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Full Length Research Paper

Enhancing road monitoring and safety through the use of geospatial technology

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The geographic information system (GIS) and the global positioning system (GPS) are the 2 geospatial technologies that are being used in monitoring of transportation generally. Transportation is a requirement for every nation regardless of its industrial capacity, political stability, population, size or technological development. Moving goods and people from one place to another is crucial to maintaining strong economic and political ties between the various components of any given nation and among nations. How that movement takes place can be unique to location and technological development, but the most reliable and widely embraced means of transportation is road. Road transportation is the most widely used means of transportation in all countries generally and Nigeria in particular due to its affordability. Because of its contribution to national growth, various measures and devices had been and are being developed to enhance its continuity, sustainability and safety. Geo spatial technology is an electronic system for capturing, storing, retrieval, analyzing and displaying data related to positions on the earth. In this paper, geospatial technologies were used to generate a digital map of Nigeria roads to ensure easy location of vehicles and incidents on these roads.

Key words: Transportation, GIS, geo spatial, highway, geodetic data.

INTRODUCTION

Transportation can be briefly defined as the movement of people and or goods from one place to another through a means. The means may be walking on land, vehicle on road, train on the rail and plane in the air or ship on the sea. The concern of this paper is the movement of vehicles on roads in general which will be henceforth referred to as road transportation. Road transportation therefore is the conveyance of people and or goods on road from one place to another by a particular mode. Road transporttation is characterized by its multimodal system whose may be by walking, cycling and driving. There are many benefits associated with the multimodal characteristics of road transportation and these benefits contributed to the popularity of road transportation. Also, this multimodal feature of road transportation makes it easy to categorize it into motorized and non motorized mode.

The means of transportation generally be it vehicle, plane or ship can either be regulated or unregulated. In a regulated transportation, the mode of transportation are owned and operated based on government policies, rules and regulation that are formulated and made to be in operation from time to time which are also complemented by international policies, rules and regulations that are enforceable worldwide. Furthermore in a regulated means of transportation, the means of transportation are owned and managed by fleet operators which may be government, corporation or any other legal entities. In addition to government rules and international regulations governing the operation of such means of transportation where applicable, their owners also set their own internal rules and regulations in order to ensure the safety and reliability of the system, render effective and efficient services to the people. Road transportation is the cheapest and most affordable means of transportation that is capable to penetrate every nook and corner of an area. Because of its wide acceptability, cheapness and affordability, it is exposed to various degrees of dangers which people and government are aware but pays little or no attention to curb. Just as road transportation is rehabilitation of roads and construction of new ones and new vehicles are being

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introduced to ply our roads so also there are advances in the field of computing and communication which can be applied to road transportation to monitor its activities and enhance its safety.

One noticeable feature of other systems of transporttation, air and water that makes them safer and secured than road transportation is that they have their peculiar means of location and methodology of exchanging information from the point of departure till they reach their final destination. Therefore, this has been one major deficiency in road transportation which has been impacting negatively on the system. Since there are techniques by which geodetic data of other systems of transportation can be easily got, it is desirable to develop a functionally similar technique for road transportation. This paper is concerned with developing a system that can be adopted to obtain geodetic data of any road.

INTELLIGENT TRANSPORT SYSTEM

Many factors are responsible for the rapid increase in the use of road transport and among these factors are construction and rehabilitation of roads, increased welfare packages, establishment of more industries and transformation of rural areas. These factors have combined together to make possession of a mode of road transportation a necessity to every household. The growth in motorization brought about the need for a system that will assist in navigation, ease congestion, and make road transportation safe and reliable. All these needs and other critical factors have combined together to open a new sector in road transportation called intelligent transport system; I.T.S. for short. ITS are systems that are utilizing synergistic technologies and system engineering concepts to develop and improve transportation systems of all kinds. It encompasses all systems, equipment, devices etc developed or designed for use on the road. Intelligent transportation systems vary in technological design and application. It ranges from basic management systems such as car navigation, traffic light control systems, container management system, variable message signs or speed cameras to monitoring applications such as close circuit television (C.C.T.V.) systems and then to more advanced applications which integrate live data and feedback from a number of other sources, such as parking guidance and information SYSTEM (PG and IS), weather information, bridge devising system and the likes. Additionally, predictive techniques are being developed, to allow advanced modeling and comparison with historical baseline data. Some of the devises and systems that are in use, designed and implemented in I.T.S are described in seriatim subsequently.

