous utilization of several of them on a single data acquisition session, distributed data acquisition architecture has been implemented in the experimental area.

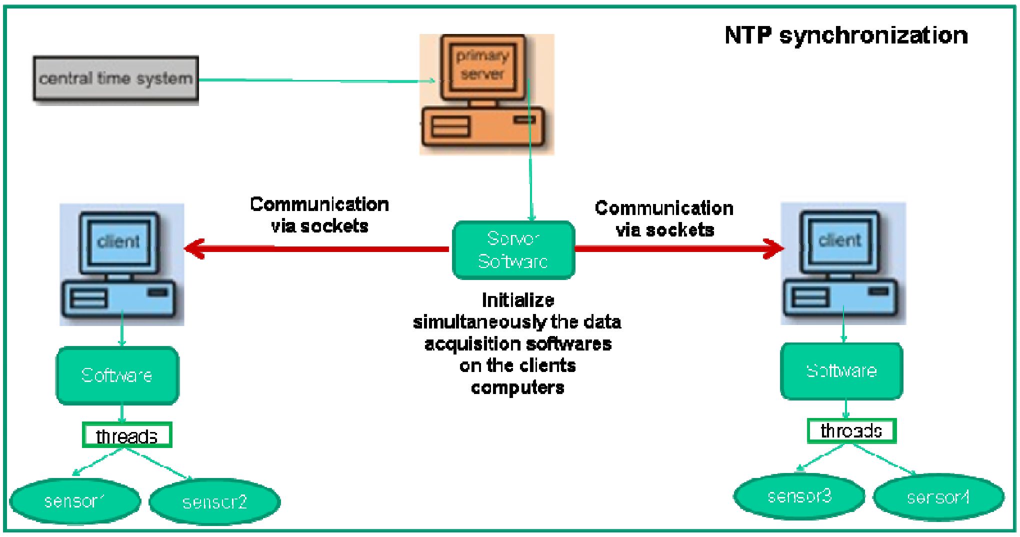

Figure 1 – General representation of the data acquisition architecture implemented in the experimental area.

In this data acquisition architecture, each computer can has one or more data acquisition devices connected to it. All the computers involved on the data acquisition session are connected by a TCP/IP computer network. One of the computers of this architecture works as server and the remaining ones (computers which have data acquisition devices connected to it) work as clients. Software clients for each of the data acquisition devices (Polhemus Liberty, Videre Stereo camera, CybergloveSystems CyberGlove II, Tekscan Grip System, instrumented Rubik cube, Unibrain Firewire Monocular Camera) have been developed, as well as a software for the server computer. The main idea behind this approach is to have the server software coordinating all the data acquisition process. The server software is responsible by acknowledging the connection requests of the clients' software at the beginning of the data acquisition session, building a list of all the clients connected to it. After all the required clients' software are connected to the server software, it is possible to initialize simultaneously the data acquisition from all the devices by selecting the corresponding option on the server software menu. Each client software manages both the data acquisition from the respective device, as well as, the storage of the data. The data acquisition from all the devices is also finished simultaneously by indication coming from the server software. The communications between the server and clients' software is established through TCP/IP sockets.

All the data acquired from the different devices is time-stamped. In order to have a common temporal reference between the different computers involved in the data acquisition session, the Network Time Protocol (NTP) is used for clock synchronization of the different computers. NTP is a free, widely available protocol designed to synchronize the clocks of computers over a network.

The acquisition of the data can be centralized in a single laptop/desktop commputer or multiple computers with synchronized clocks over the network using Network Time Protocol. The Polhemus Liberty central unit is connected to a laptop/desktop computer through a RS-232 connection. The stereo camera STH-MD CS3, Unibrain Fire-I digital camera are connected through a Firewire connection and the tactile device TekScan Grip system, as well as the CyberGlove II device, through a USB connection.

2 Network Time Protocol synchronization

The Network Time Protocol (NTP) was designed to synchronize clocks of hosts and routers in the Internet. NTP provides nominal accuracies of low tens of milliseconds on WANs, submilliseconds on LANs, and submicroseconds using a precision time source such as a cesium oscillator or GPS receiver. NTP software has been ported to almost every workstation and server platform available today - from PCs to Crays - Unix, Windows, VMS and embedded systems, even home routers. NTP is a free, widely available protocol designed to synchronize the clocks of computers over a network. Once all our data collecting devices are synchronized to the same reference (ex. Universal Time Clock), we can begin collecting data using the same time stamp time reference.

