BDS Is the Most Useful Method for GPS

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Abstract

In these days, the Taylor method and BeiDou Navigation Satellite System method (BDS) are the common methods which are applied to GPS systems. However, the BDS method will provide a more precise location to the user than the Taylor method. I will describe how do these two methods work and compare them to prove that the BDS method far surpasses the Taylor Method. Mainly, the BDS method applies two algorithms. Using a combination of algorithms determines a location with better accuracy. In addition, the BDS method prevents accidents, decreases the time and energy used in searching of a location, and improves the world economy. Even though there are lots of benefits of using the BDS method, the BDS method can cause social issues. Most of the users are vulnerable to tracking systems, losing their personal privacy, and receiving threats from stalkers. Therefore, if the governments strengthen its privacy law which is related to the usage of the GPS system, the privacy problems will be decreased.

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Introduction

In the past, when people were trying to find their location, they had to use the image of a map which was big to hold and had to call everywhere to find their children. In the modern day, most of the electronic device users have a Global Positioning System (GPS) to find a restaurant they are looking for, a place where they have never been before, or check on their children to ensure their safety. Hence, a lot of methods have come out to develop the accuracy and speed for GPS, such as the Taylor method, iterative method, nonlinear least squares method, and BeiDou Navigation Satellite System method (BDS). Publicly, people say that Taylor method and BDS method is the most efficient method to apply in GPS. Undoubtedly, the BDS method is better at locating mobile electronic devices than the Taylor Method for global positioning because it uses more satellites. Additionally, it penetrates wavelength obstacles and helps security institutions which can find criminals and survivors. In the support section, it will provide the definition of the BDS method and the Taylor method, algorithms to do these methods in order to operate satellites to become more accurate, how these methods can function, and why the functions of BDS method far outweigh those of the Taylor Method. First in foremost, the audience should understand the technical details of each method and social concerns on how these methods are affecting our society.

Background

Wei Pan, Tengda Pei, and Yan Liu describe the BeiDou Navigation Satellite System (BDS) method which uses two algorithms based on linear algebra (2017, p.3875). They are the researchers at Liaoning Engineering Laboratory of BeiDou High-precision Location Service The algorithms are the combination of the traditional satellite selection algorithm and the fast satellite selection algorithm. Traditional satellite mainly uses Geometric Dilution of

Precision which is a Geometric Dilution of Precision which is applied in navigation engineering to specify the effect of satellite geometry and precision of positioning. The Taylor method uses nonlinear equations to find the location by using the iterative algorithm. Anhong Tian, Dechun Dong, Deqiong Ning, and Chengbiao Fu explain that the Taylor method applies only four satellites to precisely locate places (2013, pp.16-17). They have published four peer-review journals which are related to satellite positioning at the IEEE Conferences. Using these methods in GPS can cause a lot of concerns in our modern society. Even though GPS helps us reach the place where we want to go, a person can track anything which has a location system in it. The most frequently tracked electronic device is a person's cell phone. Therefore, people can track a person even if a personal tracking is illegal. Additionally, GPS can invade personal privacy. The governments or big companies, such as Apple Inc., Samsung, and AT&T, will track people to find out where people usually go, what places are popular for a specific age group, how much time do people usually spend on the specific location, and for what purpose are people going there. In the future, the government might claim that for safety reasons, they should track people continuously. Then people will lose their privacy from the government. To avoid tracking, people started to use devices with changeable wavelengths to get away from tracking. However, using the device for protection can still cause a problem. For example, when people need to be rescued from a mysterious place, the emergency crew should track their electronic devices to save them, but if they have an interrupting wavelength device, the emergency crew cannot help them. This problem illustrates the benefits of the BDS method over the Taylor method. To know more specifically about which parts does the BDS method surpass the Taylor method, people need to know how the Taylor method works.

Precedents & Related Work

Anhong Tian, Dechun Dong, Deqiong Ning, and Chengbiao Fu (2013) give an

information that GPS uses pseudo-range measurement to receive precise location information (p.16). The technology differences between the BDS method and the Taylor method is choosing in which satellite will be used to determine locations. The Taylor Method's algorithm applies linearization to allow the Taylor method to interpret the nonlinear equation. The Taylor method requires four satellites for positioning. Each satellite applies pseudo-range measurement which requires the geometrical range between satellite and receiver, beginning time for the receiver, beginning time for the satellite, the error value of ionospheric measurement, the error value of tropospheric measurement, and observation delay. Ionospheric is a height from 60 kilometers to 1,000 kilometers above from the ground (*Ionosphere,* 2018). Tropospheric is a height which is the lowest in the atmosphere (*Tropospheric,* n.d.). The algorithm for pseudo-range measurement is complicated. First, find the gap between receiver and satellite beginning time and multiply by the speed of light when it is in a vacuum condition. After that, add all of the errors and geometrical range. Then, pseudo-range for each satellite will come out. The next step is checking the accuracy of measurement. It requires satellites to find the initial coordinates and the increment parameter value for four satellite (Tian, Dong, Ning & Fu, 2013, p.17). Add them together will give the receiver coordinates. Set the pseudo-range equals to receiver coordinates timed by coefficient numbers. If the matrix is transformed into a simple matrix, it will give us the distance error. If the distance error is larger than 0.01 meter, repeat the equation until the error becomes less than 0.01 meter. Since we have learned the Taylor Method, we also need to learn the system of the BDS method and the process of how the BDS method locates the position.

