IMPLEMENTATION OF REAL TIME MEASUREMENT SYSTEM FOR PRECISE SURVEYING APPLICATIONS

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Abstract

Conventional data gathering is not practical and is subjected to several errors due to human factor or instrumentation limitations, especially the gross and systematic error. Precise surveying (especially deformation monitoring and industrial surveying) requires measurement automation and real time measurement system. To date, several real time measurement systems have been developed for deformation monitoring (DIMONS, Leica GEOMOS, Leica APSWin) and industrial surveying (Leica Axyz). The main aim of this research is to develop and implement a real time measurement system for precise surveying application using high precision Leica TCA2003 robotic total station (RTS). This paper discusses the software/system development methodology and the implementation using Microsoft Visual C++.

INTRODUCTION

Surveying have special measurement and analysis techniques to achieve high reliability data in order to represent the deformation or dimensional measurement of objects. Many aspects must be considered such as data collection, surveyor individual skill, processing and analysis. Traditionally, all the measurement data are written on the field book and processed in the office. This traditional method may introduce gross error from surveyor himself and also systematic error from the instrumentation.

Since electronic distance measurement (EDM) and total station enter the market in late 90's, automated instrumentation take place as a medium for data collection. Geodimeter instrument series use servomotor to facilitate pointing of the telescope. Servomotor technology gives new concept in surveying application in term of single operator or "one man". The moving telecommunication unit, Remote Procedure Unit (RPU) is used as reflector unit. The one-man concept has operational and manpower cost advantages.

Consequently, two or more theodolites linked to a microcomputer create a there dimensional (3D) coordinating system with real time calculation. These systems are used for highest precision and deformation monitoring surveying over small area. Leica Axyz (Leica Geosystem) and UPM400 (Geotronics, Sweden) are example of such systems for industrial and dimensional measurement.

In the latest technology, automatic target recognition (ATR) connected to APSWin or GeoMOS (also manufactured by Leica Geosystem), offers continuous deformation monitoring campaign. This ATR technology was installed in precision theodolites by the 1980's. The Wild DIOR 3002 (also known as Leica Geosystem) instrument used this ATR technology (Bannister & Raymond, 1992). Leica TCA series are attached with ATR component, consisting of an external video camera and separate servomotor. Certain deformation campaigns need to monitor dynamic structure such as bridge, dam or high-rise building, landslide or open-pit monitoring. Using ATR function, dynamic monitoring and analysis can be realized.

Currently, the implementation of real time concept in precise measurement is an important task. These dimensional and deformation measurement technologies are important where data must be presented on-site and real-time, in terms of change in shape or dimension. This high tech system has been used in automotive industries, shipbuilding, aerospace and other application. But there are some constraints when using this system such as the requirement of expert surveyor, high cost, and site license. This research tries to find alternative to the high precision measurement system. The ReTIME system will be developed and implements the methodology for deformation and industrial measurement.

LITERATURE ON RECENT SYSTEMS

AUTOMATIC POLAR SYSTEM FOR WINDOWS (APSWIN) AND GEOMOS

APSWin is manufactured by Leica Geosystem to conducted real time deformation monitoring of any engineering structure (Leica, 1998). This system supports automatic operation, data capture and data processing for all motorized Leica total stations (TM3000x, TPS1000 family). The change in instrument position (translation along x, y, z), theodolite rotation and factor affecting the vertical readout can be determined (for individual cycle) during station calculation. There are two different types of station calculation, namely Linear transformation and Helmert transformation.

The Linear transformation is a simple transformation procedure in which only two pairs of points are required. The defined connections to the reference points are used to determine the parameter of linear transformation, mean value and standard deviation. In the Helmert transformation, the coordinates of the reference point for the actual cycle are transformed so that the sum of the squares of residual divergences is minimum (Leica, 1998). APSWin has been implemented in bridge monitoring at Shanghai, China (Leica, 2005). Several tests were also conducted at UTM Skudai on APSWin capability (Halim & Khairulnizam, 2005). Figure 1 shows the APSWin data flow from data capture to data bank and station calculation.

