GPS Search for Advanced Total Station Operation

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SUMMARY

The Global Positioning System (GPS) is a widely accepted tool for navigation purposes. Surveyors have embraced the technology for a variety of survey applications. Since GPS is accepted within the survey industry, manufacturers are utilizing GPS technology to assist with conventional survey instrumentation, such as optical total stations. While some integration has focused on the application of survey grade GPS receivers with optical total stations, there has been limited integration with cheaper, low accuracy commercially available GPS receivers.

Trimble has long been an industry leader in the application of GPS technology and has now extended that leadership through the use of low cost, commercially available GPS integrated with a Robotic Total Station system. Using a patented Trimble technique, a GPS position can be used to provide a robotic total station with an approximate position of the robotic rod. The instrument can be quickly directed to the GPS position and a search performed to re-acquire the target at the robotic rod. This GPS assisted technique, called GPS Search, provides a very efficient and effective method of acquiring the target on the robotic rod.

The following sections describe the principles of GPS Search. The method of operation within the Trimble Survey Controller software is defined and the benefits to the advanced robotic total station user are explored.

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1. GPS SEARCH HARDWARE

GPS Search functionality is available in the Trimble Survey Controller software that operates on the Trimble TSC2 and Trimble CU controllers. GPS Search can be used with either a Trimble S6 or Trimble 5600 robotic total station. The typical hardware that is used to provide GPS Search is a consumer-grade navigation GPS receiver. However, GPS Search functionality is also available with the Trimble 5800, Trimble R8 GNSS or as part of the Trimble IS rover when operated with the Trimble CU or Trimble TSC2.

When using the Trimble TSC2 controller, GPS Search functionality can be fully integrated through the use of the GPS Compact Flash (CF) card as shown in Figure 1.

(Not to scale)

Figure 1: GPS CF card and Trimble TSC2

The GPS CF card provides a fully integrated cable free solution and the receiver is automatically configured by the Trimble Survey Controller for use with GPS Search.

GPS Search functionality is also available with the Trimble CU and the Trimble TSC2 through the use of the GPS BT mini receiver as shown in Figure 2.

Figure 2: GPS BT mini receiver

The GPS BT mini receiver is a small consumer-grade Bluetooth® device that is designed to be mounted on the top of the prism on the robotic rod and also provides a clean, cable free solution for GPS Search.

The GPS CF card and the GPS BT mini receiver are both capable of providing a GPS position to an accuracy of 10m, which is usually sufficient for navigation purposes. For the application of GPS Search the GPS position accuracy is sufficient for turning the instrument to a location to commence the search.

2. PRINCIPLE OF GPS SEARCH

The principle of operation for GPS Search is identical in the Trimble Survey Controller Software irrespective of the hardware solution being used. The GPS position data is streamed from the receiver in an industry standard format defined by the National Marine Electronics Association (NMEA). GPS positions received via the NMEA data stream are referenced to the WGS-84 datum. Since conventional total stations are often operated on a local coordinate system or with an arbitrary orientation reference, it is necessary to relate the GPS positions to the total station setup.

The Trimble Survey Controller software accomplishes this task in a highly efficient and effective manner that requires no interaction by the user. Once a station setup has been performed, the Trimble Survey Controller software continually receives a stream of horizontal (HA) and vertical (VA) angles from the instrument, which are considered for addition to the GPS Search computation. As these angles are received they are matched with a corresponding GPS position from the receiver, as depicted in Figure 3.

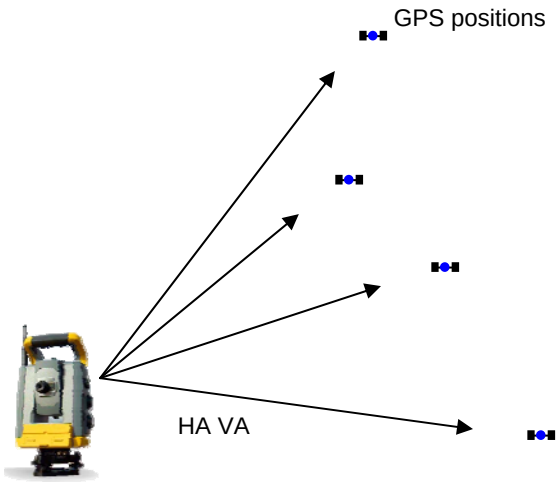

Figure 3: Collection of total station angles and GPS positions

To ensure that the GPS Search computation will provide a suitable solution, the Trimble Survey Controller software uses a number of specific criteria that must be satisfied before any matched HA VA measurements and GPS positions are added. The criteria include:

- a station setup must have been performed to define the total station orientation;
- the user must be connected robotically to the total station;
- Autolock must be enabled and the instrument locked onto a target;
- the GPS position must have a HDOP of 7 or less;
- the GPS position must not be older than 0.5 sec;
- if an angle and distance from the total station are available then no GPS positions within 10m of the instrument will be accepted;
- an HA and VA measurement and GPS position matched pair will not be added to the solution if they are within 5m of the previous matched pair. This ensures that a suitable solution geometry is maintained;
- the first HA and VA measurement and GPS position pair is discarded as the instrument may still be locked onto the backsight target from the station setup.

3. GPS SEARCH COMPUTATION

The GPS Search computation is essentially a resection computation that uses the total station HA and VA measurements to the positions from the GPS. The results of the computation are the relative GPS coordinates of the instrument point and an orientation correction between the GPS coordinates and the defined station setup.

The first step in the computation is to transform the GPS positions from the WGS-84 datum to more user friendly Grid coordinates. This task is very easy if a coordinate system has been defined in the Trimble Survey Controller software. However, if there is no coordinate system defined (ie scale factor only definition) then the Trimble Survey Controller software uses a default Transverse Mercator projection to convert the GPS positions into Grid coordinates for the GPS Search computation.

The second step in the computation is to calculate the angles only resection to the GPS positions to determine the orientation correction and GPS position of the instrument. The resection calculation requires at least five valid HA and VA measurement and GPS position pairs. Once five valid HA and VA measurement and GPS position pairs are available the Trimble Survey Controller software will automatically calculate a resection solution. The solution is deemed to be acceptable once the standard error of the orientation correction is less than 10°. If the standard error is greater than 10° then additional position pairs are added and the resection calculation repeated until a maximum of 10 position pairs has been added. If there is still no solution available then the first position pairs are systematically removed and replaced with a new position pair until a satisfactory resection solution is available.

Once the Trimble Survey Controller software has obtained a successful GPS Search computation the user is informed “GPS Search ready” and the Target icon on the status bar changes to illustrate that GPS Search is available for use, as circled in blue in Figure 4.

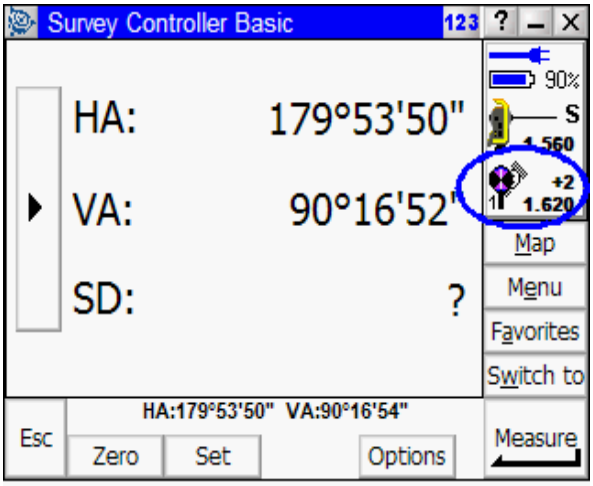

Figure 4: Target icon when GPS Search is available

When the user elects to perform a search for the target the instrument can now turn to the GPS position of the robotic rod and commence the search. If the GPS Search solution is good then often the instrument will automatically lock onto the robotic target without requiring the additional search.

4. IMPROVING THE GPS SEARCH SOLUTION

Once a successful GPS Search solution is obtained, the Trimble Survey Controller continues to add matched HA VA measurements and GPS positions to further improve and refine the solution using a number of quality criteria that includes:

- the GPS position must have a HDOP of 7 or less;
- the GPS position must not be older than 0.5 sec;
- no GPS positions within 10m of the instrument will be accepted;
- if an angle and distance from the total station are available then no GPS positions outside of 20m from the computed total station position will be accepted;
- the standard error of the orientation correction must be within 10°
- new position pairs will not be added to the solution if they cause the resection computation to fail.

