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Deployment Of Surveying And Geoinformatics In Search And Rescue Mission

A. N. Jatong
Department of Surveying and Geoinformatics,
Federal Polytechnic Mubi,
Mubi, Nigeria
anthonyjatong@yahoo.com

Abstract - The **problem of rapid response to emergency has remained a mirage either due to inadequate workers to cope with growing problems or lack of reliable navigational tools and information to chart reliable routes at any given point and time between the service centers and those in urgent needs of such services. In attempt to provide rapid response to health, security challenges, accident scenes, rescue etc., service centers have in the past resorted to various but unreliable methods. The intention of this research is to apply Surveying and Geoinformatics tool, Geographic Information System (GIS) in charting shortest routes at any given point and time for reliable and rapid search and rescue missions. A georeferenced topographic map of the study area was loaded on Global Mapper environment to determine the required bearing and distance between the Command and Control Center (CCC) and supposed caller station at cursor command. A computer program, DIST program was used online to validate and determine the forward and back bearing and distance between the reference station/CCC and various selected caller locations for impromptu locations not included in the database. It was shown that with a database created in respect of bearing, distance and location or position (X, Y or φ, λ), it is possible using GIS to response to emergency events much better than the conventional method where only description of a location is involved. The results show that both Global Mapper and DIST program have the capacity to determine distance as well as the bearing or azimuth between the reference station and the caller location. Database linked to azimuth and distance programs in GIS environment for search and rescue missions is a necessary option while installation of self-position transmitting device on platforms such as aircraft, ship, train, etc. will enhance rapid search and rescue in the event of mishap.**

Keywords-Geographic Information System, coordinates, azimuth, Location, rapid response, access.

I.INTRODUCTION

While search is an attempt to find somebody or something, rescue is an action intended to save something or somebody in or from danger. On a daily basis, its either somebody is searching among others for misplaced car key, office key, missing, kidnapped or abducted persons, missing or stolen properties and so on. Searches are meant to discover and recover. Unfortunately the number of searches have not always resulted in corresponding discovery and recovery or rescue. Search and rescue operations require quick or emergency approaches.

Emergency is a sudden unforeseen crisis usually involving danger that requires immediate action [1]. Similarly, [2] broadly defined emergency as a deviation from planned or expected behavior or a course of events that endangers or adversely affects people, property, or the environment.

There are basically two types of emergencies; natural which are unplanned events such as hurricanes, earthquakes, floods, tsunamis, tornadoes, and man-made emergencies which are unplanned events resulting from human activities such as utility failures, bio-terrorism, chemical-terrorism, attacks such as robbery and so on.

Response to emergencies can be marred by many factors such as equipment, lack of adequately trained personnel, lack of timely response mechanism, inadequate information etc. to speedily track any emergency scene. Rapid and timely response to emergencies require parameters that would guarantee quick search and location of disaster or emergency scene and hence rescue. In the past, search to discover and rescue were mostly done by mobilizing a community or some interest groups to search in any probable and assumed direction of missing person or property. This type of random or trial and error search and rescue approaches result in enormous waste of time and energies and hence frustration without in many cases anything to show for.

Effective search and rescue missions require deployment of modern technologies in computer hardware and software in semi or full automation; semi where human intervention is required such as transmission of positional information by human to a control room and full where a position transmitting device, transmits positional information of its location continuously to a control room without human intervention. The search and rescue of a missing aircraft, ship, train, and so on could be rapid if position transmitting devices are installed in secure places such as black boxes. Surveying and Geoinformatics which is an embodiment of Geodesy (Physical and Geometrical), Mathematical sciences, Astronomy, Aerial photogrammetry, Remote Sensing, Hydrography, and such tools as Geographic Information System (GIS) has proven again and again that it has the required capacity to effectively handle search and rescue operation including the search and location of unknown terrestrial and extraterrestrial bodies. In surveying and Geoinformatics a target can be 'seen' and located whether beneath or above the earth surface.

