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Identification of location co-ordinates of blood in simulated crime scene using DGPS

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Abstract
The location of any evidence in a crime scene is of vital importance and so, is the location of blood in a crime scene. In this research investigation, identification of the location co-ordinates of blood is performed in simulated crime scene using DGPS. DGPS co-ordinates of all evidences were taken using DGPS receiver and the distance of blood source and blood stain is computed using Co-ordinate Distance Calculator. The baseline measurements of the scene along with other evidence was also carried out. Further, the computed data was compared to manual measurement to find the difference between the measurements using the two methods. The results indicate that the mean difference between the computed distance using DGPS co-ordinates with Co-ordinate Distance Calculator and manual measurement is 1.6, 1.93, 4.4, 1.95, 2.4, 1.6, 0.33 and 3.95 for 8 crime scenes. The average of the calculated mean difference of all eight scenes were calculated as 2.27 feet. Thus, DGPS can be used in crime scene management for collection of location with co-ordinates of evidence, like hair, fiber, saliva, blood stain etc. which was helpful in crime scene reconstruction.

Keywords: DGPS, blood source, baseline measurements, computed distance and Co-ordinate distance calculator

Introduction
Investigators often encounter with different types of crime scene. Some of them even contain blood stains or the bloodstains in specific manner (blood patterns). Locard's Exchange Principle states that every time an individual makes contact with another person, place or thing, it results in an exchange of physical materials [4]. The study of evidence at a crime scene is particularly based on this principle.

Blood is a specialized body fluid in animals that transports necessary substance such as oxygen and nutrients to the cells and carry metabolic waste products away from those cells. Blood consists of blood cells or corpuscles (cellular part) and blood plasma (fluid part). Plasma is mostly water and contains dissipated proteins, mineral ions, glucose, carbon dioxide, hormones, platelets and blood cells. The blood cells are mainly erythrocytes, leucocytes and platelets.

Blood is the common, well known and most important evidence to be found. Presence of blood always links suspect and victim to one another and to the crime scene. Location of blood stain in a crime scene is of keen importance for the reconstruction of crime scene. Events that occurred during commission of crime can be interpreted or linked on knowing the exact location of blood stain. GPS is an acronym of NAVSTAR GPS (NAVigation System with Time And Ranging Global Positioning System). It is a satellite-based system which uses a constellation of 24 satellites to provide a user an accurate position for both static and dynamic objects or sites. The GPS system consists of three "segments" namely: Control Segment, the Space segment and the User segment. The proper functioning of these three segment results in accurate and reliable operation of the entire system.

The time taken by a signal to travel from a satellite to a GPS receiver is affected by several types of random errors and biases (systematic errors) which may be classified as: those originating at the satellites (ephemeris/ orbital error, satellite clock errors, and effect of selective availability of satellites), those originating at the receiver (receiver clock errors, multiple clock errors, receiver noise, and antenna center variations), and those that are due to signal propagation (atmospheric refraction: ionosphere and troposphere) [4].

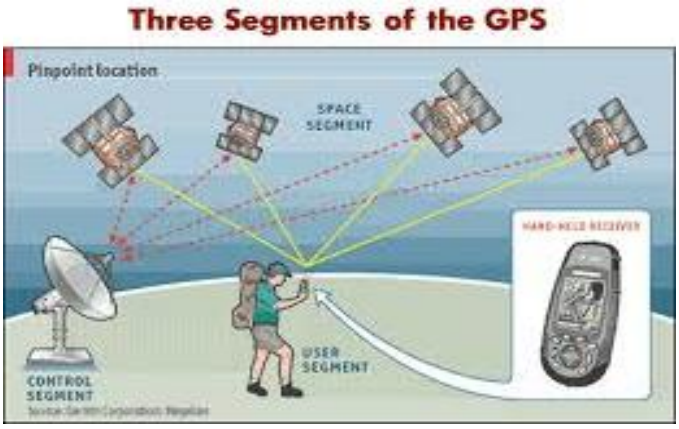

Fig 1: Figure showing the three segments of GPS: Control segment, Space segment and the user segment

It is only in the vacuum that GPS signal travels at a speed of light. Additionally, GPS position is affected by the geometric locations of the GPS satellites as seen by the receiver. The GPS accuracy is directly proportional to the spreading out of satellites in the sky.

GPS users employ different techniques to achieve the highest possible positional accuracy. One such technique is DGPS (Differential Global Positioning System), in which one GPS receiver (Reference station) is used as a rover. The Reference station is placed at a known location, thus is able to correct error in the satellite signals. It accomplishes this by measuring the range of each satellite, by using the signals that are received from each satellite and then compare the measured range to the actual ranges calculated from its known position. The difference between the measured and the calculated range in view is known as 'differential correction' of the position[2].

The DGPS co-ordinate of one's position is measured in terms of latitude, longitude and height of the position of the DGPS receiver. The distance of two GPS locations can be further computed using software like ArcGIS, or using Co-ordinate Distance Calculator.