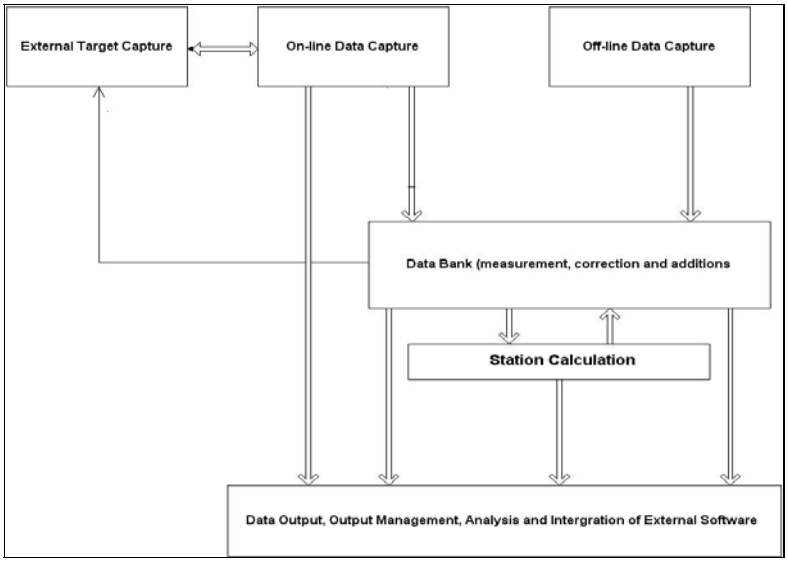

Fig 1: Overview of APSWin data flow

GeoMOS or Geodetic Monitoring System is a new generation system for deformation monitoring, developed by Leica Geosystem using Microsoft Visual C++ technology. The system offers sensor manager components for handling TPS, GPS, metrological and geotechnical sensors (Figure 2). GeoMOS system consists of Monitor and Analyzer applications. Monitor is the real time application of GeoMOS responsible for data collection and online measurement control. While, Analyzer is for analyzing and reporting of the measured data (Sippel, 2001; Hill & Sippel, 2002). GeoMOS system has been used widely in United Kingdom (UK), Germany, Switzerland and others. For example from 2000 to 2015, GeoMOS has been setup to monitor three major dam on Swiss Alps during the construction of great 57km long Gotthard base tunnel under the Swiss Alps (Leica, 2004). It also has the capability to measure over 1000-prisms 24 hour everyday for monitoring a rail complex during tunnel construction at East London, UK (Leica, 2004).

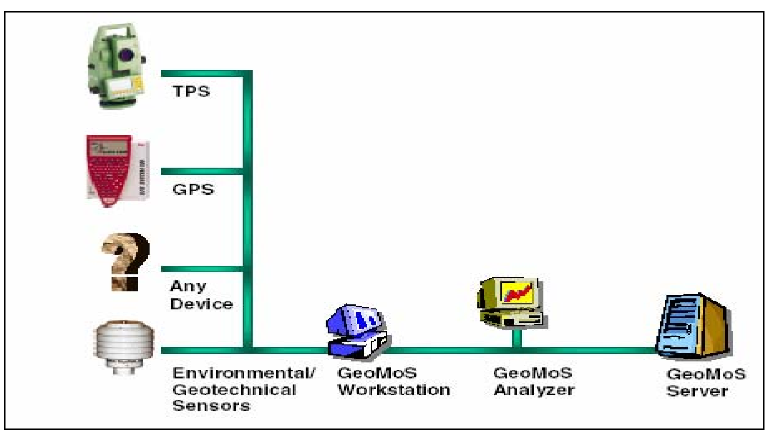

Figure 2: An example of a medium to large scale GeoMOS Workstation system configuration (Sippel, 2001)