Support

What is the BDS method?

The BeiDou Navigation Satellite System method (BDS) is described by Wei Pan, Tengda Pei, and Yan Liu. They are researchers at Liaoning Engineering Laboratory of

BeiDou High-precision Location Service in Dalian University (2017). The BDS method uses two algorithms. During the process of locating, two algorithms will be operated, and one algorithm, which is faster and more precise, will be implemented. The first algorithm is the traditional satellite selection algorithm, which heavily relies on the GDOP satellite selection algorithm (pp.3875-3876). It uses six satellites for positioning. The process of first six satellites selection is done by using an azimuth angle and an elevation angle. Next, using the model of GDOP calculation and the genetic algorithm which is part of the GDOP, the last three satellites will be selected. The definition for elevation angle is the angle from the satellite to the horizon, and the azimuth angle is the angle between the receiver and the north pole. When the six satellites are selected, each satellite creates the coordinates. Three satellites will provide the receiver coordinates, and the rest of the satellites will provide their own position coordinates. There are two steps to find the station rectangular coordinate system vector. First, Subtract the satellite coordinates from the receiver coordinates to get the observation vector. Next, multiply the coordinate transformation matrix with the observation vector to find the station rectangular coordinate system vector. The coordinate transformation matrix is multiplied because the coordinates must be changed to pseudo-range. Then, the equation of elevation angle is arcsine (3rd row of the station rectangular coordinate system vector / pseudo-range), and the equation of azimuth angle is arctan (1st row of the station rectangular coordinate system vector / 2nd row of the station rectangular coordinate system vector). The second algorithm used the algorithm called “The fast satellite selection algorithm” (p.3877). Unlike the first algorithm, it uses satellites up to 24 satellites. By using GDOP calculation, it encodes chromosomes of individual and determines the individual which satisfies the condition of the evolution termination. Jun Xiong, Maozhong Song and Bin Zhou explain how does the BDS signal work. They are the researchers from Nanjing University of Aeronautics and Astronautics (2015). Since BDS signal is unable to directly

used to the receiver, the BDS signal generator uses Industrial Personal Computer (IPC), FPGA, and DDR2 (p.465). IPC receives the BDS signal and makes it transferable. DDR2 converts the BDS signal to computer readable data and send it to FPGA. Finally, FPGA process the data from DDR2 and provide the signal to the satellites. Using the information about the BDS method, researchers showed the effectiveness of the BDS method.

How does the BDS method work?

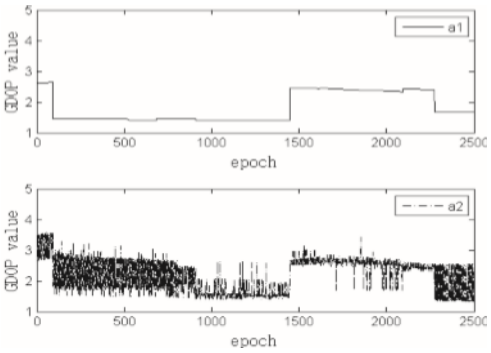

Figure 1 contrast of GDOP values

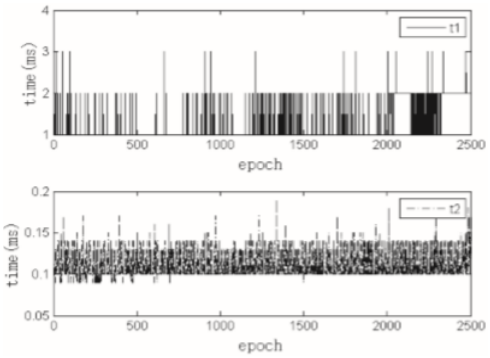

Figure 2 contrast of the running time

Wei Pan, Tengda Pei, and Yan Liu used the K258 board of ComNav Technology Ltd on the roof of Dalian University building to test the BDS method (2017, pp.3878-3879). Figure 1 shows the GDOP value between the traditional algorithm and fast satellite selection algorithm. The result shows that the fast satellite selection algorithm contains a higher GDOP value. Also, Figure 2 represents that the fast satellite selection algorithm is faster and is ten times more efficient than the traditional algorithm. However, the standard deviation for fast satellite selection algorithm is higher than the traditional algorithm. If the standard deviation is high, then the gap between other values is huge. Therefore, by using both algorithms, the BDS method will generate exact and early locations to the receivers. Because of the effectiveness of the BDS method, other researchers have been applied the BDS method for measuring the precision of the GPS system.

