Researchers improving GPS accuracy in the 3rd dimension

August 17 2011, by Jessica Orwig

Researchers who are working to fix global positioning system (GPS) errors have devised software to take a more accurate measurement of altitude – particularly in mountainous areas.

The software is still under development, but in initial tests it enabled centimeter-scale GPS positioning – including altitude – as often as 97 percent of the time.

Researchers hope the software will help to improve the vertical accuracy of measurements in potentially hazardous regions at high altitudes, such as areas of soft, loose land that may be prone to landslides. They also claim that their software could be used to measure how quickly glaciers at high altitudes are melting.

The GPS is most commonly known for its ability to provide on-the-spot locations for drivers, but this application is just one of many possible uses, explained Dorota Grejner-Brzezinska, professor of civil and environmental engineering and geodetic science at Ohio State University. As the level of GPS precision increases, so do potential applications for scientific research.

While drivers are generally concerned with tracking their own location in two dimensions on the earth's surface, the third dimension of altitude has always been available through GPS – just with lower accuracy than that of the horizontal coordinates.

Recently, Grejner-Brzezinska and her colleagues from the University of Warmia and Mazury in Poland have developed software that will allow GPS to relay locations to within a few centimeters' accuracy, including altitude. While this high level of precision is not necessary for driving directions, it is necessary for recognizing small shifts in topsoil that may lead to dangerously destructive landslides.

She explained that a lot is going on behind the scenes during a typical use of GPS.

GPS satellites transmit information in the form of radio waves to the GPS receiver held by the user. At the same time, the signals must also travel to at least one other ground-based receiver to obtain a location reference, which allows the user's receiver in turn to accurately calculate its own position in 3D. Before the satellite signals reach the receivers, they must travel through Earth's atmosphere, which results in time delays that affect accuracy.

When the user's receiver and the reference receiver reside at drastically different altitudes, however, each location experiences different amounts of time delay, which complicates matters even further. So, in mountainous regions where height differences can vary greatly over a short distance, acquiring the altitude of locations to within a few centimeters is difficult.

"Time is the heart that drives GPS, so it is important that we have a proficient method that accounts for delays from earth's atmospheric layers," said Grejner-Brzezinska. "It would be ideal for all GPS signals to travel in a straight line directly to their destination, but due to electron interaction and refraction in the lower atmosphere, the signal's path is far from straight," she continued.

Electron interaction and tropospheric refraction effectively re-route the

GPS signal, which means that the signal travels an extra distance and requires extra time, said Grejner-Brzezinska.

She and her colleagues looked specifically at troposphere delays – those caused by the lowest level of the atmosphere. Their study can be found in a recent issue of the journal *Measurement Science and Technology*.

In the past, scientists have tried to account for troposphere delays by using basic models of Earth's atmosphere, said Grejner-Brzezinska. But these models may not fully account for changes in the weather or temperature, which can have a significant effect on the amount of interference the GPS signals experience on their way down to earth.

Not only weather and temperature, but also the height difference between two stations can greatly affect the accuracy of a GPS-based height determination.

Using ground station receivers located in the Carpathian Mountains in Poland – a region known for its steep slopes – the researchers collected GPS information over a 13-hour period.

They looked at two pairs of receivers with different height changes. The first pair was located 72 kilometers apart and had a height difference of 32 meters. The second pair was 66 kilometers apart with a total height difference of 380 meters.

"We figured that the easiest scenario would be provided by the receivers with 32-meter height difference, and the most challenging one with a height difference of 380 meters," said Grejner-Brzezinska.

Using processing software developed originally in Grejner-Brzezinska's lab at Ohio State, and further expanded by her research collaborators at the University of Warmia and Mazury in Poland, the researchers applied three different methods to measure GPS accuracy for the receivers.

The results showed that, out of the three methods of handling tropospheric delay in GPS measurements that were tested, there was one that provided an accurate location, including the height of the receivers, 97 percent of the time.

"Of the three methods we tested, the third and most accurate was also the most complicated," said Grejner-Brzezinska. "This method was developed by our team, and required knowledge of three or four reference stations in order to perform the calculations properly."

The other two methods did not require the use of multiple reference points – just a single one – but their levels of accuracy did not match the third method's positioning capabilities.

Further testing will follow. But this early study shows that GPS accuracy for altitude estimation can be improved, and may lead to the precision estimates that researchers need to analyze, for example, the stability of mountaintops and glaciers with 10-minute temporal resolution.

Provided by The Ohio State University

Citation: Researchers improving GPS accuracy in the 3rd dimension (2011, August 17) retrieved 26 April 2024 from https://phys.org/news/2011-08-gps-accuracy-3rd-dimension.html