Out of various DGPS receivers available in the market, Trimble R1GNSS is one such DGPS receiver with some really good features such as: small, roughness, lightweight of GNSS receiver for great mobility; higher-accuracy location data; Bluetooth connection to Trimble handhelds or consumer-grade smart devices; flexibility to choose your data collection device; flexibility for professional data collection in more places and View Point RTX that provides sub-meter accuracy via IP or satellite (which is available on Trimble R1 GNSS Receiver with RTX only).

Here 8 simulated crime scenes were prepared and further crime scene investigation was performed using DGPS system to measure exact locations of the blood spots present at the scene of crime. This study was conducted with following objectives to visually locate blood drops in different simulated crime scene.to get GPS co-ordinates of identified blood drops and blood source (body) at simulated crime scene and to calculate distance between blood source to blood drop using Co-ordinate Distance Calculator with Differential-GPS co-ordinates.

2. Methodology

Materials used

DGPS receiver with inbuilt antenna: Trimble R1 GNSS, measuring tapes, crime scene tapes, camera, note pad, pencil, human dummy (blood source), ruler, evidence number plates, red colored solution in water (as blood), road barrier cones and miscellaneous evidences.

Fig 2: Trimble R1 GNSS

Methodology

A. Sample Collection

For each simulated crime scene, different locations that is suitable to create a simulated crime scene were visited. Firstly, a simulated crime was planned and then all the evidences were placed and accordingly the simulated crime scene was barricaded. Sketching and Manual measurements were performed using baseline mapping method, and so the two static points were cautiously selected (if no static sites available, then barrier cones were as considered static points). The photography of the scene and evidences was performed.

The baseline measurements of each evidence was taken by noting EB (distance of each evidence from the baseline) and B_x (the point at which EB lay perpendicular on baseline BL). Similarly, the DGPS co-ordinates of B_x, each evidence, each blood stain, blood source, first and the last blood drop (in case of series of blood drops), static sites BL_A and BL_B and CRPs was collected.

B. Calculations

The distance between the blood drop and the blood source was measured manually as well as computed using Co-ordinate Distance Calculator (CDC) using Differential-GPS co-ordinates. A difference between above mentioned manually measured distance and that computed using CDC. For the scenes comprising of more than one blood drop multiple distance was measured for different blood drops and blood source. In such cases, mean of the difference between the manually measured distance and computed distance was calculated. At last, the total average of the mean difference for the 8 scenes together was calculated. Also, distance travelled by the blood source after the impact (first and the far most blood drop and the blood source) and the direction of the blood source that caused the blood drop was computed using CDC.

Fig 3: Figure showing Blood source (A) and Blood stain (B) in simulated crime scene

Result and Discussion

Table 1: Comparison of DGPS computed reading with manual measurement (Distance of the blood source to the Blood (in feet and inches))

S. No	Simulated crime scene No.	Two sites in the scene	A	B	C
1.	1	E3 and E5	16.4 ft	18 ft	1.6 ft
2.	2	E2 and E1b	2.6 ft	5 ft	2.4 ft
3.		E3 and E1b	3.6 ft	5 ft	1.4 ft
4.		E4 and E1b	5.0 ft	7 ft	2.0 ft
5.	3	E1 and E2	20.4 ft	16 ft	4.4 ft
6.	4	E3a to E4	11.6 ft	15 ft	3.4 ft
7.		E3b to E4	8.8 ft	10 ft	1.2 ft
8.		E3c to E4	7.2 ft	9 ft	1.8 ft
9.		E3d to E4	4.4 ft	3 ft	1.4 ft
10.	5	E2 to E7	20 ft	22 ft	2 ft
11.		E3 to E7	16.4 ft	20 ft	4.4 ft
12.		E4 to E7	11.2 ft	10ft	1.2 ft
13.		E5 to E7	8 ft	11 ft	3 ft
14.		E6 to E7	4.4 ft	9 ft	4.6 ft
15.	6	E3 to E2	4 ft	0 ft	4 ft
16.		E4 to E2	6.4 ft	6ft	0.4 ft
17.		E5 to E2	11.6 ft	12 ft	0.4 ft
18.	7	E3 to E5	14.8 ft	15 ft	0.2 ft
19.		E4 to E5	8.8 ft	8 ft	0.8 ft
20.	8	E1 to E6	44.4 ft	40 ft	4.4 ft
21.		E2 to E6	36 ft	33 ft	3 ft
22.		E3 to E6	30.4 ft	26 ft	4.4 ft
23.		E4 to E6	24 ft	20 ft	4 ft

Where A= Manually measured distance, B= Distance computed using Co-ordinate distance calculator, and C= Difference between A and B.

Table 2: Mean difference between the manually measured distance and the distance computed using Co-ordinate distance calculator between the blood source and the blood drop in different simulated crime scenes (all readings in feet and inches):

S. No.	Simulated crime scene No.	Mean difference between co-ordinate distance calculator and manual measurements for each scene (in feet)	Distance travelled by the blood source after the impact	Direction of the source that caused the blood stain
1.	1	1.6	18 ft	South- West
2.	2	1.93	7 ft	South
3.	3	4.4	16 ft	South
4.	4	1.95	15 ft	West
5.	5	2.4	22 ft	South-West
6.	6	1.6	12 ft	South-East
7.	7	0.33	15 ft	South
8.	8	3.95	40 ft	North- East
		Average: 2.27		

The mean of difference between manually measured distance and CDC computed distance between blood source (body) and blood drop (in feet) was calculated as 1.6, 1.93, 4.4, 1.95, 2.4, 1.6, 0.33 and 3.95 in simulated crime scene number 1, 2, 3, 4, 5, 6, 7 and 8 respectively. Furthermore, the average of the mean difference for all 8 scenes together was calculated as 2.27 feet. Also, the distance travelled by the blood source after the impact and the direction of the blood source that caused the blood drop for all eight scenes have been calculated (as indicated in the above mentioned table).

