APPLICATION OF GPS IN ORIENTEERING COMPETITIONS

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ABSTRACT

The Global Positioning System (GPS) is made up of the satellites, ground control centers and the receiver. With this system, it is possible to pinpoint a subject's location on earth and help for the navigation. In recent years, GPS was widely used in orienteering competitions with developing new discipline, mapping, live broadcast and live tracking. It made a summary of the advantages and shortages in the current application of the GPS in Orienteering competitions. It also forecasts the future on GPS use in the sport.

KEYWORDS

GPS; Orienteering; map-making; DGPS

1. INTRODUCTION

Since human beings stepped into the l9th century, science and technology has been not only gradually changing people's life and the world, but also changing the way we engage in various sports activities. Under the changing trend, the Orienteering Sports, with more than 100 years' history, has also blended in respectable technical components like CAD, electronic timing system and global positioning system technology, which are being widely used in project development, cartography, training and sportscast, contributing to technological progress.

2. UNDERSTANDING THE GLOBAL POSITIONING SYSTEM

Global Positioning System (GPS) was developed by the U.S. military since 1970s, lasting 20 years, costing 20 billion dollars. In 1994, it served as the satellite navigation and spotting system which has the comprehensive real-time three-dimensional navigation and positioning capability in the sea, on the land and in the air.

2.1. Constitution of GPS

GPS is composed of the space satellite net, ground control and user facility. The space satellite net is a distributed network consisting of 24 satellites in space, with the satellite respectively distributing in the fixed geosynchronous orbit, which is 6 kilometers away from the ground and 55o angle of inclination. The ground control center is composed of a master station, five global monitoring stations and three ground control stations. Each monitoring station is equipped with a precise cesium clock and a receiver that can continuously measure all visible satellites. The observed data from the monitoring station, including the ionosphere and meteorological data, will be primary processed and passed to the master station. Thus, the master station collects and tracks

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data from- each monitoring station, calculates the satellite's orbit and clock parameters, and passes the results to the three ground control stations. The user facility part is equipped with receiver hardware, machine software and GPS data post-processing software package. Its main function is to catch the satellites that adhere to the chosen drag angle and to track their movements. When the receiver caught the signals from the tracked satellites, it means that the receiving antenna to the satellite's slewing rate bf pseudo distance and distance can be measured. According to these data, the micro computer of the receiver can calculate by positioning methods and obtain information about the user's location such as the longitude, latitude, speed, time etc [1].

2.2. Positioning Principle of GPS

The basic positioning principle of GPS positioning is: Regard the high-speed satellite's instant position as a known counted data. Satellites consecutively send their star calendar parameters and time information to the receiver and send it to the user.

By the spatial distance method of junction of the rear we can calculate the three-dimensional position and direction, as well as the speed and time information of the receiver. Usually, due to the existence of the unavoidable error between the satellites and the earth, user clock error is introduced as the fourth variable. The computation formula is as follows:

$$(R_i - ct) = (X - X_i)^2 + (Y - Y_i)^2 + (Z - Z_i)^2$$

In the formula, i = l ~ 4, c stands for the speed of the light, t is for clock error. Therefore, at least four satellites' coordinates are needed in order to position the ground location. If we can only receive three satellites' information, only two-dimensional coordinates will be provided.

3. APPLICATION OF GPS IN ORIENTEERING COMPETITION

3.1. GPS Orienteering

GPS Orienteering is a newly developed form of orienteering sports siding with Orienteering along with the popularization of GPS receivers, whose form is similar to the general hiking orienteering, but the GPS receiver is to replace the compass and become the only legal tool in the whole process. We can only mark the starting point and terminal point in the map.

The result of the game is reckoned by time. During the race, the setting of the control points are specific coordinate parameters, such as "C1: N59 " 41.884'E012 " 37.218' (rock) ", which means that No.1 control is a rock located at latitude 59 " 41.884, longitude 012 " 37.218.

During the competition, players can get the coordinate information and explanations of the controls one minute before their departure.

