International Journal of Scientific Engineering and Science
Volume 4, Issue 5, pp. 71-76, 2020. ISSN (Online): 2456-7361

Developing a Novel Approach of Data Storage and Retrieval for Online Multimedia GIS Applications using Multimedia in GIS Approach

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Abstract— *This research was aimed at mmbreaking the jinx of non-availability of suitable database for multimedia GIS especially the GIS in multimedia mode. An overview of existing database systems is given. The multimedia data collected included the audio, image, text and video. The audio, image and text after processing were first stored in Cyberlink software, then in online software called tunestotube and finally in YouTube. The video was uploaded directly to YouTube after rigorous processing. The online Relational – Hypermedia database was then created through integration of Codd and Nelsons' models and named as University of Nigeria Relational – Hypermedia database. This database owing to its nature was termed 'super variant' of the database systems developed through this research. The database is highly responsive and amenable to queries. To every query raised, it gave a corresponding answer.*

Keywords— *Database, Super variant, Relational – hypermedia, tunestotube, Youtube.*

I. BACKGROUND TO THE STUDY

Database technology can be said to be one of the fastest growing areas of computer – based information systems. This has been spurred by the increasing amount of data already stored in different forms of databases which may be measured in billions of bytes, and the corresponding financial involvement which undoubtedly is gigantic. Successful organizations owe their successes to their reliance on accurate databases for their hitch free operations.

A database is a computer based data recording and retrieval system whose mandate is to record, store, maintain and retrieve or display information. Database management systems are employed to manage such databases. A database management system (DBMS) is any software system that employs a coded approach in order to store and organize data. By such software applications, data can either be added, deleted, or even updated using structured algorithms and queries.

Types of database management systems. Database management systems are many.

In this discourse nine of them are discussed along with the novel one developed. Panwar (2020) gave the types of databases as eight while Nelson (1965) developed the ninth one. An overview of these is given as follows:

i. Hierarchical databases
ii. Network databases
iii. Relational databases
iv. Object – oriented databases
v. Graph databases
vi. ER model Databases
vii. Document databases
viii. NoSQL databases
ix The Hyperlink Database.

1. *Hierarchical databases:*

This type of database system was developed by IBM in early 1960s. This system is simple but inflexible owing to its parent – child, one to many relationship.

In this system data is stored in a parent – children relationship node, where apart from data, there are also records containing information about their groups of parent/child relationships.

Here data is organized into a tree – like structure where data is stored in the form of a collection of fields with each field containing only one value. The records are linked to each other via links into a parent – children relationship where each child has one parent and a parent can have many children.

Data retrieval has to go through the tree until data sought is found. This database can be accessed and updated rapidly, the disadvantage in that there is no relationship among the children.

2. *Network database:*

This system employs a network structure in order to create a relationship among data elements especially on extensive digital computers. This Network is a variant of the Hierarchical databases, but unlike hierarchical one, a node has relationship with multiple data elements making it more like a cobweb. Here children are termed members and parents are called occupiers with the result that a child can have more than one parent. This data model was designed by Charles Bachman. The databases include integrated Data Store (IDS), Integrated Database Management System (IDMS), Raima Database Manager, among others.

3. *The relational databases*

In this system data is stored in tabular format of rows and columns, while a column represent an attribute, a row represent a data value. The structural Query language [SQL} is used for enacting query on the RDBMS i.e. the relational database management system. Through this SQL one can insert, update, delete and search records. Relational databases

are the most popular and more widely used of all databases. Among the database management system are the Oracle, SQL server, MySQL etc. It has the advantage of being user friendly where a user can use with or without training and database can be modified without having to specify the entire body.

4. The object - oriented Model.

They require object- oriented programming language. Its ability is anchored on the cyclical treatment of consistent data in databases and transient data in executing programs.

Object oriented databases use small recyclable software called objects. These objects are stored in the object oriented database and has two basic elements namely.