NTP synchronization adjusts the time in the machine clock to be as accurate as possible relative to the time in the UTC server machine.

2.1 Network Time Protocol Server setup in Ubuntu

1.Install NTP packages

```
sudo aptitude-install ntp
```

2.Edit the NTP configuration file, typically located at /etc/ntp.conf. Replace the content of this file by the following text. Save the file at the end.

```
#To save our drift values
driftfile /var/lib/ntp/ntpserv.drift

# To enable statistics to be logged.
statsdir /var/log/ntpstats/

statistics loopstats peerstats clockstats
filegen loopstats file loopstats type day enable
filegen peerstats file peerstats type day enable
filegen clockstats file clockstats type day enable

# Set the reference server to ourself (pretending to be a stratum 8
server)
server 127.127.1.1
fudge 127.127.1.1 stratum 8 refid NIST

# Default restrictions
#To ensure that all remote clients on my subnet have access to the
server. I also explicitly allow access from the localhost subnet, to
ensure that the server can query itself.

restrict default notrust nomodify

# Restrict access to clients on our subnet and ourself
#These two lines of code should be adjusted to the local network
#configuration, which is going to be used in the data acquisition
#session
restrict 10.231.1.0 mask 255.255.0.0 nomodify
```

```
restrict 10.231.11.0 mask 255.255.0.0 nomodify

restrict 127.127.0.0 mask 255.255.0.0 nomodify
```

3. At the end, the NTP server should be restarted in order for these settings to take effect using the following command.

```
sudo /etc/init.d/ntp restart
```

2.2 Network Time Protocol client setup in Ubuntu

1.Install NTP packages

```
sudo aptitude-install ntp
```

2.Edit the NTP configuration file, typically located at `/etc/ntp.conf`. Replace the content of this file by the following text. Save the file at the end.

```
# /etc/ntp.conf, configuration for ntpd

driftfile /var/lib/ntp/ntp.drift

# Statistics to be logged.

statsdir /var/log/ntpstats/

statistics loopstats peerstats clockstats
filegen loopstats file loopstats type day enable
filegen peerstats file peerstats type day enable
filegen clockstats file clockstats type day enable

# IP of the NTP server to talk to, in this example the IP of the NTP
# server is 10.231.11.26

server 10.231.11.26
```

3. At the end, the NTP client should be restarted in order for these settings to take effect using the following command.

```
sudo /etc/init.d/ntp restart
```

4. In order to determine if the clients are correctly synchronized with the server, and if the server is correctly synchronized with itself, the following command should be used.

```
sudo ntpq -np
```

This command provides a list of configured time servers and the delay, offset and jitter that your server is experiencing with them. For correct synchronization, the delay and offset values should be non-zero and the jitter value should be under 100. A star in any one of the chosen server names means that the system clock is synchronized with that NTP clock. If a star is not visible near one of the listed NTP servers, it means that the clocks are unreachable.

3 Data acquisition software setup

As described before in this document, the devices used in the data acquisition session are integrated a in broader distributed data acquisition architecture.

The global steps involved in the configuration of a data acquisition session are:

1- Start up the Server (software which launch others software simultaneously) on a Linux console run the application:

.\server_acquisition

A menu will be displayed on the console.