Adigun (1994) developed a system of communication to enhance safety by prompt reporting of incidents along the road. The major reason for the development of (Adigun, 1994) was lack of effective and efficient medium by which law enforcement agents can communicate with each other (person to person), the need to integrate the evolving technology of internet with police activities and the need to introduce sanity to our roads. He designed a vehicle based system for reporting and maintaining records of road transportation offenders and other offences which he called national police command and control system. A means by which crimes committed along the road and any other incidence can be reported immediately to the police and by police to his stations was proposed in this study. The system centered on the use of vehicle based communication system for reporting, detecting and preventing crimes generally.

Another device that was developed to enhance safety on the road was (Kramer, 1997). In it a system called automatic road transportation system with radar guidance and precision navigation to aid navigation was proposed. This system was also motivated by the observation of (Castillo and Cochram, 1995) for a system that will make navigation easier, ease road congestion and eliminate breaking of traffic rules and regulation. He consequently identified the scientific requirements for the design of a scientifically based system of navigation that emphasized on the need of in-vehicle equipment to aid communication in road transportation. The use of in-vehicle equipment such as distance monitoring radar, obstacle avoidance radar etc. had been previously suggested by (Chatterjee and Brake, 1981) to assist drivers in communicating with their base station and provide additional safety for users of road transportation but could not be achieved due to the level of technology then. It could be said therefore, that it was against this backdrop that (Kramer, 1997, 1999 and 2001) were developed. The main contribution of this system is the deployment of radar guidance and precision navigation to road transportation. However, (Kramer, 1997) himself pointed out one of the disadvantages of such equipment when he noted that in case of an accident the decision is left for the driver to decide whether he should have noted at which instant to override the automatic or whether it was justified for him to trust it. This means there is a limitation to the reliability and efficiency of this system. Consequently, he identified the need for equipment that will take care of this shortcoming. So in addition, a fully automatic road transportation system which does not need human interaction, maybe except for an emergency brake button and can therefore provide numerous benefits like unmanned automatic transportation of goods, driverless vehicle movement to parking facilities, etc. was proposed by him. This led to (Kramer, 1999) that proposed a system consisting of these 3 basic elements, a central guidance system, a sensor network monitoring all cooperative and non-cooperative road users as well as random obstacles, whose signals are also usable for precise navigation and a sensor system monitoring road conditions and tractions parameters.

An improvement on this system was in (Kramer, 2007). He proposed a system comprising of 3 components as was in (Kramer, 1999, 2001) but the composition of the 3 components were clearly different. The 3 components are

central guidance system, a sensor network monitoring cooperative and non-cooperative road users as well as random obstacles providing also precision navigation and a sensor system monitoring road conditions and traction parameters. The contribution of the system to road transportation is its compatibility with local and global traffic situation and development of a driverless vehicle that their implementation is compatible with the presently existing road traffic.

The intent and purpose of (Kramer, 1999, 2001 and 2007) is the development of an automatic road transport system. In other words, they proposed vehicles with the capability for safe and reliable autonomous operation. Another system developed for use in road transportation is (Ola, 2007). A specific time.

Alert (STA) that is useful for tracking vehicles in road transportation. The primary objective of the system is to provide the means by which stolen vehicles could be traced and tracked. In this system, the GPS provides independent positioning and timing information to the system by capturing, analyzing and distributing such information along with other complementary data for tracking vehicles. The usefulness and relevance of such system had already been clearly stated in (Tanenbaum, 1996) and (Falaki, 2002). This system and other similar ones had assisted the law enforcement and corporate organizations to track missing and stolen vehicles.

There are other devices as in (James, 1992) and (Jun Hu et al., 2008) which have contributed immensely to save motoring and effectiveness of the system but these devices are incapable of conveying the geodetic data of vehicles on request rather they can only access it through another system. Because of this limitation, there is a need to develop the spatial data of roads in road transportation

DISCUSSION ON ROAD TRANSPORTATION AND GEOSPATIAL TECHNOLOGY

The contribution of road transportation towards the economic development and poverty reduction in any nation is immense. That is why it has been generally acknowledged that a nation without a safe road transportation network cannot attract serious and genuine investors and her populace will perpetually be subjected to the grip of poverty.

