Monitoring applications by using the Remote Survey Method

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ABSTRACT

In 2014 a methodology of Remote Survey was introduced. This methodology is a combination of instrumentation, software and means of communication, which allows surveyor to sight and measure, without having to be at the designated site. This successful experiment took place in the laboratories of the NTUA, where the surveyor managed to operate an Image Assisted Total Station (IATS), using two intermediate devices (PCs) and an internet connection, with acceptable results, according to the ISO17123-3 procedure. The goal of this paper is the presentation of implementing the methodology of Remote Survey for constructions monitoring. For this purpose an IATS will be placed on the appropriate monitoring position at the construction by using internet connection via WiFi network. Also, it will be essential to synchronize the internal clock of the IATS with the global time servers and to report automatically the real time of the observation, which by default is different than the one when the surveyor gives the command via the PC in office. The most important advantage of this methodology is the fact that free software mid cost instrumentation combined with common wireless connection and low cost PCs can provide to the engineers the potential to obtain the remote control and handling of a total station without any additional costs. The pros and cons of this attempt are presented and further discussion is presented in how this methodology can be implemented.

I. INTRODUCTION

In the last decades the main instrumentation used by the surveyors for their field works, are the Total Stations. These stations (Kavanagh, B. F., 2000) are comprised of an electronic theodolite, an interfaced EDM and a microprocessor. These instruments can read and record horizontal and vertical angles together with slope distances and the microprocessor can perform a variety of mathematical operations. Nowadays, the evolution of technology in surveying scientific domain made possible the production of the Image Assisted Total Station (IATS) or Image Assisted Scanning Total Stations - IASTS (Scherer, M., 2009). An IATS is an instrument that incorporates in its telescope at least one high resolution CCD camera. This incorporated camera serves for the presentation of the instrument's field of view picture to the display which is also mounted on the IATS. Furthermore in the IATS a common operational system, such as Windows CE is installed, which allows the user to take advantage, through the aforementioned display, of several useful surveying applications, which control the instrument and enable the practice of multiple jobs in the field. Also, the IATS has various ways of communication, such as USB cable, WiFi and Bluetooth connections that allow the intercommunication between the instrument and a PCs or other possible controlling devices. Finally, the IATS has the ability to perform motorized movements and reflectorless measurements. These characteristics eliminate the

observer's intervention, during the field work. The above innovations in the IATS, created the basis for the development of a new survey procedure, so-called Remote Survey (Lambrou, 2014). By performing the Remote Survey, the measurements may be carried out remotely by the surveying engineer just by using a combination of controlling devices, for example a combination of computers or even a computer and a tablet or a smart phone.

II. METHOD DEFINITION

The basic concept of the Remote Survey Method (Lambrou, 2014) is that an IATS has all the technological features that permit an engineer to use this instrument by distance. This could be feasible with the use of two auxiliary devices, such as personal computers or tablets or laptops or smartphones. The first of the two devices, is dedicated to serve the IATS in situ, so it is named as "Server device" and the second one is used by the engineer at the remote place and is named as "Client device". An internet connection is essential in order to facilitate the bidirectional communication between the two devices. A key element of this method is that only free of charge software is used, because the intention is to be widely used from any surveyor that wants to implement this procedure, at nil cost. Furthermore, in the present evolution of the original Remote Survey Method, a specific goal was set, to synchronize the

internal clock of the IATS with the global time servers and to report automatically the real time of the observation, which by default is different than the one when the surveyor gives the command via the PC in the remote place.

III. Concept of time in Remote Survey

Every computer, including those installed in every IATS, has an internal clock. This clock provides the necessary time information for the operation of the computer. Usually, if a common computer is synchronized to a reliable high accuracy time source in the beginning of a week, then it is expected that by the end of this week this clock will drift some seconds, maybe up to 1 sec per day (Mills D., 1991). This observation became a serious problem with the expansion of the Internet. The solution to this problem was presented in the year 1985 by the Professor of Delaware University David L. Mills. He developed the Network Time Protocol, known as NTP (Mills D., 1985). This protocol was optimized until the year 2010 when the 4th edition of NTP was presented (Mills D., 2010) and synchronizes the computer clocks via the Internet, by implementing a hierarchy of "stratum" levels in the classification of the internet time servers. The most precise time servers are directly synchronized with a national time server or a high accuracy GPS instrument and they belong to the level "stratum 1". Lower accuracy time servers belong to "stratum 2", "stratum 3", etc (Mills D., 1991). The time servers provide the Coordinated Universal Time (UTC), a synonym for the term Greenwich Mean Time (GMT) in some countries. The basic concept of the NTP is that the client computer queries the time server via Internet at time t1cl (IAW the client computer's clock) and the time server receives the query at time t1serv (IAW the time server's clock). Then, the time server responds to this query at time t2serv (IAW the time server's clock) and the client computer receives the response at time t2cl (IAW the client computer's clock). Consequently, the time offset and the trip delay between the client and the server are computed with the following equations (Mills D., 1991):

$$\theta = 0{,}5 \times [(t1serv - t1cl) + (t2serv - t2cl)] \quad (1)$$

and

$$\delta = (t2cl - t1cl) + (t2serv - t1serv) \quad (2)$$

where θ = time offset
          δ = trip delay

Nevertheless, an essential weakness of this protocol is the assumption that the time needed for the transmission of the query from the client to the server is the same as the one from the server to the client, something that is not valid because the two devices usually are placed in long distances and the intermediate internet routers are often different and many in each way.