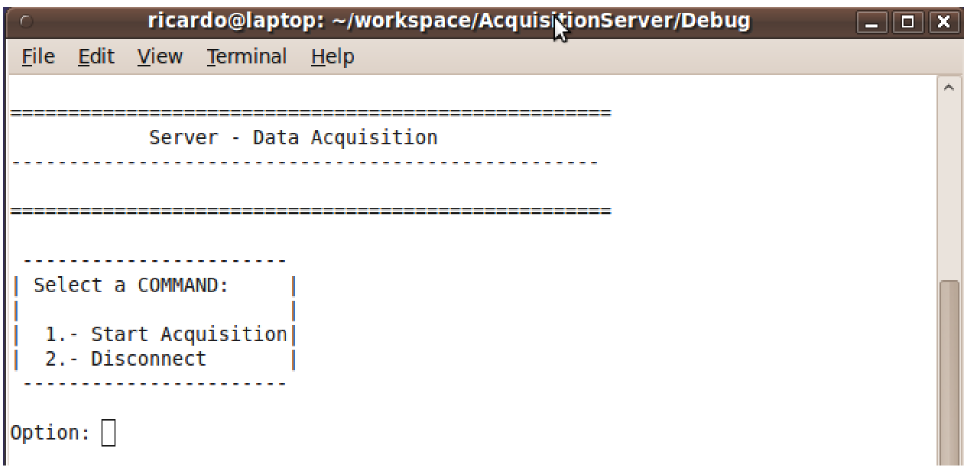

Figure 2 – Data acquisition server software menu.

4-Start up the clients of the data acquisition devices used in the session (each data acquisition device has its own software client), on Linux consoles using the following commands for the respective client software:

- .\client_polhemus serverIP folder subfolder
  .\client_viderestereo serverIP folder subfolder
  .\client_cybergloveii serverIP folder subfolder
  .\client_tekscantactile serverIP folder subfolder
  .\client_rubikcube serverIP folder subfolder
  .\client_unibrainmono serverIP folder subfolder

The parameter *serverIP* corresponds to the IP of the computer running the data acquisition software server application. The *folder* and *subfolder* parameters indicate the name of the folder and subfolders respectively where the data recorded by the software client will be stored.

The connection of each client is acknowledged by the server application.

5-After all applications have been started (server and clients), choose one option from server software menu: Choose 1 to start the acquisition.

6- Execution of the required task;

7-Finish the data acquisition session by choosing the option 2 in the server menu.

3.1 Tekscan Grip System data acquisition

In order to do the software integration of the *TekScan Grip* tactile system, an analysis was made of the software provided.

The purchased *TekScan Grip Tactile* system package came with a windows only application, *Grip Research 6.33*, which allows the users to setup the connection between the device and a computer, define the data acquisition parameters (such as, device sensitivity, data acquisition rate, data acquisition duration, enable/disable triggering mode, setting different options of the trigger).

The result of a data acquisition can be exported as a text file and each sample is labelled with a time stamp (seconds).

In opposition to the remaining data acquisition devices packages, the Tekscan Grip System basic package doesn't come with a software development kit, which is available to develop windows only applications. Taking these factors in consideration, the external triggered data acquisition mode is implemented in order to have the possibility to synchronize this device with the remaining ones used on a data acquisition session.

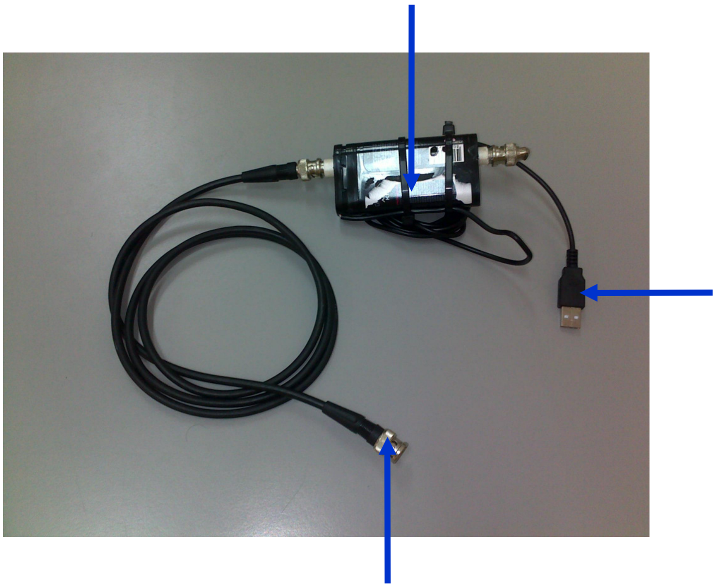

Figure 2 – Relay switch module.

Since the input trigger port of the Tekscan console reacts to the change of an open to a closed circuit, triggering the start of a recording session, the computer running the client software of this device is connected by a USB cable to a module that has been developed which closes a relay switch connected to the input trigger port of *TeckScan Grip System* console. An external trigger signal is sent to start and stop the data acquisition from this device. The time instant at which the start trigger is produced, is recorded. At the end of the data acquisition a text file is exported and it is parsed to the appropriate XML file structure. The timestamp of each sample is estimated based on the instant of the production of the start external trigger and the pre-defined sampling rate configured in the *Grip Research 6.33* software.