The BDS method in the real field

Zhang Tongyu, Xu Aihua, and Su Rui provide the usage of the BDS method in real life and compare GPS/BDS with single GPS system (2014, pp.683-684). They are the

researchers at Yantai University and published four peer-reviewed journals at the IEEE Conferences. The iGMAS company-built testing climate software which uses the BDS method. Table 1 shows that the error of distance is two centimeters and the clock error is 0.1newton second on average. The error of distance means the distance between the exact location and the position which is shown by the satellites. The error of distance and the clock error numbers imply that the BDS method is accurate and very fast. Specifically, in Figure 3,

Table 1.
Precision Level of products

Product	Precision (Compared with IGS)
GPS Precise Ephemeris	2cm
GPS Precise Clock Error	0.1ns
BDS Precise Ephemeris	Radial Direction:IGSO,10cm; MEO,15cm;GEO,15cm
BDS Precise Clock Error	N/A
Precise Ionosphere Grid	2TECU

the map indicates the positioning accuracy for one day, and most of the part is covered by yellow. The yellow part specifies that the error of distance is less than one meter. However, the Arctic and Antarctic region are covered by red which tells there is a huge error in the distance. Using these data, the authors assert that GPS with the BDS method can offer strong

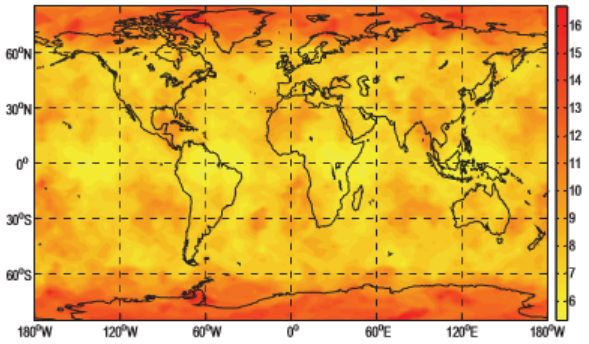

Figure 3 Average Global GPS Positioning Accuracy

services and higher accuracy than the single system. The example of GPS with the BDS methods clarifies the outstanding performance of the BDS method. Additionally, Ya-li Zhang, Jing Qin, and Xiang Huang provide the application of the BDS method in a real field (2015). They are the researchers at People's Public Security University of China. China contains enormous forests. These forests can cause fire because of climate change (p.254). However, using the BDS method, GPS can increase the search area and efficiently decrease

the time for finding positioning. Therefore, when a fire broke out, the firefighter could find the fire hazard zone and informed the place to the command center. The BDS method can save thousands of people from fire. In addition, unlike the Taylor method, the BDS method can operate its system even though there is an obstruction.

No obstruction for the BDS method

Todd Humphreys (2012), an associate professor at the University of Texas at Austin, explains that because of the consistent improvement in GPS field, in the near future, people will able to find locations with less than 1m error, and track people without their knowledge (1:16). Due to the development of GPS for tracking, people started to use electronic devices or techniques which will help them to keep them safe from tracking. One of the devices that he introduced is the Wave Bubble. The Wave Bubble creates an invisible bubble around the user so that when GPS signal is trying to reach them, the Wave Bubble will produce a different wavelength, so it makes impossible to track the user (7:37). By using the Wave Bubble, most of the GPS methods will be unable to track the location. However, the BDS method can penetrate the bubble and find the location. The reason is that unlike the other GPS methods, the BDS method applies two algorithms, a traditional algorithm, and a genetic algorithm. Using professor Humphreys' Ted Talk, it showed the efficiency of the BDS method. In addition, the BDS method can also prevent the accident, so there will be no damage to the world's economy.