Discussion

In a related research entitled, "Mapping simulated scenes with skeletal remains using differential GPS in open environments: An assessment of accuracy and practicality[5] the accuracy of DGPS units was quantified in open areas for mapping skeletal remains dispersals using the DGPS. Data collected were differentially post processed and compared in a geographic information system (GIS) to evaluate the most efficient recordation methods. They have used Trimble GeoExpoure 2008 Series DGPS receiver along with Zephyr antenna and range pole as supporting accessories for better accuracy. They found that the DGPS is a viable option for mapping dispersed human remains in open areas.

Whereas, in the research work entitled "Identification of location co-ordinates of blood in a simulated crime scene using DGPS" location of the blood drops and the blood source was collected using Differential-GPS receiver, Trimble R1 GNSS. The data collected need not be post processed as the device along with complementary software, Terraflex, itself sends the data to the receiver after post-processing it. No additional accessories are required for accuracy as the device comes with a feature of internal antenna (though the device consists of an external port). The collected DGPS data are then computed to calculate the distance between blood source and blood drop using Co-ordinate Distance Calculator (CDC). CDC also, gives the advantage of computing the direction of the second co-ordinate with respect to the first co-ordinate. The device used in this research work has accuracy of 50 cm and thus gives same co-ordinates for sites that are within 50 cm range.

Limitations: In order to operate with GPS, it is important that the GPS antenna has a clear view to at least 4 satellites. Sometimes, the satellite signals can be blocked by tall

buildings, trees, etc. Hence, GPS cannot be used indoors. It is also difficult to use GPS in town centers or woodland. Due to this limitation, it may prove more cost effective in case of some survey applications to use an optical total station or to combine use of such an instrument with GPS.

Summary

This research was conducted in SHUATS campus, Allahabad after creating 8 different simulated crime scenes (mainly comprising blood drops and one blood source) and collecting DGPS co-ordinates of the blood drops and the blood source using DGPS receiver, Trimble R1 GNSS. The distance between the blood drop and the blood source was computed using Co-ordinate Distance Calculator (CDC), using the collected DGPS co-ordinates and also measured manually manual measurements. A difference has been noticed of the above mentioned distance, measured manually and that computed using CDC. In case of scenes comprised of more than one blood drop so multiple distance was measured for different blood drops and blood source, and then mean of the difference between the manually measured distance and computed distance was calculated. Mean difference of simulated crime scene number 1, 2, 3, 4, 5, 6, 7 and 8 are 1.6, 1.93, 4.4, 1.95, 2.4, 1.6, 0.33 and 3.95 respectively. Further, the average of the mean difference for all the 8 scenes together was calculated as 2.27 feet.

Conclusion

In this research work entitled "Identification of location co-ordinates of blood in simulated crime scene using DGPS" –

1. Blood drops have been visually located in 8 different simulated crime scene.
2. GPS co-ordinates of the blood drops and the blood source have been collected at each simulated crime scene.
3. The distance between the located blood source and blood drops have been computed using the Co-ordinate Distance Calculator with Differential-GPS co-ordinates.

The above mentioned distance was also manual measurements (in feet and inches). The average of the mean difference between the manually measured distance and distance computed using CDC for all eight scenes was calculated as 2.27 feet.

DGPS co-ordinates are independent of time and environment accurate to point 8^{th} unit in degree decimal unit. Whereas, manual measurements are liable to mistakes. Using DGPS method, blood and blood source can be located even if: (1) the crime scene has been disturbed with environmental factors or any other; or (2) it has been wiped out or washed out, but only if, it can be developed using blood identification techniques like luminol test (Blood stains can be effectively detected even after nearly four years of blood deposition on soil using reagents like luminol and Blue star[1](3) in a very large crime scene where it is difficult to perform manual measurements of the scene. (4) It does not require to take multiple measurements for baseline mapping or other sketching methods to locate an evidence in the crime scene, thus decreasing time and energy consumption and changes of error. Thus, using DGPS for locating blood in outdoor crime scene is a good concept that can further help in accurate crime scene reconstruction.

Though, the method of manual measurements is commonly practiced, but in the current generations where crime is rising at an alarming rate, time and energy consuming methods are not much preferable. Moreover, the current generation and the police prefer technology and instruments based methods that can give efficient and accurate results in minimum time. Thus, new method can always be welcomed or researched for, to get better accuracy and efficiency in less time. Further, research is required to improve the efficiency and accuracy of system like GPS and DGPS, so as to overcome limitation of such system and to use indoor.

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