SOFTWARE DEVELOPMENT FOR REAL TIME DATA CAPTURING AND LEAST SQUARE ESTIMATION ANALYSIS

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Abstract

Industrial survey is a discipline of engineering surveys that requires the utmost in achievable accuracies and real time data processing. The instrumentation used in conventional industrial survey requires long painstaking procedures with very skilled craftsmen to obtain the required results. Revolution of technology with the introduction of new instruments (such as total station, computer and software) has revolutionized industrial survey. The development of three dimensional (3D) coordinating system and total station interfaced to a microcomputer provides the capabilities for on line data gathering with simultaneous processing in 3D. This research concentrates on the development of software to capture data (from total station) in real time. Least Square estimation (LSE) process is also performed on the data. For this purpose, robotic tachometry system TCA 2003 is used as a sensor and Microsoft Visual Basic V6.0 is used to develop the software.

1.0 INTRODUCTION

Nowadays, three dimensional (3D) coordinating systems are required to achieve a high-level of accuracy and at a high data rate to detect any moving object or for monitoring purpose. Typical applications include studies of dam monitoring, bridges and building under load, monitoring cranes in operation for deflections and aligning large machinery during construction.

In recent years, total station have been upgraded from instrument which can used to measure bearing, distance and also have a microcomputer to perform a simple calculation. Now, attached with servo-driven, automatic tracking and specialized software (to perform more calculation), total station is changed to robotic total station (RTS). RTS have been developed which can track a moving target and make automatic measurements of angles and distances to the target in motion (Radovanic & Teskey, 2001). These instruments can make measurements at data rates up to 1 Hz and can operate autonomously once lock to the target has been manually set by an operator (automatic target recognition).

Industrial survey is a field of engineering surveys that requires the utmost in achievable accuracies and almost invariably depends on the results being in real time (Wilkins, 1989). Capability of RTS to give 3D coordinates allows real time data processing. Normally, data processing is done by computer because the requirement of a big memory. For this reason, software connecting the computer and RTS for data communication must be developed. Consequently, this research focuses on the development of a software to capture data (from RTS Leica TCA 2003) in real time.

2.0 DATA COMMUNICATION

Communication is the process of transferring messages from one place to another. Data communications is the transfer of information from one location to another by means of communication channel. Communication involves three basic elements (Figure 1): A sending unit, transmission channel and receiving unit.

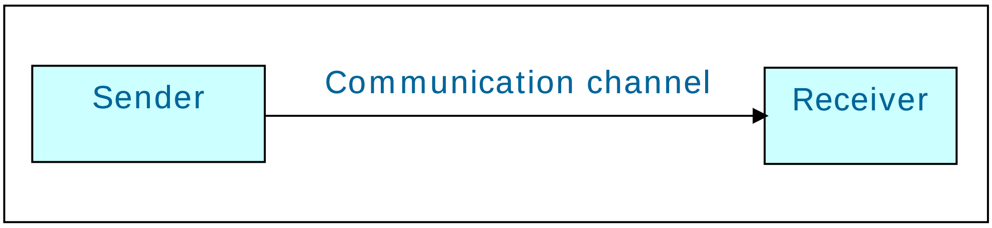


Figure 1. Communication process

In order to understand basic functioning of data communications we need to know more about how a message is sent over a communication link: modes of transmission, types of transmission and protocol.

2.1 Modes of Transmission

The mode of transmission refers to the manner in which the characters of a message are transmitted. Data transmission is carried out in three different modes: synchronous, asynchronous and isochronous transmission.

Synchronous transmission sends character in groups or blocks (Figure 2). A block of data may contain hundreds of characters. Each block is framed by header and trailer information. The header consists of synchronizing information which is used by the receiving unit to set its clock to in synchronism with the sending unit clock. The header also contains information to identify sender and receiver. Following the header is a block of characters that contains the actual message to be transmitted. The message characters are terminated by trailer. Thus the trailer contains an end of message character.