Geographic Information System, a Surveying and Geoinformatics tool meant basically to capture, store, analyse and retrieve information tied to real world situation, can collect, store, and provide information necessary for Computer-Aided-Dispatch (CAD) in rapid response to tasks such as search and rescue. GIS is also a tool for providing tools and data for response planning [3]. If a database in respect of the Easting and Northing of the command and control center (CCC) and all identified caller locations is created and in collaboration with an azimuth and distance computation program, GIS could provide the needed information to move from the command and control center to search and locate a caller location or the emergency scene with reliability, ease and speed. Endangered species of fishes and some animals have been known to be implanted with positional transmitters and released into the wild and their locations through Real Time Kinematic Global Positioning System (RTK GPS) transmitted real time to the monitoring or tracking room. The measurement and processing of survey data was before now tedious but with the advent of modern instrumentation such as GPS, computer hardware and software such as DIST program among others, the search and rescue parameters to define the path and distance to any point can be accomplished relatively easily.

There are various similar survey programs written either in FORTRAN or other computer languages to compute distance and azimuth between two points given their coordinates. Given the distance and the azimuth, a path is defined and hence the caller location from the reference station thus rapid response to any emergency situation can be provided. While health services and other similar services have always made frantic efforts to access positions from distress callers needing urgent attention, the speedy and accurate location of such positions by mere guess or description came too late in many cases. Most, villages or hamlet or just a location cannot be speedily located by mere address or description. Rapid response to emergency situations can be achieved through, the database in respect of X, Y or φ, λ coordinates for responder position and emergency scenes, DIST program, compass (a navigation instrument for finding direction).

From the coordinates of two points, the azimuth and the distance can speedily be determined and since the variable is always the caller's position and the responder location is fixed except in kinematic mode, many rapid responses can be made simultaneously by vehicles with installed program for computing azimuth and distance, and with a navigational tool such as simple compass, search and rescue operations are simplified.

The aim of this study is to apply Surveying and Geoinformatics tools (GIS) in information storage and retrieval for enhanced search and timely rescue missions. This creates and provides information and platform for the responder or service centers such as the health services to provide rapid response for health delivery services, the Armed Forces to search and provide rapid response and rescue to distress callers, the Fire service to locate and provide rapid response to fire incidences, the Federal Road Safety commission to response rapidly to accident scenes

II. STUDY AREA

The study area Mubi and environs shown in figure 1 is bounded by Maiha LGA in the South, Republic of Cameroon in the East, Michika LGA in the North, and Hong LGA in the West. It is the commercial nerve of Adamawa state, Nigeria. It is within the following geographic bounds: West longitude of 13° 9.27633' E, North latitude of 10° 23.01284' N, East longitude of 13° 22.26035' E and South latitude of 10° 10.15241' N at UTM zone 33 / Minna. Adamawa state has a population of 3,168,101[4] and a land area of 42158km^2 [5].

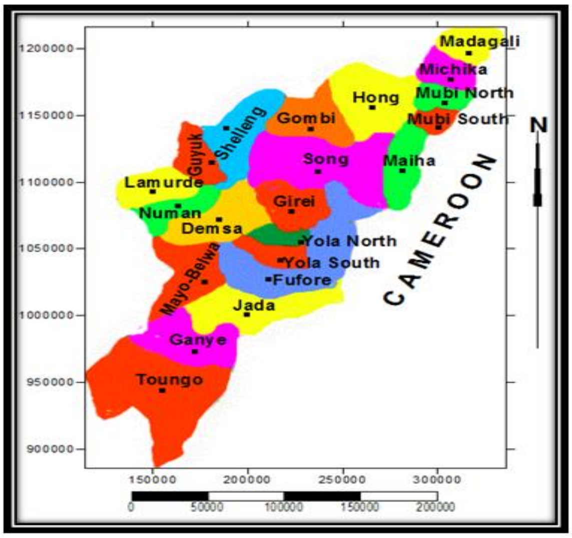

Figure 1: Map of Adamawa State Showing Mubi South and North

III. MATERIALS AND METHOD

The data were basically the coordinates of both command and control center and some selected caller stations in latitude/longitude system extracted from topographic map of the study area. These data were used as tiepoints to generate the basemap used to clearly show relative position of the command and control center and the caller locations. The coordinates were confirmed using Garmin GPS receiver. While CorelDraw version11 was used to edge-match four separately scanned topographic sheets making up the study area, ILWIS version 3.4 was used to create the georeferenced map of the study area. The geographic (φ, λ) coordinates extracted from topographic sheets were transformed to UTM grid (X, Y) coordinate system using equation (1) – (3) [6]. This is because georeferencing in ILWIS environment requires entry of tiepoint coordinates in UTM grid to create the base map (Fig. 2).