IV. Solution set-up

Initially, it was decided to establish the communication between the IATS and a laptop (with Windows 10 operating system), acting as the server device, via a USB cable, which provides Data Transfer Speed approximately of 12 Mbps. Practically, there is no time delay in the data transmission. As the IATS was connected to the server device, the "Active sync" software (http://www.microsoft.com/download/en/details.aspx?id=15) was automatically activated in the IATS and the "Windows Mobile Center" software (https://www.microsoft.com/el-GR/download/details.aspx?id=14) respectively to the server device. It has to be mentioned that "Active sync" software can be also used in the server device but only in those computers using Windows XP or an earlier Edition of Windows operational system. In newer editions of Windows the "Windows Mobile Center" is used. Both of these kinds of software, activate and verify the bidirectional connection of the IATS and the server device (Lambrou, 2014). The next step was the installation of "My mobile" software (http://mymobiler.com) in the IATS and in the server device (Lambrou, 2014). With this application it is possible to transmit the IATS's display to the server's screen and to administer the IATS from the server device. Afterwards, another laptop (with Windows 10 operating system) acting as the client device was chosen. In both server and client devices the "Teamviewer" software (http://www.teamviewer.com) was installed. This software allows the user of the client device to have full control of the server device and it transmits the entire screen of the server device, only if the two devices are connected to the Internet so as the bidirectional communication between them to be realized. Moreover, the "Precision Time Calibrator" software (http://www.fountainware.com/Products/TimeCalibrator) was installed in the two devices. The utility of this software is to synchronize the internal clock of the two devices with the global time servers. It was chosen between many similar applications because:
a. It is free of charge.
b. Displays simultaneously the time information for the UTC and the computer's clock with an analysis of 0.001 sec.
c. Provides the ability to the user to choose which time server will be used from a long list of servers.
d. Provides simple calibration tools.

Despite of the above advantages the "Precision Time Calibrator" software has a disadvantage that is also found in similar applications. The user doesn't have the option to record this accurate time data, if he wants to. Also, an important detail is that the internal computer's clock provides the time information in full seconds. So even if there is a way to synchronize this clock with a high accuracy time source, with an accuracy better than 1 second, the final time that the computer or the IATS will display will not be better than its capability. In order to record the time data from the "Precision Time Calibrator" software, with an accuracy of time better than 1 second and in the light of the above observation that this software doesn't provide the option to automatically record this piece of information, it was decided to "capture" the time in which the observer decides to make his observation with the print screen capability of Windows. To accomplish this goal the "Greenshot" software (https://getgreenshot.org/downloads) was installed in the two devices. This software provides several options for the management of the screenshots. For the specific work it was configured to automatically store the screenshots as image files in a particular folder in system files. This was a very useful option because normally by pressing the "Prt Sc" button in the keyboard the screenshot is stored temporarily in the Clipboard and if another screenshot is captured then the previous one is lost from Clipboard. The final challenge in this project was to find solution to the problem of automatically capturing the printscreens in the client device and in the server device. The solution to this problem was the installation of the "X-Mouse Button Control" software (http://www.highrez.co.uk/downloads/XMouseButton Control.htm) in the two devices. With this application the user has the option to map the mouse buttons and assign them specific functions for specific applications. So, with the use of "X-Mouse Button Control" software, the general use of the mouse remains the same in both devices and specifically for the client device, when using the mouse within the "Teamviewer" software, the click of the middle button returns simultaneously the click of the left button and the printscreen button. Also, for the server device, when using the mouse within the "Mymobiler" software, the click of the left button returns simultaneously the click of the left button and the printscreen button. With the above combination of different kinds of software and with the specific settings the following operations are accomplished:

a. The observer can operate the IATS, from the client device via the server device.

b. With a single click of the middle button of the mouse in the client device two different screenshots are captured in the two devices.

c. The accurate time of the observer's command in the client device is captured.

c. The accurate time of the execution of the command in the server device is captured.

e. By comparing the two different screenshots the time delay can be computed.

V. IMPLEMENTATION - RESULTS

The initial implementation of the method took place in NTUA, in laboratory. A Topcon Image Station was used as the IATS in this experiment. As it is already mentioned, the IATS was connected to the server device (a laptop with Windows 10 operating system), via a USB cable and the server device was connected to the Internet via an Ethernet cable connection. Afterwards, the client device (a laptop with Windows 10 operating system) was also installed in the same laboratory and was also connected to the Internet via an Ethernet cable connection. All the aforementioned applications and settings were installed in both devices. The results of this first attempt are listed below:

a. The operation of the IATS, from the client device was accomplished.

b. The time delay between the observer's command in the client device and the execution in the server device couldn't be detected because the records of time were almost identical.