AXYZ SYSTEM

In general, industrial measurement systems (e.g. Axyz) consist of one or multiple sensors and a software package for controlling the sensors and analyzing the collected 3D data. Axyz offers a comprehensive range of geometrical analysis function for all sorts of applications. Axyz consists of several modules (Figure 3). Axyz Core Data Module (CDM) offers tool for nearly every type of geometrical analysis. Axyz CAD, an additional module, provides all sorts of analysis tools for the comparison of CAD and measurement data and also graphical data (Dold, 1999). All Leica sensors such as laser trackers and theodolites are supported by the Axyz software platform. Laser tracker is controlled by Axyz LTM module, multiple theodolite system by Axyz MTM and single theodolite system by Axyz STM (Stephen, 2000).

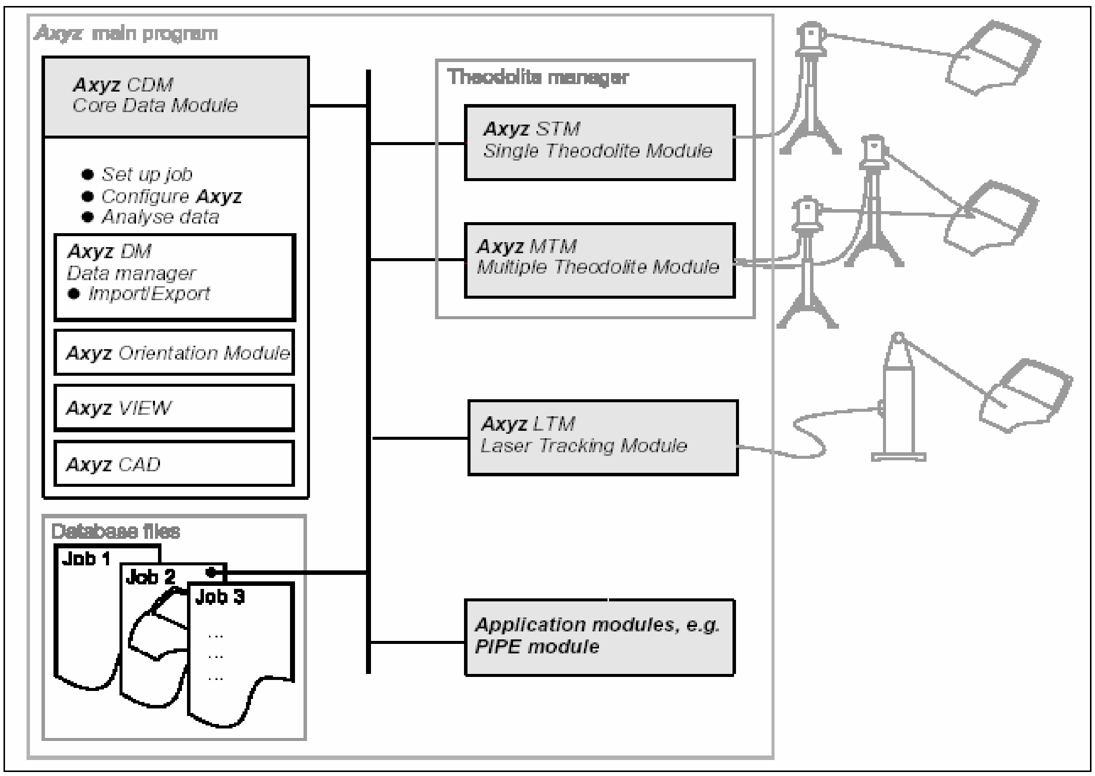

Fig 3: Structure of Axyz Industrial Measurement System (Kyle, 2000)