$N = M + w^2 K + w^4 B$ (1)

$\Delta E = wR + w^3 C + w^5\ III$ (2)

$E = E_O \pm \Delta E$ (3)

Where,

$w'' = 10^{-4} \Delta\lambda''$

$\Delta\lambda''$= longitude difference (in seconds of arc) between point and central meridian,

M = distance on the meridian from parallel of origin (Equator) to the parallel, φA of

point and is obtained from UTM table II

φ_A = latitude of point

N = northing of point

E = easting of point

E_O = False easting (500000m) of the central Meridian.

K, B, R, III are tabulated in table II for each 5' of latitude and are extracted for the latitude φA of the point.

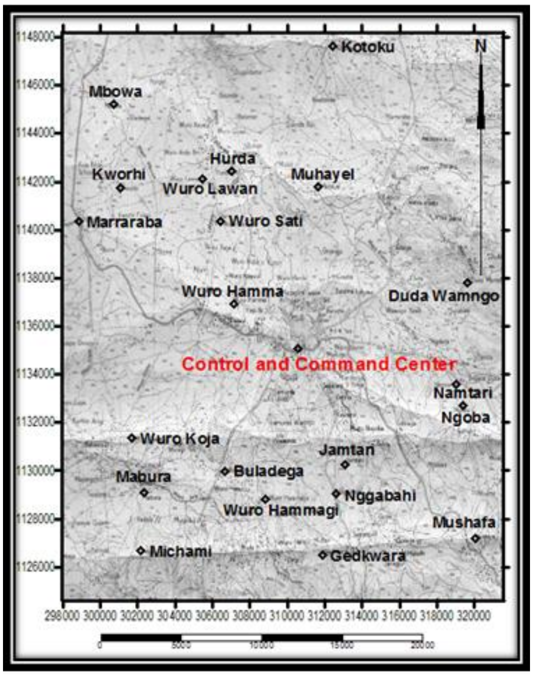

Figure 2: Georeferenced Locational Map of Callers

Global Mapper v10 determines the geographic and the grid coordinates of caller location, bearing from the CCC to a caller location, the distance between the CCC and caller location at any given cursor command. DIST program was used to compute illustrative azimuth and distance between the command and control center and the various caller locations. DIST program was written by John Boursy, modified in 1993 by Gary Kalagian and adapted in December, 1998 for internet use by Dale Bickel for the computation of azimuth and distance between two points [7].

The data (coordinates) for the computation of the distance and azimuth were entered simultaneously for the reference and caller stations in degrees, minutes and seconds in the data entry box (Figure 3) provided by the DIST program. It takes five seconds to process when the distance involved is less than 3km and up to fifteen seconds to process when the distance is greater than 3km. Figure 4 shows the distance and azimuth result window.