(i) Data - Which can include sound, video, text or graphics

(ii) Pre-written instructions telling the computer what to do with the data.

In the early part of 1980s, Object – Oriented Database Management System [OODMS] were developed and they work with OOP languages that is OO object- oriented programming. Like Delphi, Ruby, C^{++}, Java and Python among others.

Disadvantages of this DBMS

(i) Very expensive to develop (ii) unwillingness of users to convert to new or other ones

5. The graph database

These Database Systems employ graph structure to display semantic query as they are NoSQL type. Here data are stored in the form of nodes, edges and properties. In this graph Database, a node represent a data which can be a person, or any other object. This Node is the equivalent to the record in the relational database model. The Edge represents the relationship connecting the nodes, while properties are additional information to the nodes. Examples of these include the Neo4j; Azure cosmos DB, SAP HANA among others.

6. ER model database

The Entity Relationship model resembles the relational model and like the relational model, each row of the table represents an instance of an entity while the fields represents the attributes. The relationship between entities is effected by storing the key (primary) of one entity to be a pointer or using foreign key in the table of another entity. This model was developed by Peter Chen 1976

7. The document database

The Document Databases (Document DB) are NoSQL types where database are stored in the form of documents. The document itself, its relationship between other data elements and its attributes are all in document. Document database store data in a key value form. They have become very popular nowadays owing to their document storage and the NoSQL properties. These also provide faster mechanism for storage, search, and retrieval of information. Popular NoSQL database include Hadoop/Hbase, Cassandra, Hypertable, Map R etc

8. NoSQL databases

NoSQL database does not use predefined schemas, thus they are a good candidate for the rapidly changing development environments. In addition they allow developers to edit the database on the fly with no repercussions. They are classified into five: Column, Document, Graph, key-value, and Object databases. Some of them are Cosmos DB, Arrango DB, Couchbase server, Couch DB, Amazon Document DB etc. (Panwar, 2020)

9 The hyperlink database

Hypertext is digital text in which the reader navigate related information using embedded hyperlinks. Hypermedia connotes hypertext but may not necessarily mean text and could include video, map, drawings, sound and audio among others. Hyperlink Database is a computer – based informatics that allows users unlimited access to information in multiple formats about any object of interest.

Statement of the Problem

A review of literature show the lack of a Database system compatible for multimedia GIS. Jonas 1995 and shiffer 1992 argued that the relational or hierarchical database models are not compatible for the multimedia GIS. Boone (1992) added that the traditional models as shown above do not map well to the hypermedia environment for the following reasons

i. Restrictive semantics of the entities and relationship in these models
ii. Lack of support for structural abstraction. The class of semantic models provides the best fit and it supports constructors for building complex data types (Kim and Lochovsky 1989).

Aims and Objectives

Aim

The aim of the research is to develop a responsive nonlinear system that is compatible to the multimedia GIS for effective storage query, retrieval, analysis and display of online multimedia data elements.

Objectives

i. Acquisition of spatial and attribute data (multimedia data including text, sound, photograph audio and video) of specific locations
ii. Processing of the data using appropriate software package
iii. Integration of amenable database systems to generate one that is compatible to the multimedia data sets
iv. Development of an interactive multimedia web- based system with graphic user interfere (GUI) and GIS module allowing unrestricted access to both spatial and attribute data sets in an easy fashion
v. Design of efficient fast path search algorithms with optimization to find shortest path between any locations (navigation).