The holding of GPS Orienteering is restricted by the GPS signal range. All controls must be set within the location where satellite signals can clearly cover. Meanwhile, we need to avoid the setting up of controls near the transmission lines, deep gullies, crown-covered areas or other places where interference for the positioning accuracy may be produced.

In addition, you have to spend a certain time using GPS for positioning when visiting a control and navigating the next control, so players should continue a one-way visit to 50 to 100 meters

ahead. Based on this, controls cannot be set in places which are hard to walk through like the jungle, rocks and swamps.
There are no clear uniform definitions and rules for the GPS Orienteering. Some clubs in the United States, Britain and Estonia are exploring its various modes, with several reports in domestic newspapers.

3.2 Application of GPS in Orienteering Map-making

3.2.1 Features of Orienteering Maps

As is known to all, Orienteering is an activity of the map and the compass. Any forms of Orienteering Sports are inseparable from the map, the most basic material basis.

International Orienteering Federation (IOF) defined the Orienteering sports as a sport in which athletes should independently finish finding a number of controls drawn on the map and ground with the help of a map and a compass, and finish the whole course as soon as possible.

It can be seen that Orienteering map has a high status in this sport. From the aspect of cartography, the Orienteering map belongs to a type of special map specially drawn for Orienteering Sports. The drawing of an Orienteering map is usually based on a topographic map, combined with on-the-spot measuring, and further processed on the basis of the characteristics and needs of the Orienteering Sports. In the eyes of the mapping department, the accuracy of Orienteering maps is relatively lower.

According to the standard of International Specification of Orienteering Maps Version 2000, the basic principle is that participants do not have any wrong understanding to the maps. Under normal circumstances, if the spacing error between the two adjacent features is less than 5olo, it meets the requirement of the accuracy.

Even though there is not such a description in the eventually issued short-range Orienteering mapping specification of ISOM2000, its ratio is greater than the mapping scale of the ratio 1:10000 and 1:15000 of the standard field map in ISOM2000, and its requirement for the mapping accuracy is higher.

Any Orienteering map's essential usage is helping Orienteering athletes to find the finish line in the shortest period of time. The practical description in map making should combine Orienteering's characteristics, focusing on reflecting the quality of run ability and visibility: The characteristics of deterrence’s should be mainly reflected. The level of information of obstruct passing and easy passing above plays a decisive role for players to choose a right line and is the basis of fairness in the match as well.

At the same time, in the practical operation process, many cartographers still find that a topographic map provided by mapping departments exist errors such as in the details of the contour lines, some real sites such as valleys and bridges, roads, buildings, water etc not marked in the map. Besides, some important information of surface features is outdated.

Therefore, it is necessary to further resurvey according to its own characteristics of the Orienteering Sports .and the standard of ISOM2000 or ISSOM2007. At present, cartographer’s site investigation not only plays a significant role in the Orienteering map making, but also is the most time consuming part in the whole process of map making.

3.2.2 Orienteering Cartography with the aid of GPS

With the popularization of GPS receivers and GPS's features of high accuracy and efficiency, all-weather and simple operation, especially the abolition of usability restrictions by U.S. Military, the accuracy of civilian used GPS receivers is greatly improved. Nowadays the error is controlled within 10 meters.

The development of Differential GPS (DGPS) technology enables the high-quality GPS receiver to get even more accurate positioning. An increasing number of people are adopting GPS to design Orienteering cartography.

The main software used to design Orienteering Cartography at present' is produced by OCAD Corporation in Switzerland. Its latest new versions OCAD8, 9 pro also have the function of charging data directly with GPS receivers. Nowadays Orienteering Cartography with the aid of GPS takes two forms.

First, collect Orienteering maps' auxiliary information with the aid of GPS receivers. Usually this kind of method is used to obtain basic information like point symbols (rock, saddle, summit), line symbols (path, ridge line) and to obtain the chart level information and then transforms them into the DXF form, pouring into the OCAD software, finally carrying on the superimposition manufacture based on the map document as the primitive map's basic proportion topographic diagram chart level. Traditional method is still needed to survey the hand-drafted map, to revise it, at last takes the template to draw up the final chart in OCAD.