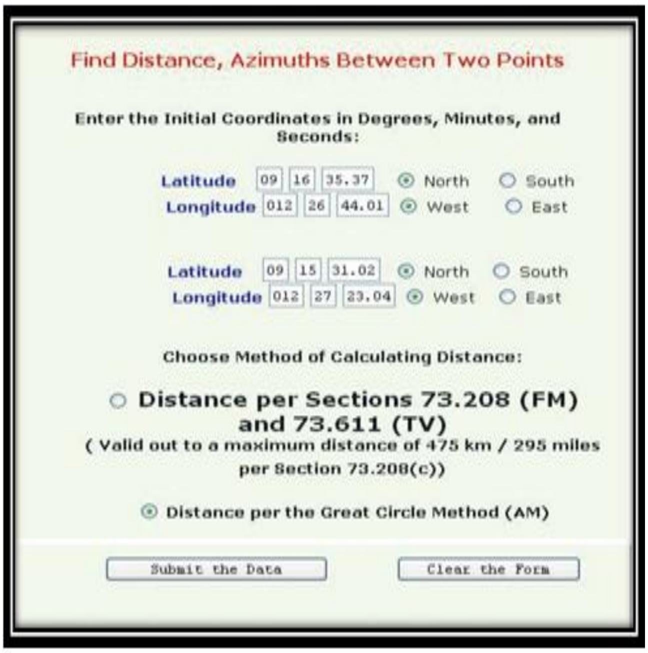

Figure 3. Data entry box

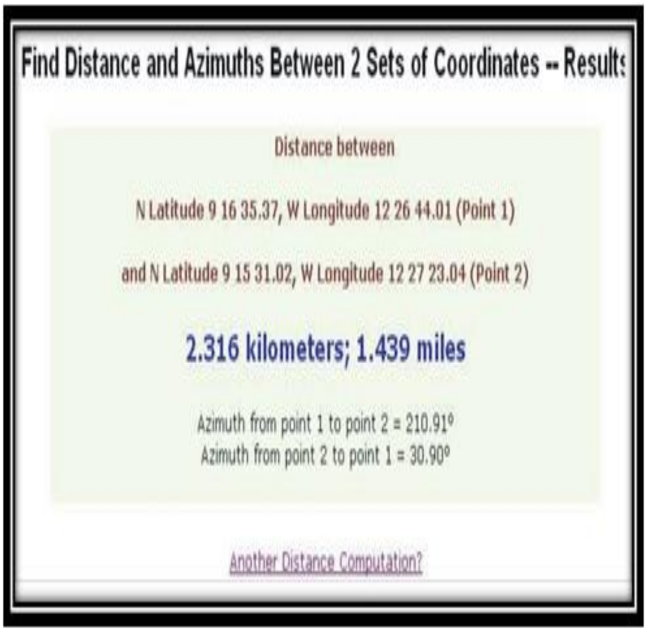

Figure 4. Distance and azimuth result window

The azimuth and distance between two points i and j are computed from inverse Gauss mid-latitude formulae given the latitude (φ) and longitude (λ) of the two points i and j as in equation (4) - (16):

$$\left[\alpha_{ij} + \frac{\Delta\alpha}{2}\right] = \tan^{-1}\left[\frac{\Delta\lambda}{\Delta\varphi}\frac{N_m\cos\varphi_m}{M_m}\right] \quad (4)$$

$$\alpha_{ij} = \tan^{-1}\left[\frac{\Delta\lambda}{\Delta\varphi}\frac{N_m\cos\varphi_m}{M_m}\right] - \frac{\Delta\alpha}{2} \quad (5)$$

$$\alpha_{ji} = \alpha_{ij} + 180 + \Delta\alpha \quad (6)$$

$$S_{ij} = \frac{\Delta\lambda N_m\cos\varphi_m}{\left[\sin\alpha_{ij} + \frac{\Delta\alpha}{2}\right]} \quad (7)$$

Where,

α_{ij} = Azimuth of line ij on the ellipsoid,

$$\Delta\alpha = \Delta\lambda\sin\varphi_m \quad (8)$$

$$\Delta\lambda = \lambda_j - \lambda_i \quad (9)$$

$$\Delta\varphi = \varphi_j - \varphi_i \quad (10)$$

$$N = \frac{a}{\sqrt{[1-e^2\sin^2\varphi]}} \quad (11)$$

$$N_m = \frac{N_i + N_j}{2} \quad (12)$$

$$\varphi_m = \frac{\varphi_i + \varphi_j}{2} \quad (13)$$

$$M = \frac{a(1-e^2)}{\sqrt{[1-e^2\sin^2\varphi]^3}} \quad (14)$$

$$M_m = \frac{M_i + M_j}{2} \quad (15)$$

e = First eccentricity of the reference ellipsoid

$$e^2 = \frac{a^2 - b^2}{a^2} \quad (16)$$

a, b = Semi major and Semi minor axes respectively.

N, M = Radius of curvature of the ellipsoid on the prime vertical and the meridian plane respectively.

The implementation of the Gauss mid-latitude algorithms was done in DIST Program and Global Mapper environments for the search and rescue parameters (Table 1).