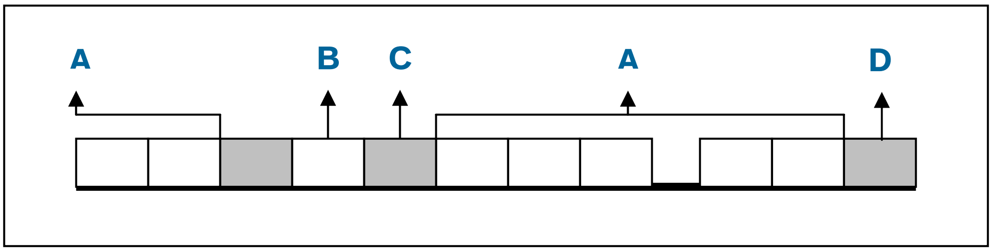


Figure 2. Synchronous transmission

A	Character
B	Indefinite time interval between two blocks of data
C	End of block indication
D	Header

Asynchronous transmission sends characters one at a time (Figure 3). Each character is identified by a start bit and a stop bit. Preceding the character is a start bit and following the character is one or two (depending upon the system) stop bits. This type of transmission is said to be asynchronous because the receiver can identify a character by its start and stop bits regardless of when it arrives. Thus, characters can be sent at irregular intervals.

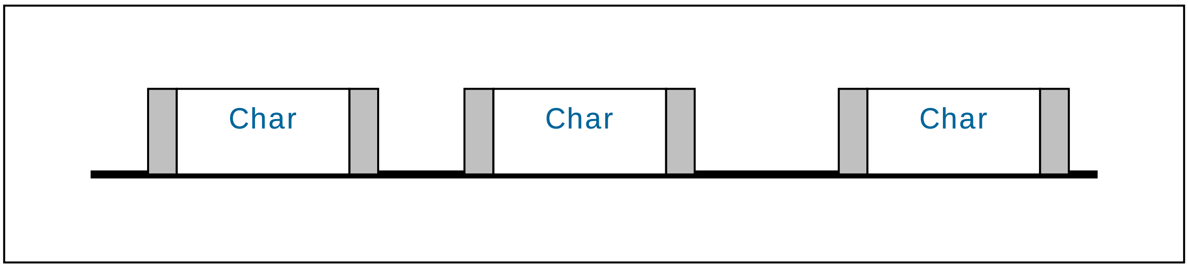


Figure 3. Asynchronous transmission

Isochronous transmission combines features of synchronous and asynchronous transmissions. In this type of transmission characters have identifying start and stop bits and the sender and receiver are synchronized.

2.2 Types of Transmission

There are three ways for transmitting data from one place to another. These are simplex, half duplex and full duplex transmissions. Simplex transmission is one way (Figure 4). The communication can take place in only one direction. Devices connect to such a circuit is either a send-only or receive-only devices. The sending unit always sends and the receiving unit always receives. For example, a printer connected to a computer is restricted to receive information to be printed. It cannot be used to transmit message to the computer.

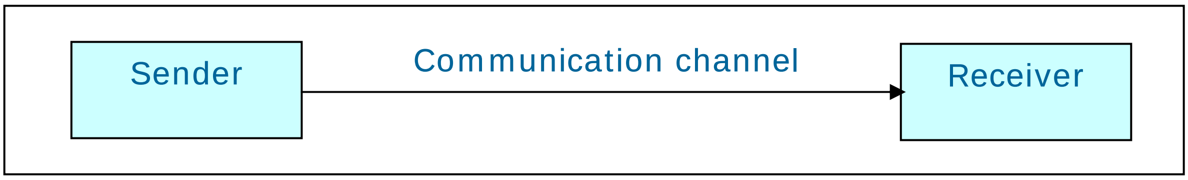


Figure 4. Simplex transmission

Half-duplex transmission permits transmission in both directions, but in only one direction at a time (Figure 5). That is, one unit can send a message to another, but receiving unit must wait until the reception is completed before transmitting message of its own.