GPS spoofing result in bad output

One magazine called "Why GPS spoofing is a threat to companies, countries" written by Logan Kugler, who is a freelance technology writer based in Tampa and has written for over 60 major publications at the Communications of the ACM, describes the weakness of GPS at spoofing attack (2017, p.18). The definition of a spoofing attack is giving falsifying data to gain an illegitimate advantage (Larcom & Liu, 2013). In 2013, Humphreys and his

team were invited to an $80-million yacht to test the GPS spoofing equipment. When the main GPS send its signal to the satellites, the spoofing equipment also sends its signal (p.19). Therefore, it can lead the satellites to gradually swap the actual GPS signals with false ones. Fake signals cannot be detected from the yacht. Therefore, the yacht might collide with the obstacles. The experiment from Logan Kugler implies that the GPS spoofing is disadvantageous to modern society. Also, if the GPS spoofing is applied to self-driving cars, the roads will become chaos. Using the BDS method can prevent the GPS spoofing about modifying the signals. Even though the GPS spoofing equipment gives false signals, the genetic algorithm will determine the actual location (Pan, Pei, & Liu, 2017, p.3877). Since the genetic algorithm can use up to 24 satellites, giving a fake signal will only affect one satellite. Hence, the rest of the satellites will receive the exact signals from the user. Even though the BDS method provides a positive effect on our society, it can also bring any social concerns.

Systematic Ethical Analysis

According to the CBS Chicago, Cristina Parker, who loves storing pictures in her smartphone, received a message said “I Can Stalk U” from the anonymous person (CBS, 2010). Parker responded to ask how the anonymous person got Parker location. It turns out that Parker’s image included GPS information called geotags. Every time she posted a photo on social media or her blog, other people can find the place where she took the picture. Gerald Friedland (2010), a professor at the International Computer Science Institute Berkeley, claim that the accuracy of the location system in the smartphone contains less than one-meter error. In addition, the information about the location gives enough data, so anonymous people can stalk people and cause harm to them. Unfortunately, if people keep using the GPS system for illegal and malicious purposes, all people who use the smartphones or the electric devices which include location system will lose their personal privacy. In

addition, since privacy is protected by law, the people who did the tracking for personal purpose or non-permitted tracking, they will go to jail or pay an insignificant fee. John Locke and John Stuart Mill's ethical philosophies can be applied to the usage of the BDS method. John Locke is the supporter for utilitarianism. Utilitarianism's basis is that if the doctrine is useful and gives benefit to the society, then it is a right action. The BDS method helps people to save their time and find exact places. Hence, people do not have to spend more time and pay more attention to finding a place. As a result, they can focus on their works than the past. Even if the BDS method can cause social concerns to our society, the benefits of using the BDS method far outweigh the social concerns, so it suits John Locke's ethical philosophies. John Stuart Mill's ethical philosophies, natural rights, can also applied to the BDS method. Natural rights contain several genres: life, liberty, property, pursuit of happiness, right to revolution, freedom of thought, and freedom of speech (Paine, 2018). Because the BDS method does not have to worry about obstacles and give exact location to the user, it can invade the personal privacy which is part of the property and pursuit of happiness. It is true that the BDS method's performance surpasses the Taylor method, but people have to be careful about privacy problems based on the John Stuart Mill's ethical philosophies. Positive rights and negative rights can also apply to the BDS method. The employees from GPS company, telephone company, and statistic company have positive rights. They need to make a better service to make the user use the BDS method easier and more convenient. Positive rights for employees can improve the quality of the GPS system. Therefore, our social concerns related to GPS can be solved, and the user can use the GPS system at low cost. Users, user's family, user's friends, and co-workers have negative rights. When people use the BDS method, they should not use GPS in illegal ways, such as personal tracking and unauthorized tracking. These actions can cause ethical problems and invade personal privacy. In addition, people should not interrupt the users. For example, they should not give the

wrong location to the user to make him or her confused

Conclusion

The GPS system has been helped people to find the route which took the minimum time to travel, spend less time finding the locations, and conduct surveillance on criminals. To improve the better precision of the GPS system, the Taylor method and the BDS method can be implemented. Undoubtedly, the BDS method surpasses the Taylor method. The Taylor method needs to use only four satellites. Hence, the Taylor method might not give accurate location data to a user, because the coordinate which the user receives will be less accurate than the BDS method. On the other hand, the BDS method uses 24 satellites. Compared to the Taylor method, the BDS method includes 18 more satellites for just one coordinate. Thus, the BDS method gives a coordinate to the user with a less error of distance. In addition, unlike the Taylor method, the BDS method does not have to worry about obstruction when the satellites are receiving or sending the signals to the user. When the obstacle generates different wavelength or provides false signals, other methods cannot penetrate or avoid the false signals, because they only use one algorithm. However, the BDS method will provide exact position by using standard deviation and average, also determine to use the signals while operating the algorithm. But keep in mind that the BDS method can threat the personal privacy. Thus, the government should strengthen privacy laws and usage of GPS system laws to enhance the safety of the person's information. If the computer scientist, who is professional at location system field, get more information about the BDS method and GPS system, they will try to generate better methods for the GPS system based on the BDS method. As a result, the privacy problem will be decreased, and people might be able to track anything by using the GPS system in the future.

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