Under this pattern, its operation may save 25% of the measuring time in the field survey. This method was used in the World Orienteering Championship in Japan in 2005 and the Ukraine World Orienteering Championship in 2007 [2].

Second, conduct the held survey with the aid of CPS receivers and the PC connection. This method needs the GPS to be connected with the Pocket PC or the Tablet PC.

The Arcpad is used to record the data, transform the received data into OCAD format so as to complete the map. Before using this method, we should transform the standard signal of ISOM2000. ISSOM2007 into three types: point symbols, line symbols and polygon marks. After finishing the field survey, make use of the ArcGIS system conversion graph form at DXF and inducts OCAD to carry on the plan and the revision. In addition, University of Nottingham in Britain developed the GRINGO software by not using DGPS equipment and succeeded in making the i2th signal channel hand-receiver to record the data of pseudo range and signal carrier more precisely. The pseudo range's data error is smaller than 5 meters; the carrier data achieves a centimeter level.

In the process of using this software to carry on the test procedure, the fast Orienteering map making conducts a good performance [3].

When using this method to conduct the field survey, in order to enhance the precision we usually test the linear terrain first, then carries on the determination of point terrain. Because we are not able to survey all surface shape terrain's boundary, we often use the vegetation boundary's certain frame to carry on the survey. But because of the small screen of the Pocket PC, there still exists many difficulties in the actual operation. In addition, this method demands more to the equipment and the expenditure. And, the final map can only be called an approximately standard Orienteering map due to the immature technology.

The research group in Switzerland has invented the OCAD program which can work simultaneously with GPS receivers in Pocket PCs and Tablet PCs, yet without any later report on its practical operation. Whatever methods are used to make a map, we need to adjust the geographic coordinates and magnetic force angle.

Although GPS has such theoretic characteristics as high accuracy, all weather, high efficiency, multi-function and simple operation, yet in practical operation, the following problems appeared according to the present literature review.

The signal is unstable, especially in the areas like mountain valleys and thick crown-covered areas. It is hard to satisfy the simultaneous receipt of 3 satellites. When measuring the buildings, the precision declines as a result of the shade of buildings. Metal nets have the function of signal shielding. Signal drifting may appear in the measuring in the neighborhood. In addition, the human body has counteracted to satellite signals. Sometimes it's necessary to use the exterior antenna [4].

The elevation data are unable to obtain or the precision is low. The map is not only a science, but also an art. It can undoubtedly enhance the precision of field survey, but the high-quality draftsmen are able to complete the same work by using the techniques in hand.

The more important thing is that map making is not simply making all kinds of terrain in the correct position; it also includes some working procedures like simplification, charting synthesis techniques and exaggeration to enhance the possibility of map reading. In addition, the map makers often have individual styles. Even if they are standing in the same area, they will present different expressions [5]. This kind of questions cannot be solved by GPS technology.

3.2.3 Real-time tracing of Orienteering events

Orienteering Sports is an individually experienced activity carried on in outdoor jungles. The above essentials attribute to a great limitation of the promotion of Orienteering Sports. Although the appearance of the World Park Tour (PWT) and its setting up of short distance orienteering form caused this activity to be more able to intimate with the audience, the audience is still unable to know the athletes' performances in the competition process.

Benefiting from the GPS technology, the real-time tracing service provided by Danish TracTrac Company easily solved this problem.

The product of TracTrac is based on the carrying of GPS to record real-time path and launching of the athletes through the signal server's GPS technology, to broadcast on television and internet synchronically. Up to date, TracTrac has provided real-time tracing service for WOC, Jukola, Tiomila, PWT and many other important competitions. Besides the real-time tracing service, TracTrac also provides the service of looking back the competition, which enables the audience and the Orienteering lovers to learn the Orienteering skills and principles from top competitors.
Although the use of GPS endowed Orienteering with brand-new developing direction, the audience with the chance to appreciate the fierce competition within the Orienteering Sports, it still has some limitations at present. Firstly, the GPS signals are sometimes inaccurate when used in the forest. Secondly, GPS is too expensive for the organizers to provide for all competitors. Thirdly, due to the limitation of Orienteering Sports, the effect of using this technology to boost watch ability of the competition is still indistinct.