Position pairs are continually added to the GPS Search computation until a maximum of 75 points have been added. Each pair of HA and VA measurements and GPS positions that are added to the GPS Search computation are also given a weighting value that is based upon the geometry of the matched pair, the distance from the total station and the accuracy of the GPS position. The weighting value is used for further refinement of the GPS Search computation. When the maximum 75 position pairs have been added, the weighting value is used to determine which position pair to remove from the solution to allow a potentially improved position pair to be added. The pair with the lowest weight value will be removed to ensure that the quality and geometry of the resection computation is maintained.

The status of the GPS Search computation can be viewed at any stage by selecting *Instrument / Autolock and Search Controls* from the main menu and then selecting the *GPS* softkey. The GPS Search status displayed is shown below in Figure 5.

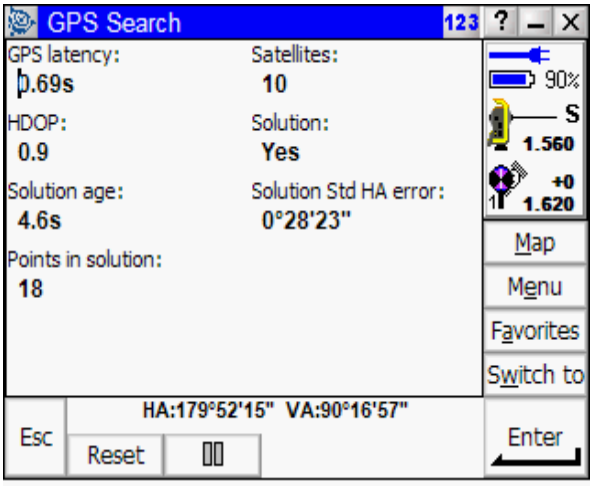

Figure 5: GPS Search status

The GPS Search status includes the GPS position latency, number of satellites being tracked, HDOP of the GPS position, solution status, solution age, standard error of the orientation and the number of position pairs in the GPS Search solution. Figure 5 also illustrates the additional controls that are available to control the operation of GPS Search. The *Reset* softkey allows the user to reset the GPS Search solution at any stage. The  softkey allows the user to pause adding position pairs into the GPS Search computation. This can be particularly useful when turning to another prism nearby or moving into a heavily obstructed area to help avoid the addition of incorrect data. The user can also select  to perform a search without the total station turning to the GPS, for example, when searching for another target. The user can select the  softkey to resume adding points to the GPS Search computation.

5. GPS SEARCH BENEFITS

GPS Search with the GPS CF card or the mini GPS BT receiver provides a low cost solution for quickly locating the robotic target anywhere, anytime. With GPS Search the Trimble S6 will typically turn and search for the prism within three seconds. However, often the position provided by GPS Search is so accurate that the instrument locks directly onto the prism. This performance maximizes the impressive speed of the Trimble S6 Total Station and ensures that you can be more productive in the field. GPS Search significantly reduces time spent searching for the target, which translates into more time available to take measurements.

In addition, GPS Search does not have a limited operational range. It can be used throughout the full Autolock range of the total station. This unique feature provides the user with full confidence of being able to find the correct target without requiring visually confirmation that the instrument is aimed correctly. This is particularly important at longer ranges when it is often difficult to visually determine the direction the instrument is aiming.

6. CONCLUSION

The integration of a consumer-grade GPS receiver with the robotic total station provides an impressive solution to greatly reduce the time taken to re-acquire a robotic target. The Trimble Survey Controller software makes use of this technology to provide GPS Search functionality with the Trimble CU and Trimble TSC2 controllers. GPS Search enables the user to quickly and accurately re-acquire the target at the robotic rod, which continually increases survey productivity.

BIOGRAPHICAL NOTES

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Tim Lemmon is an Applications Engineer for Trimble Navigation. His experience includes Optical and Scanning based products. Tim has a BS and MS in Applied Science from RMIT University, Melbourne, Australia.

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Practical experience: Cadastral surveying, engineering surveying, geodetic surveying, expert in application software.

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