ALERT AND DIMONS

The Canadian Centre for Geodetic Engineering (CCGE) has created a software package called ALERT and DIMONS. Both systems have been developed to improve the accuracy and reliability by reducing the effect of systematic error produces by atmospheric reduction and unstable instrumentation and reference point position (Wilkins et. al., 2002; 2003). The system that use multiple and different types of sensor have been successfully tested at the Diamond Valley Lake reservoir in California and the Highland Valley Cooper mine in British Columbia (Lutes et. al., 2001; Duffy et. al., 2001; Wilkins et. al., 20030

The system allows for a remote control and pre-programming of observation with Robotic Total Station (RTS) and other sensors. It allows fully automatic reduction and processing of positioning surveys, as well as automatic identification of unstable reference using the Iterative Weight Similarity Transformation (IWST). IWST is a method to detect any deformation on the structure rigorously (Chen, 1983; Chrzanowski & Szostak, 1995).

RESEARCH MOTIVATION

Since 1995, Surveying Engineering Research Group (formerly known as Center of Industrial Measurement and Engineering Surveying) at Universiti Teknologi Malaysia has done intensive research on the development of precise measurement system. Deformation software such as DEFORM99 (Ong, 1999; Halim & Ong, 1999), Robust (Ranjit, 1999) and GPSAD2000 (Halim & Bong, 2000; Halim & Bong, 2001) have been developed through robust and non-robust methodology. 3D-CDS or Three Dimensional Coordinate Determination System has been developed to solve shape and dimensional analysis in 3D (Ong, 2003). All these software only allowed off-line analysis, and users need to input the data into specific file format. Moreover, as the software do not support any automated data collection/ analysis, the current research focuses on real time measurement system.

As mentioned earlier, Leica Geosystem is one of the manufacturers that developed the industrial and monitoring system. The Department of Geomatic Engineering at Universiti Teknologi Malaysia has both Leica APSWin and Leica Axyz systems, for real time monitoring and industrial surveying respectively. However, both systems are expensive; require dongle, and users need knowledge in measurement methodology and instrumentation.

Leica Geosystem instruments such as TCA family series can communicate with other program via special protocol known as GeoCOM. Users can write their own programming code to activate and “talk” the function in instrument firmware using GeoCOM protocol.

For that reason, this research focuses on the development of real time low-cost measurement system (called ReTIME) using Leica RTS TPS1000 family, i.e. TCA2003. This system will interact with user/operator during the measurement. Data will be collected automatically and stored into the database.

ReTIME SYSTEM DESIGN

The ReTIME system contains two parts, the instrumentation and software. The instrument, TCA2003, has an active beam sensing capability. An emitted IR signal is transmitted to the prism that passively reflects the signal back to the instrument. The return spot is imaged on a high resolutions (500 x 500) pixel CCD array (Leica, 2000). In this research, two set of TCA2003 will be installed as an ‘active units’.

The main engine of this software is a communication protocol between instruments and computer based. The communication protocol used is GeoCOM command set. Instrument with

GeoCOM are able to recognize and act on certain sequences of character (commands) send via the serial port. The basic communication concept of GeoCOM is a point-to-point communication system. The two communication participants are known as the client (external device) and the server (TPS1000 instrument) (Figure 4).

Fig 4: Communication flow between client and server.

Modules	Major Hardware/Software
Module one – Initialized GeoCOM	- Leica TCA2003/1800 - Portable Notebook - In house developed ReTIME system - Communication by RS-232
Module two – Measurement Process	- ReTIME system - PC-based database; Microsoft Access/Excel
Module three – Processing and Analysis	- ReTIME system - Least Square Adjustment - Deformation and Dimensional Analysis. - Result presentation: Microsoft Excel

Figure 5: ReTIME overview

In the field, Leica TCA2003 motorized total station with Automatic Target Recognition (ATR) will take the measurement to the target point, and field notebook will perform field data reduction. The observations (i.e. distance, horizontal and zenith angles) are directly obtained from the instrument command function. The ReTIME system comprises of three modules (Figure 5), and is developed using Microsoft Visual C++ programming language. The system methodology is illustrated in Figure 6.