The second result maybe was caused by the fact that two devices shared the same internet router and the two records of time for the same observation were not independent. In the second attempt, the initial implementation of the method chanced. As far as it concerns the hardware and the software there was not any change. In order to be as realistic as possible to the needs of a surveyor engineer it was decided to connect the client device to the Internet, via a common WiFi router in an apartment in Ilioupolis and the server device also to the Internet via a WiFi connection by using a mobile phone as "Internet Hotspot" in the 3rd floor of the Lampadario Building in NTUA. The physical distance between the two devices was approximately 5 km. The results of this second attempt are listed below:

a. The operation of the IATS, from the client device was also accomplished.

b. The time delay between the observer's command in the client device and the execution in the server device was detected and varied from 0.045sec to 0.351sec.

In Figure 1 it is presented the screenshot at the time of the observer's command in the client device and in Figure 2 it is presented the screenshot at the time of

the execution of the command in the server device. The time information which was used for the computation of the time delay was the "Internet Time-UTC", presented in the "Precision Time Calibrator" software in the two devices and is highlighted in the Figures within a red circle.
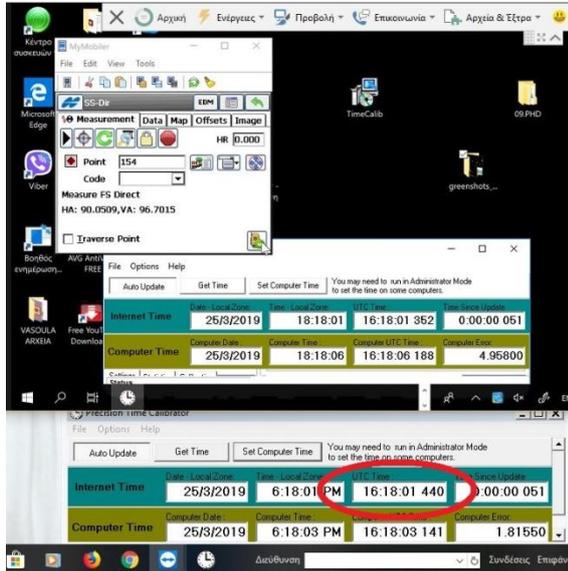

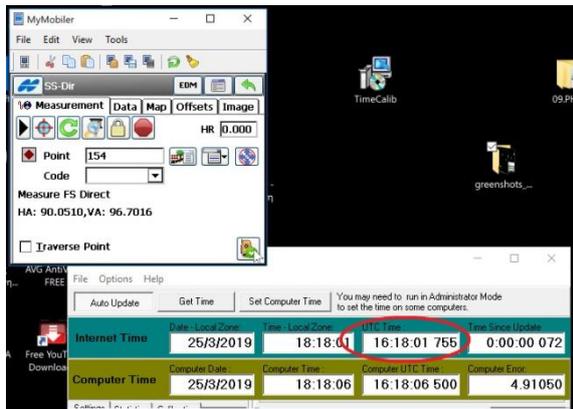Figure 1. The screenshot at the time of the observer's command in the client device

Figure 2. The screenshot at the time of the execution of the command in the server device

VI. CONCLUSIONS

The basic conclusion of this work is that the remote survey with the recording of UTC time at the client device and the server device is feasible. Furthermore the basic principle of using no-cost software in the implementation of the procedure was kept. During the development of this procedure following conclusions were realized:

i. The internal clock of the IATS and of the laptops even if they are synchronized with a high accuracy time source, with an accuracy better than 1 second, the final time that they will display will not be better than their capability. Thus, the time will be expressed in hours, minutes and full seconds with no further subdivision.

ii. The "operating panel key" has many buttons that can't be used from the client device or the server device.

iii. In case of a hardware failure (for example in case of lost of the IATS's correct level or lost of electric power) or software failure then the observer must go and fix the problem in the designated place of the IATS.

iv. Almost all the aforementioned free applications are not compatible to the operating system of the IATS (Windows CE). So, the direct connection of the IATS to the Internet without using the server device was not feasible.

v. The option to use the Bluetooth connection between the IATS and the server device was not adopted because during the tests, a small time delay was recorded approximately of some seconds and this is not acceptable.

vi. The use of tablets or smartphones as client devices was tested and was successful via the Teamviewer software, but no recording of time was accomplished with this option.

VII. WAY AHEAD

The next steps in order to optimize the Remote Survey Method should include more experiments in order to determine the influence of the different internet connections in the recording of time. Also, it is crucial to find a way to program all the buttons of the "operating panel key" in order to have the full control of the IATS and not only the control that can be achieved through the instrument's display.

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