The provision of roads and transportation facilities are fundamentally important to the development of any nation as well as the well-being of its inhabitants. Therefore, all roads need to be kept safe and monitored always in order to reduce the carnage on the roads. In 1997, the standard number of vehicles to people is put at 12 to 1000. This means that to every 1000 people there must be a minimum of 12 vehicles to convey them from one place to another. Despite the importance and heavy reliance on road transportation, it is extremely difficult to locate where these roads are on the map especially in the developing nations. Though there are maps of these countries showing each town and the road that connect them together but it is not comprehensive enough to describe the actual location of any point on these roads. This inadequacy is because the maps are not digitalized. The total road network in Nigeria for example can be succinctly put at 200,000 km. As it is in both developed and developing nations, this road network is made up of highways and trunk roads that covers the entire 924,000 km^2 which is the entire area covered by Nigeria. It is therefore imperative to device a means by which any point on these roads can be located and the accomplishment of this can only be made realistic by the use of geo spatial technologies.

GIS is a computerized database management system that is used to capture, store, retrieve, analyze and display spatial data or an electronic system of capturing, storing, checking, integrating, manipulating, analyzing and displaying data related to positions on the Earth's surface. Furthermore, spatial data is the conversion of the Earth and its properties to a database that defines location and properties of individual features of interest or duplicating the real world in the computer by collecting or duplicating the real world in an electronic form by collecting information about things and where these things are collected. From these definitions, it is clear that the application of GIS to road transportation is possible and is capable to show the exact location of these roads as precise as they are shown on any map (primary source data) and any object or incident along these roads. There are many GIS software that can be used to serve this purpose and among them are integrated land and water information system popularly called ILWIS, ESRI and Arcview. GPS is a device that shows the exact location of an object in the earth surface. The GPS make use of a receiver to determine the location of an object and among these receivers are Germin, differential GPS and bluetooth GPS. The determination of the exact location of an object on the earth surface is achieved by using the GPS receiver to take down the coordinates in geodetic forms. In other words, this involves taking the longitude and latitude of the location which are thereafter converted to Universal Transversal Mercator (UTM). The GIS software will act upon these data to produce a digitalized version (object).

APPLICATION TO ROAD TRANSPORTATION

Road transportation involves movement on roads. There are different types of roads that provides this mobility and these are highway, trunk and local roads. The highways are constructed and maintained by the central government of each nation. The purpose is to connect the various parts of the nation together. Succinctly, highways are constructed to link the various regional/state headquarters together. Trunk roads are desired to link the various towns in a region or state together. They are normally constructed by each regional or state government