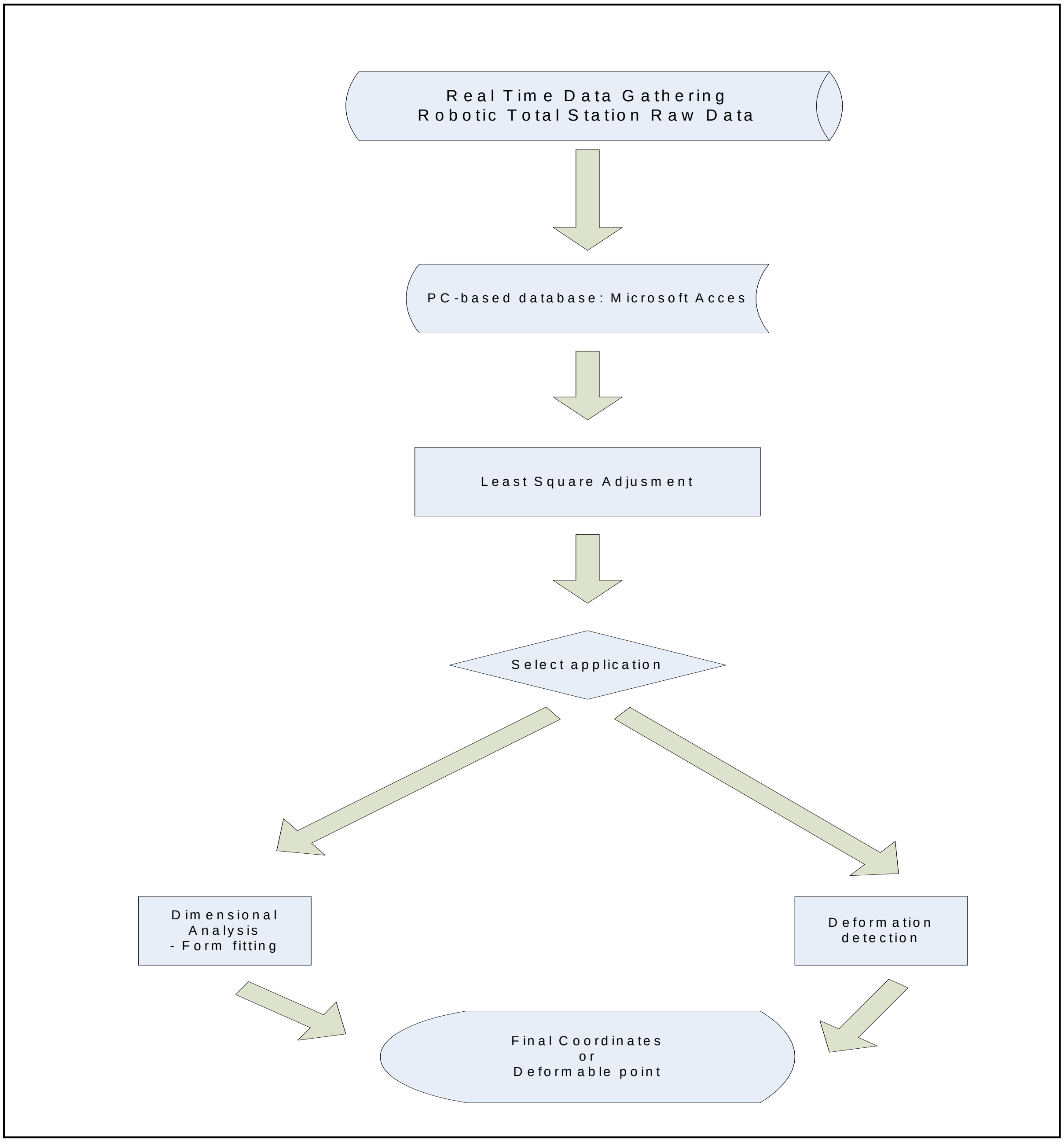

Figure 6: Methodology of ReTIME

PRELIMINARY RESULT

Initially, the first stage is the initialization to setup all the instrumentation communication parameters. This system allows communication to four instruments simultaneously, by implementing the multithreading concept. Figure 7 and Figure 8 show the system interface and the measurement process workspace respectively.