3.2.4 Training Analysis

Orienteering is not simply a country-cross race, but also includes a large number of cognitive factors. In the practical race, the problem that the athletes should think about all the time is the choice of the route. Athletes may choose different routes even if they are in the same place, which makes the analysis of competition process rather complicated. Before that there are a lot of researches in Orienteering from the angles of athletic physiology and psychology [6], but these researches are not carried out in the real process of Orienteering race. Some of them even have no essential connections with the address and speed of Orienteering. Some are carried out under the circumstance of cross-country race of fixed routes.

Some change the route of orienteering race into route of cross-country lace with timing for test [7]. With the development of DGPS, especially after the invention of GPS, it is possible for us to record the performance of athletes all the way[S]. Thus, it is a creation to combine the GPS and equipment of physiology index test. Peter Larsson, after having applied this method, indicates that the fault rate of athletes anaerobic threshold value is lower (r: .0.64, $p < 0.05$) and athletes with high aerobic and VO2peak threshold deplete less stamina in the race. These threshold values are important reference data to predict the result of race.

The special function of GPS to record the route of the race plays an important role in the analysis of Orienteering training and the analysis of the.1ace. By applying the function to record the athlete's practical route and special analysis of software, we can get a concrete analysis of the process of race.

Besides, it is a favorable assistance of Orienteering race from GPS receivers and to find out shortcomings and advantages by comparing with the records of their route choice. The application of these techniques can not only vivify education, but also improve the teaching efficiency. At present, the leading GPS receivers are the Forerunner series of Garmin Company in America and the FRWD series of FRWD Company in Finland.

These receivers have the function of collecting data as well as testing heart rate. There is more software that highlights the special function of Orienteering Sports such as OTrack, Routegadet, SportTracks, QuickRoute etc. Among them, OTrack and QuickRoute are applied widespread for their high compatibility with the data of GPS receivers such as Trimble and Magellan. Secondly, they can show athletes' practical routes by combining the athletes' races and training maps. They can list data all the time as follows: distance from the starting line, instantaneous speed and accumulative total height of climbing. At the same time, the equipment of testing heart rate can supply data of athletes' heart rate all the way.

Coaches can monitor and analyze the condition of athletes' anemia from data and software. Besides, the data from the software can be skimmed over and replayed on the web of Google Earth. This kind of software can not only monitor and analyze athletes' anemia conditions, but also help athletes to find out their own shortcomings. As a result, we can adjust our training plan.
Furthermore, OTrack can automatically get analysis of corresponding time from GPS data so as to avoid the potential threats resulting from the electronic equipment installed in the open air (such. as loss of card device). At present, some clubs in Britain change the electronic timing devices such as SI and Emit into GPS receivers and orienteering flags. This series of products is a breakthrough in the history of Orienteering Sports. However, these products have limitations in themselves due to the disadvantages of GPS itself.

Accuracy is one of the lasting shortcomings, which has been overcome by the function of revising by hand in most software. Besides, accuracy should be reckoned with from two aspects. One is cc mistakes by signal disturbance of GPS satellites, and the other is the discrepancy in map-making.

4. FUTURE EXPECTATIONS

GPS sprang up for its use in Orienteering Competitions only in recent years. Although there are many striking advantages in every aspect, it has not been reported used due to the lack of technology and funds. It has not even been reported and researched in China. It is believed that GPS will be used in every area of Orienteering Sports with the further development and spreading of GPS receivers.

GPS was developed by Americans.

To decrease the dependence of technical resources, countries like UN, Russia and China get into the autonomous researches in GPS with higher accuracy. For example, Gallileo system in UN raises their accuracy to 1 meter in civilian use. It is believed that with the development and application of these systems, there will be richer signal resources assisting Orienteering Competitions with higher accuracy.

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