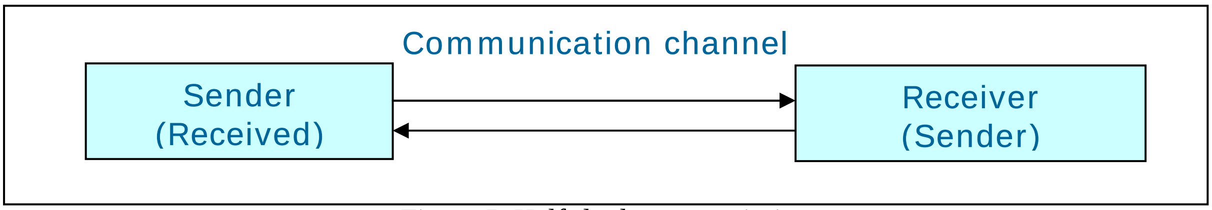


Figure 5. Half-duplex transmission

Full-duplex transmission permits information to flow simultaneously in both directions on transmission line (Figure 6). Thus, full duplex transmission allows a unit to send and receive messages simultaneously.

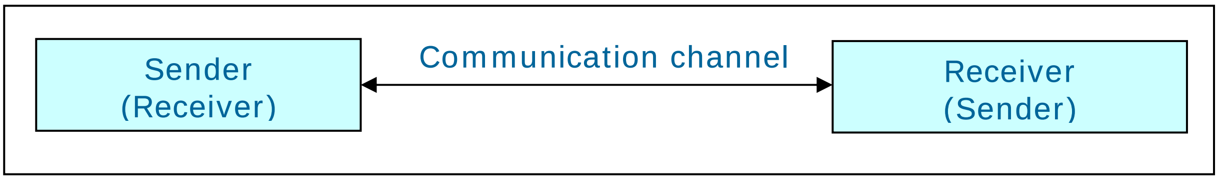


Figure 6. Full-duplex transmission

During software development, GeoCOM Protocol (provided by Leica) has been used. This protocol is implemented as synchronous communication and half-duplex transmission because a request or reply pair may not be interrupted by another request or reply. Instead, a communication unit must be completed successfully before a new communication unit may be initiated.

3.0 SERIAL COMMUNICATION

Serial communication is a very common protocol for device communication that is standard on almost every PC. Most computers include two RS-232 based serial ports and one IEEE 488 based parallel port. Serial is also a common communication protocol that is used by many devices for instrumentation. Furthermore, in this research, serial communication can be used for data acquisition in conjunction with a remote sampling device.

The concept of serial communication is simple. The serial port sends and receives bytes of information one bit at a time. Parallel communication allows the transmission of entire byte at once. Thus, parallel communication is faster than serial communication. However, there are several disadvantages of parallel communication:

1. Parallel cables cannot be longer than serial cables.
2. Parallel transmission (19 or 25 core cable) needs many wires than serial transmission (3 core cable).
3. Cannot used for infra red transmission.

Typically, serial is used to transmit ASCII data. Communication is completed using 3 transmission lines: (1) Ground, (2) Transmit, and (3) Receive. The important serial characteristics are baud rate, data bits, stop bits and parity. For two communication port, these 4 parameters must match.

1. Baud rate: a speed measurement for communication. It indicates the number of bits transfers per second.
2. Data bits: a measurement of the actual data bits in transmission. When the computer sends a packet of information, the amount of actual data may not be a full 8 bits. Standard values for the data packets are 5, 7 and 8 bits. These values depend on the information to be transferred.
3. Stop bits: used to signal the end of communication for a single packet.
4. Parity: a simple form of error checking that is used in serial communication.