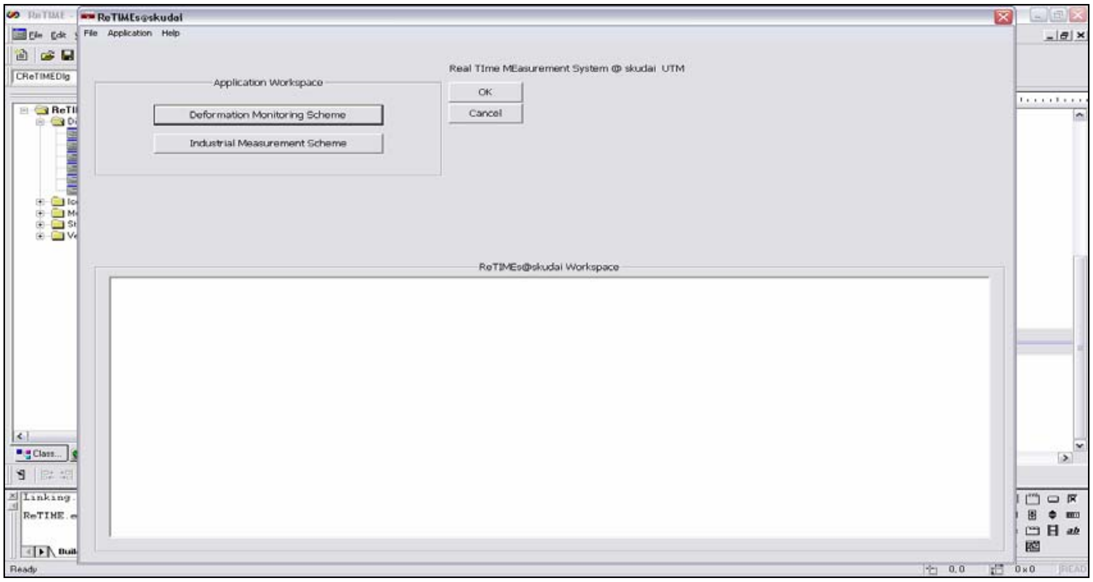

Figure 7: ReTIME interface

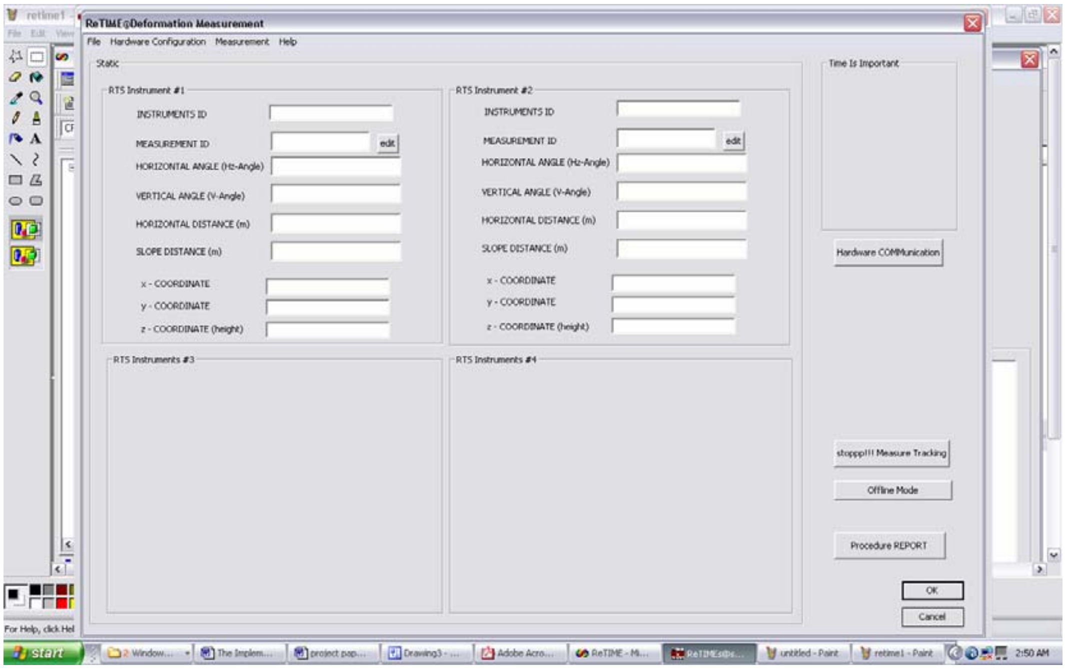

Figure 8: Measurement Process Workspace

After initialization, user can interact with instruments directly through notebook by clicking the measure button. The run-time measurement data interface (Figure 9) displays horizontal angle, vertical angle and distance. The coordinates will be stored into the database. Meanwhile, dimensional and deformation detection modules are still under construction.