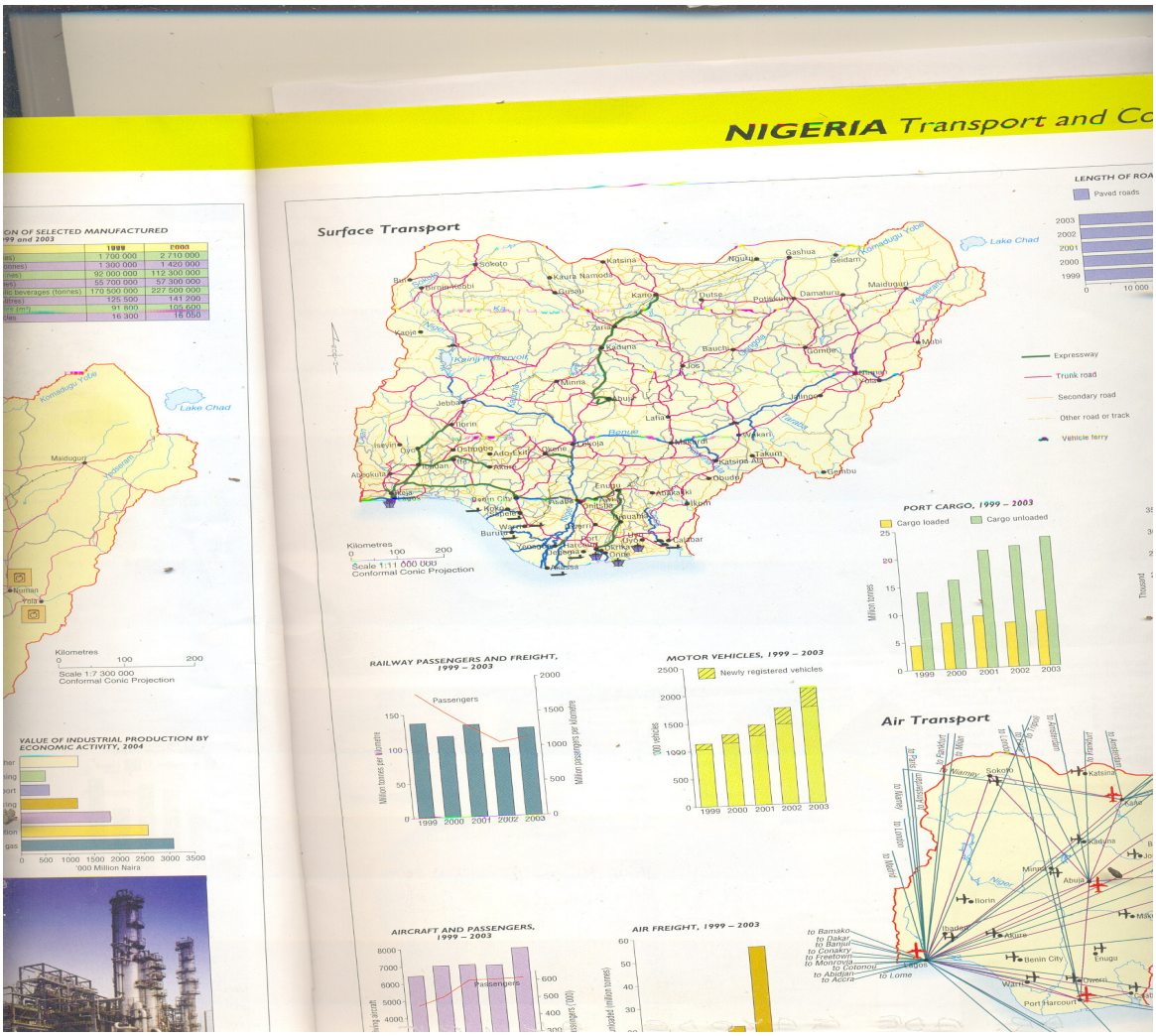

Figure 1. Source Map: Map of Nigeria showing road networks.

as application. In this paper, the road network of Nigeria is considered with emphasis on the highways that is roads that link the capitals of each state together. In Nigeria, there are 36 states and the roads linking the headquarters of these states are the focus of this research. The GIS tools were used to perform the 5 steps of data acquisition, manipulation, pre-processing, management and analysis. The data acquisition entailed the use of the GPS receiver to record the coordinates of these roads. The coordinates are the northings and eastings (in UTM system) which correspond to latitudes and longitudes (Geodetic system). The data were entered into the computer system. Arcview 3.3 software programme was used to generate the digitalized map of Nigeria road networks. The implementation of these procedures applied here and that will work in any type of road anywhere in the world is summarized succinctly in seriatim thus: The first step is to get the coordinates of all the roads linking the various state capitals together. (Figure 1 is a scanned copy of map of Nigeria showing the road network of Nigeria).

The coordinates of the roads linking the state capitals in a (geodetic system) were taking and entered into the computer system.

The second step is the conversion of these coordinates obtained in geodetic system to UTM system. The third major step is geo referencing which is the application of GIS software Arc view to geo-reference. The geodetic data of all the roads linking the headquarters together are as in Table 1. At view 1 in arc view, file menu was chosen and at extension menu image analysis, database access, digitizer, JPEG image support, legend tool X tool extension and spatial analyst were activated and readings were updated by changing feet to meters. Thereafter, table menu was chosen and add submenu was selected, double click on C to pick delimited text then the recording that was saved in C. The design continues by selecting view, clicking on add event theme and at table click on