Table 1. Search and Rescue Parameters for Caller locations

S/No.	From	Easting (m)	Northing (m)	Bearing	Dist.	To
1	CCC	310529.897	1135059.270	° ' "	Km	CCC
2		306680.525	1129900.043	216° 45' 38"	6.45	Buladega
3		308899.260	1128750.577	194° 05' 42"	6.52	Wuro Hammagi
4		312628.339	1128997.846	160° 53' 17"	6.47	Nggabahi
5		313056.047	1130227.506	152° 32' 10"	5.51	Jamtari
6		311786.289	1126478.379	171° 25' 08"	8.67	Gadkwara
7		320126.594	1127039.746	129° 45' 46"	12.5	Mushafa
8		319324.642	1132626.681	105° 14' 57"	9.12	Ngoba
9		318896.934	1133609.072	099° 59' 19"	8.5	Namtari
10		319591.959	1137839.371	172° 31' 41"	9.48	Duda Wamngo
11		311585.801	1141788.987	008° 34' 41"	6.79	Muhayel
12		306894.379	1142457.281	333° 36' 35"	8.22	Hurda
13		305384.035	1142056.305	323° 27' 41"	8.67	Wuro Lawan
14		306373.110	1140345.473	321° 35' 24"	6.71	Wuro Sati
15		301093.590	1141641.963	304° 41' 29"	11.49	Kworhi
16		298848.123	1140372.205	294° 12' 25"	12.82	Marraraba

IV.RESULTS AND DISCUSSION

When the distance between two points exceeds 3km, it is usually known as long line and the usual bearing and distance algorithm through the square root of the summed squares of change in easting and change in northing no longer apply but a resort to rigorous one such as Gauss mid-latitude where the search parameters are computed from geographic rather than grid coordinates. In this approach the radius of curvature of the ellipsoid on the prime vertical plane, the radius of curvature of the ellipsoid in the meridian plane, change in longitude, change in azimuth are first determined and then the forward and back azimuths and the distance follow. The results for different caller locations are shown in Table 1. The results provide the coordinates of all caller location, forward bearing from where the back bearing can be deduced and the distance between the CCC and each caller location. From Table 1, the least distance of 6.45km is between the CCC and Buladega while the longest distance of 12.82km is between the CCC and Marraraba. This result can be used to create a GIS database where queries can be issued to provide the bearing to a required location and the distance to such location, or the coordinates of any location contained in the database. While DIST Program can determine search and rescue parameters to a maximum of 475km, Global Mapper can go beyond this.

V.CONCLUSIONS AND RECOMMENDATIONS

The research has demonstrated the direct use of DIST program for online services at any given time, to determine the distance, forward azimuth as well as the back azimuth of the same line, it takes seconds for results (distance, forward and back azimuth) to be processed and displayed. Both Global Mapper and the DIST Program do not require to be close or at an emergency location to provide the search and rescue parameters. For the Global Mapper what is needed is a georeferenced or a digital map or a Digital Elevation Model covering area of search and rescue while the DIST Program requires the coordinates of the caller location.

Rapid Health services delivery and indeed other services like Federal Road Safety Commission, Police, Army, Fire service etc. have in most cases been marred by inability to timely determine the location of the person(s) in need of such services. This study has shown and demonstrated the application of Surveying and Geoinformatics tools in search and rescue mission. This is achievable since the position of the responder station and the caller location are known or can be known. The implication of this study is therefore that the shortest route at any point between a command and control center or a mobile responder point and a caller location can be defined and the hitherto slow response to distress calls in Health services delivery, the Army, Police, Fire services, Rescue missions etc. should be a thing of the past.

These innovations could go a long way in ensuring rapid response to security challenges and emergencies in general. For Federal Road Safety commission responsible for responding to vehicular crash, rapid response is easy if mileage stones on highways show their coordinates in addition to the usual mileage information.

And so if Federal Road Safety commission, the Armed forces, the police, the health center, and all service centers charged with the duty of responding to emergency calls create a database of coordinates of all potential emergency locations, in collaboration with azimuth and distance program, search and rescue operations become easy and reliable. Self-position transmitting devices could enhance rapid search and rescue operations when installed on platforms such as aircraft, ship etc. as these devices have the capacity to receive positional information and transmit same to a control room for any service delivery.

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