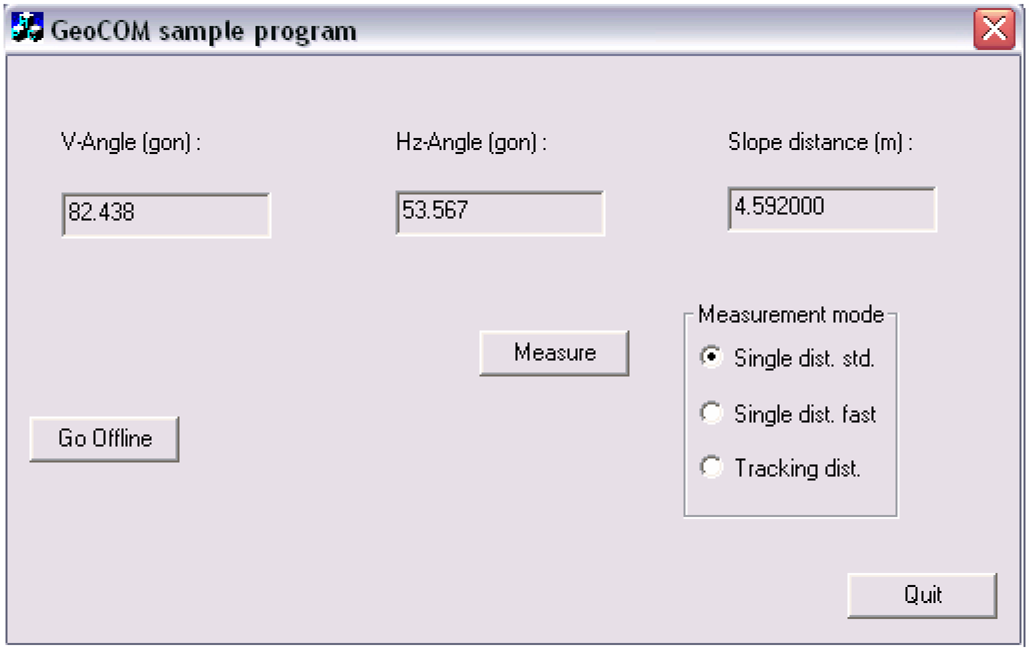

Figure 9: Run-time Measurement Process

CONCLUSION

The system when finished will be a fully automated data gathering and analysis tool for industrial or deformation monitoring. In the early stage, integration between robotic total station and system software, researcher found the methodology will help surveyor to reduce systematic error.

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