4.0 PROTOCOL COMMUNICATION

Leica provides two different languages to control the instruments via RS232 interface (serial communication): Geo Serial Interface (GSI) and GeoCOM. GSI is a simple and easy understandable language which operates mainly four commands: SET, CONF, PUT, GET with which the main functionality of the instrument can be controlled. But GSI is mainly used to get data from the instrument and there are only a small number of commands available that actually steer the instrument. Below is a GSI8 example (Table 1):

<u>GSI8</u>

[**110001+0000A110...**] 81..00+00005387 82..00-00000992

Table 1. GSI8 Data Tansmission (Leica, 1999)

Character Position	**Examples**	**Description**
Position 1-2	11	Word Index (WI)
Position 3-6	0001	Information related to data
Position 7	±	Sign
Position 8-15	0000A110	Data (8 digit)
Position 16	....	Blank

Second protocol is GeoCOM (used for this research), might be seen as the successor of the GSI protocol and allows to command the instrument with the full set of commands. GeoCOM itself handles all necessary communication with no intervention of the programmer in respect to the communication. GeoCOM is implemented as a point to point communication system. The two communication participants are known as the client (external device) and the server (TPS1000 instrument). One communication unit consists of request of a request and a corresponding reply. Hence, one communication takes place when the client sends a request to the server and the server sends a reply back to the client. GeoCOM is implemented as synchronous communication. A request/reply pair may not be interrupted by another request/reply (half duplex transmission). Instead, a communication must be completed successfully before a new communication unit may be initiated. Although the ASCII protocol allows sending the next request before the corresponding reply has been received, it is not recommended to do that because subsequent request will be buffered when the previous request has not been finished so far. But if the buffer content reaches its limit in size then data may be lost. Below is a sample for data request using GeoCOM protocol (Table 2):

GeoCOM protocol (request)

```
[<LF>]%R1Q,<RPC>[,<TrId>:[<P0>][,<P1>,…]<Term>
```

Table 2. GeoCOM Protocol (Leica, 1999)

Parameter	**Description**
`<LF>`	An initial line feed clears the receiver buffer.
`%R1Q`	GeoCOM request type 1.
`<RPC>`	Remote Procedure Call identification number in between0 to 65535.
`<TrId>`	Optional transaction ID: normally incremented from 1 to 7. Same value in reply.
:	Separator between protocol header and following parameters.
`<P0>,<P1>,….`	Parameter 0, Parameter 1, ...
`<Term>`	Terminator string.

5.0 SOFTWARE DEVELOPMENT

In this research Microsoft Visual Basic V6.0 is used for software development and GeoCOM is the selected protocol because of the ability to capture and steer the instrument with full set of commands. Programming with VB is based on the Dynamic Link Library (DLL) concept. To enable access to GeoCOM the special module stubs_p .bas has to be included in the project. This stubs_p .bas module includes all constants, data types and function prototypes, which are available in GeoCOM.

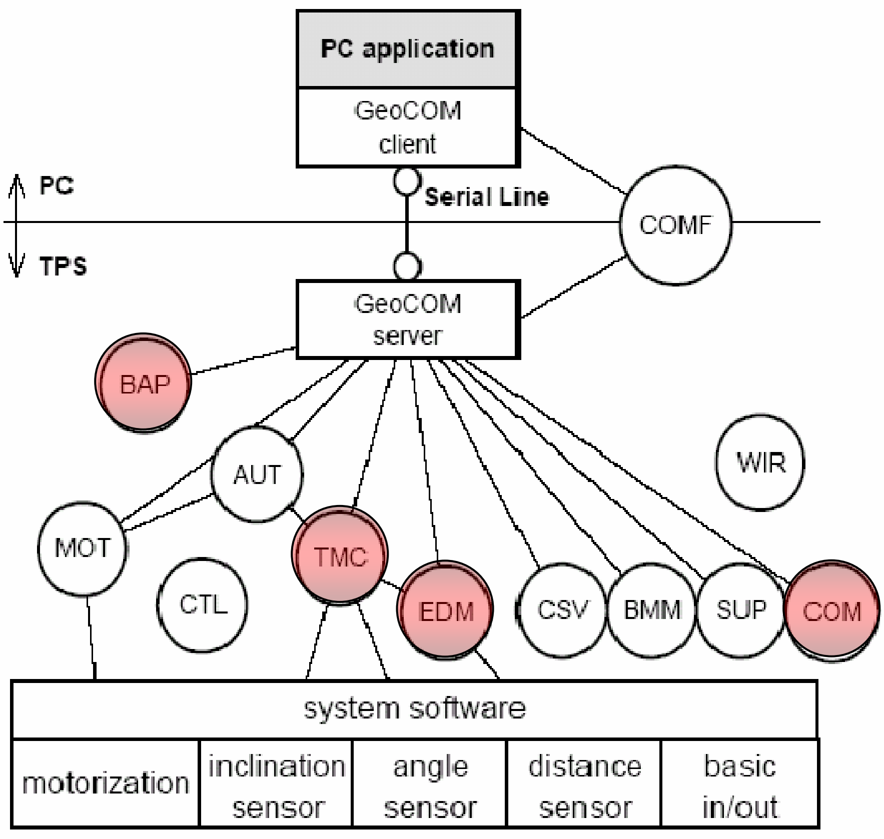
The software consists of 4 core modules. Module 1 for communication between RTS TCA2003 and computer, module 2 for acquisition of data (observation), module 3 for executing simple calculation (to produce three dimensional (3D) coordinates) and module 4 for converting data format from raw data into Starnet (LSE software) format.