To do the integration of the *TekScan Grip* System, besides the computer running the developed client software, another computer with a Windows operative system is necessary to run the *Grip Research 6.33* software configured in the trigger start data acquisition mode.

The *TekScan Grip System* provides a software, *Grip Research 6.33,* which has tools to define the data acquisition parameters such as the sensitivity mode of the sensor. The software also allows the configuration of several data acquisition parameters, such as the data acquisition duration, data acquisition rate, as well as, setup the data acquisition starting mode (manual, by an external trigger), noise thresholds and other parameters.

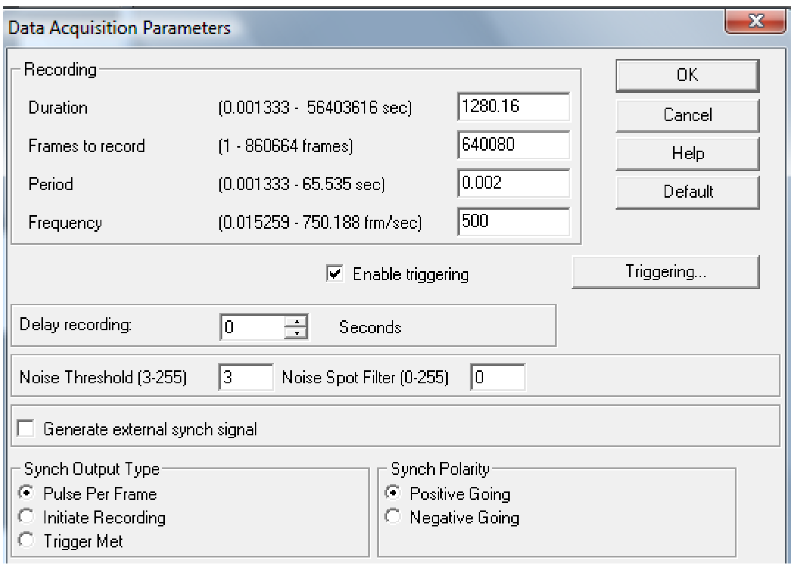

Figure 2 – Data acquisition parameters definition menu.

As explained before in this document, the data acquisition from this device is be started by an external trigger. The *"enable triggering"* option should be checked and the triggering parameters should be configured in the triggering menu. The external trigger is used to start and stop the data acquisition.

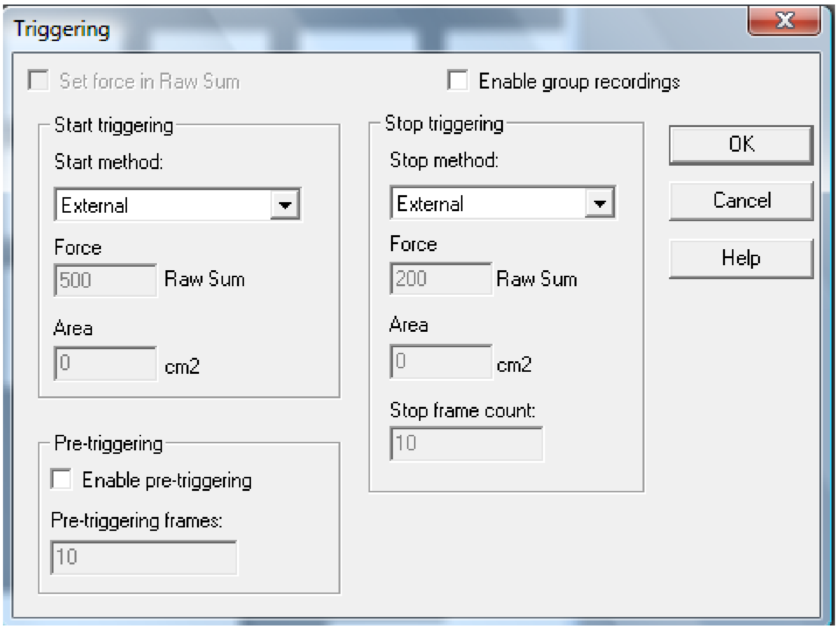

Figure 3 – Triggering definition menu.