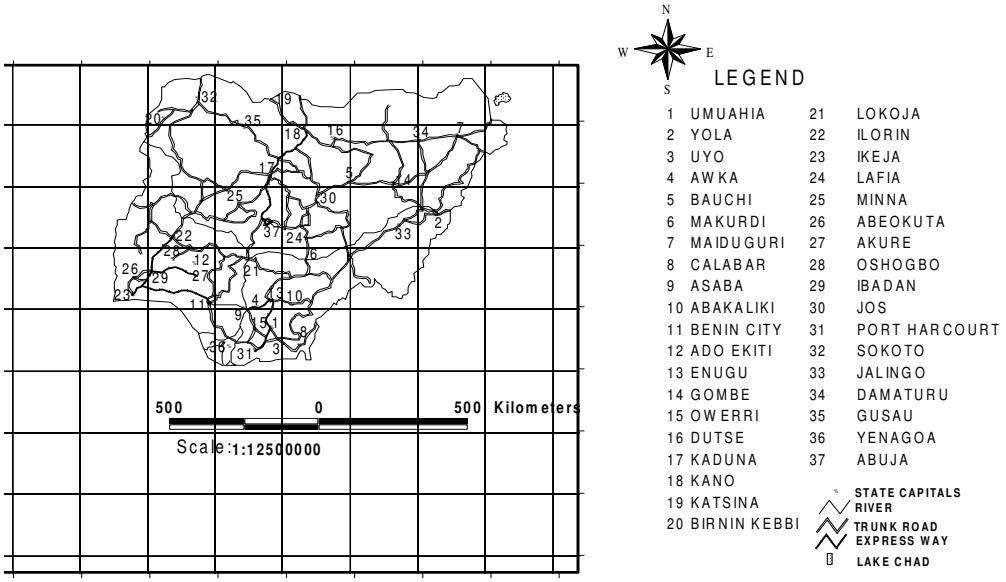

Figure 2. Digitalized map of Nigeria showing road networks.

Table 1. The coordinates of the linking roads in degrees and minutes.

Easting	Northing
5.59	7.47
9.28	12.48
5.02	7.82
6.24	7.49
10.34	9.82
4.96	6.18
7.73	8.56
11.91	13.06
4.98	8.31
6.26	6.72
6.36	8.10
6.44	5.61
7.66	5.19
6.48	7.50
10.29	11.13
5.51	7.01
11.81	9.36
10.55	7.45
11.98	8.51
12.99	7.65
12.45	4.28
8.56	4.61
7.83	6.75
6.61	3.36
8.48	8.55
9.68	6.55
7.16	3.35
7.28	5.21
7.80	4.58
7.43	3.85
9.93	8.86
4.82	6.96
13.04	5.34
8.92	11.36
11.79	11.96
12.20	6.69
9.08	7.96

Table 1. Contd.

the file saved; in X field easting was picked and in Y field northing was picked. The align tool was picked to generate the points of each of the roads.

The fourth step is to digitalize in order to produce the object map and this involve selecting X tools and activate make line from points; double click on C, to name the file.

The above procedures were applied to the scanned copy of the map showing Nigeria road networks to produce a digitalized version which is referred to as object map and is as shown in Figure 2. From this object map, it is possible to:

i.) Locate any point along the roads
ii.) Determine the distance from one point to another
iii.) Give the geodetic data of any point within the area covered.

One of the major problems being faced by the law enforcement agents and vehicle inspection officers (V.I.O.) patrolling these roads is their inability to accurately

ascertain the location of events that happens along the roads. The effect of this is that traffic offenders and other criminals are being arrested by law enforcement agents without the person making the arrest knowing the exact location where the offence is committed. Also, passengers and drivers rely primarily on kilometer board being displayed along the road to determine distance covered and distance left to be covered by the vehicle while driving on the road. The multiplier effect of all these deficiencies is that the roads are unsafe and unreliable for driving. With this application, it will be possible for the appropriate law enforcement agents to establish exact location where any offence is committed and where any event, accident and/or incidence occurred on the roads. Also, drivers and passengers are enabled to know their kilometer coverage at any point along the roads.

Conclusion

The GIS techniques were used to generate a digitalized map of Nigeria highway roads. Consequently, it is possible to determine the location of any object, incident, accident or event along these roads and determine distances between points thereby enhancing efficient monitoring of vehicles along these roads and safe driving.

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