Module 1 is important module because it involves data communication, i.e. which data observation from RTS can be received by computer using this module. This module was developed using GeoCOM protocol and serial communication have been used. Using serial communication, programmer need to set 4 parameters (baud rate, data bits, stop bits and parity) to allow communication between two devices. Hence, it is programmer responsibility to synchronize the values between computer and instrument.

Table 3. Serial Communication Parameter for RTS TCA2003

Serial communication parameter (*robotic total station* TCA2003)	**Value**
Baud Rate	9600
Data Bits	8
Stop Bits	1
Parity	None

In GeoCOM protocol, many functions are available, such as automatisation (AUT), basic applications (BAP), basic man machine (BMM), communication (COM), central services (CSV), control task (CTL), electronic distance meter (EDM), motorization (MOT), supervisor (SUP), theodolite measurement and calculation (TMC), and word index registration (WIR). Figure 7 below shows the GeoCOM functions.



Picture (1) - Overview Client/Server Application

Figure 7. GeoCOM Functions (Leica, 1999)

In this research, only basic applications (BAP), theodolite measurement and calculation (TMC), electronic distance meter (EDM) and communication (COM) is used. BAP is a function which can easily be used to get measuring data, TMC is the core module for getting measuring data, EDM is the module which measures distances and COM is a function to perform communication between RTS and computer.

To acquired raw data such as slope distance, vertical and horizontal angle , module 2 has been used. This module used BAP and TMC functions to get raw data from RTS TCA2003.

Module 3 is a calculation module to get 3D coordinates. From module 2, raw data can be received then using module 3 this raw data are processed using simple calculation to get 3D coordinates.

In industrial or deformation survey, the data must be adjusted before the analysis. To get an adjusted results or data, least square estimation (LSE) is used. In this research, Starnet (LSE software) is used to get an adjusted results but to use this software the data must be compiled according to Starnet format. Therefore, module 4 can be used to convert the data into Starnet format. Below is a sample to convert data into Starnet format (Figure 8) and flow chart for software development (Figure 9).

The "BM" Code: Bearing and Measurements to Another Station

Format for 2D Data:

BM	From-To	Bearing (or Azimuth) Distance	[Std Errs]	

Formats 3D Data - Depending on the "Distance/Vertical Data Type" mode:

BM	From-To	Bearing (or Az) Slope Dist Zenith	[Std Errs]	[HI/HT]
BM	From-To	Bearing (or Az) Horiz Dist Elev Diff	[Std Errs]	[HI/HT]

Figure 8. Starnet Data Format (Starnet V6, 2001)

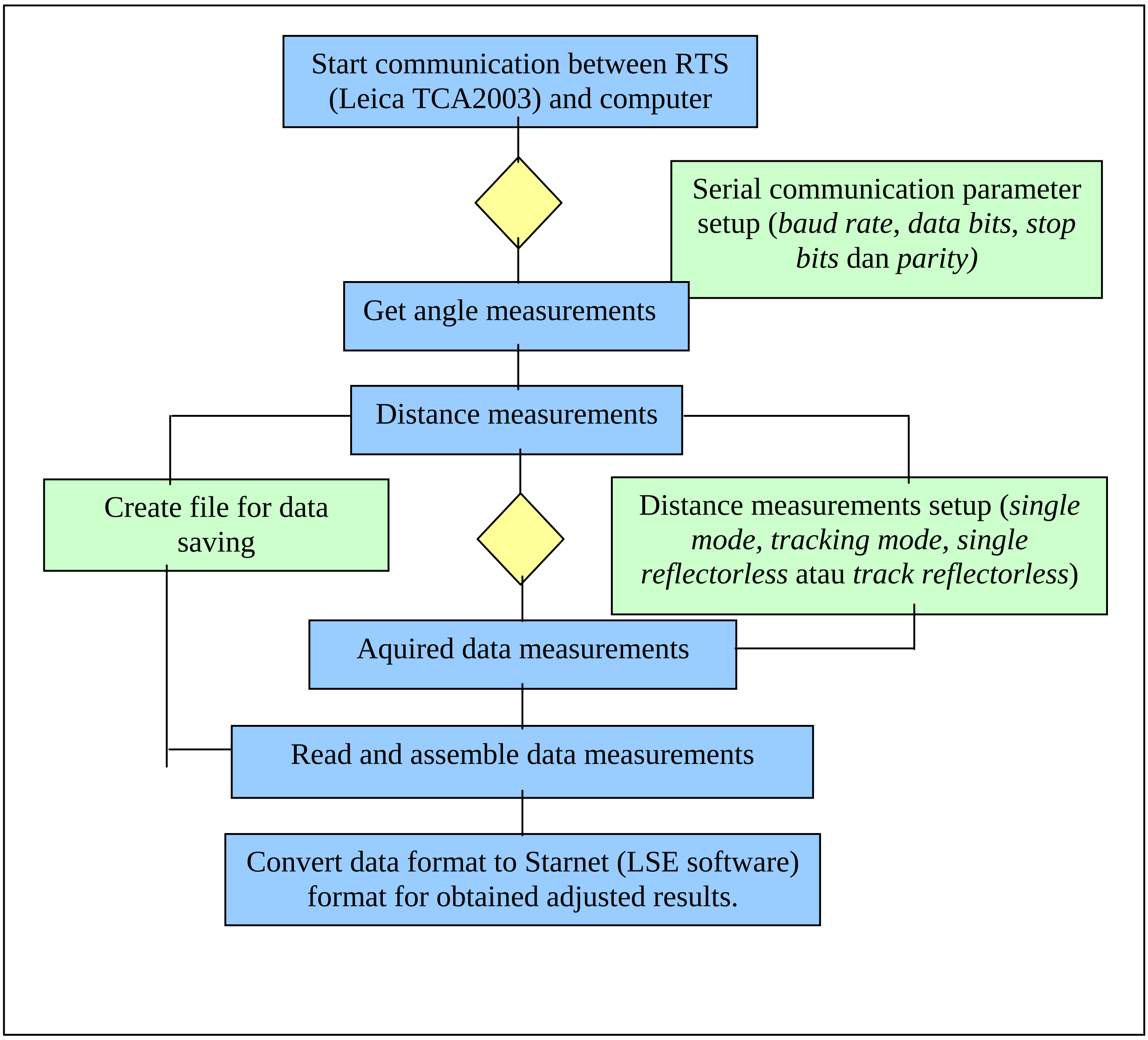


Figure 9. Flow for software development

6.0 CONCLUSION

The development of software for real time data capturing requires the understanding on the modes of transmission, types of transmission or protocol. For serial communication, 4 important parameters (baud rate, data bits, stop bits and parity) between computer and instrument must be synchronized, to allow the communication between these two devices.

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