II. Review of Literature

Feng and Song (2012) developed a real time method of encoding georeferenced media with mobile terminal, with automatic integration of video, audio and GPS, which supported the real-time transmission using ASF (Advanced Streaming Format). Blat, *et al.* (1994) developed a GIS system with multimedia content for territorial planning i.e. the ParcBIT case, on one hand this used software namely Arc/Info, MapII, ArcViewI and Atlas*Pro and on the other hand Macro Media Director, Photoshop, sound Tools, Premiere, Quick Time etc. Canciani *et al*. (2014) implemented a new GIS enabled map of villa Adriana. This was a very rich

Multimedia guide to the ancient city where a new plan orientated to a new coordinate system was created based on an ortho photo, also the 3D survey was carried out with the aid of photogrammetry to verify and upgrade drawings. This was followed by the creation of the database to store, analyze, share edit and display linked data. This in turn led to the generation of the 3D model of the villa Adriana and finally the multimedia guide, based on a mobile application. This acquired information from the database to show, in reasonable time, during the tour; position of a visitor and what she/he can see around him/her. This was made possible with the aid of AutoCAD and online ArcGIS.

Ayeni *et al.* (2004), designed and implemented a Multimedia GIS for Tourism in Nigeria through the use of a relational database created using ArcView and map, sound, picture data and video elements were hyperlinked into the multimedia GIS database. The other software used to make this possible were; AutoCAD release 14, CAD Overlay, Microsoft Excel, Media Studio Pro 5, and Video Editor among others.

Fajuyigbe *et al.* (2007) implemented an internet based Geographic Information System for Oyo State of Nigeria by the use of ArcView 3.2 where maps created were launched to the net using Web view standard edition which was an Add - in component of ArcView.

Jaegeol *et al.* (2012) designed and implemented Video on Display (VOD) Database system by the use of servlet of Java. Abdulhamid and Gana (2010) developed a Destination Information System for Tourist in Niger State of Nigeria. This was achieved through Java Applet (Net Beans IDE 6.1), HTML, PHP, and JAVA script, while MySQL was used as the back-- end database. This had two MySQL Servers namely MySQL query browser and WAMP5 SERVER in order to be able to compare the efficiency of this system.

Hu (1999) developed an Integrated Multimedia Approach to the Utilization of an Everglades Vegetation Database by developing a robust approach for combining multimedia data with geographic information system in a database which was developed solely for the area.

This database contained text, digital video, digital photographs and audio which describes the features of Everglades plant kingdom, it also contained individual species, and non-native ones, along with animal- plant interaction, degree of hurricane and after fire succession.

Hu and Lancaster, (2000) developed an approach by combining GPS, GIS, digital image processing and multimedia technology for Terrell's Island around Winnebago pools Wisconsin. This rendered a digital database of the vegetation in Arc/Info using field vegetation survey and aerial photo interpretation. This was further linked to a database containing multiplicity of formats: text, photographs and video clips showing the characteristics of the vegetation.

Dauda and Lawali, (2014) employed GPS, GIS, data and Remote sensing for the road network mapping of Gombe metropolis. In the research, satellite imagery, ground survey data and ArcGIS software were used.

Alexander, (2015) used hand held GPS receiver to locate tourism sites and for updating existing digital maps of Cross River State. On - screen digitization was employed to produce the tourism map of the state. Using Arc GIS 10.1 a relational GIS database was created. Ulead video DV X2 and an adapter (fire wire) were used in downloading video clip recorded by the Digital video camera unto a personal computer (PC). Ulead video studio Pro X2 which had the ability to convert recorded sound to wave files, and further converted into AVI file format was used, this also converted photographs into video clips while Microsoft window media player was used to play the video clips.

III. METHODOLOGY

Data Acquisition

The data required for this research are two namely spatial and attribute data. The spatial data is the location. Based one enjoying castings Nothings coordinate values of points of interest. The attributes data included the photograph, video, audio and text information. The spatial data were acquired using the mobile topographer software on an infinite X 572 Cell phone reading to approximately 0.08m of accuracy

The Digital camera was used in collecting the multimedia dataset. The video was a (avi) format, the photo in (jpeg), the audio was in window media audio (.wna) and 3gpp formats the Google map in raster format and text in Microsoft ward (.doc) format

Data Processing

Cyber link Power 2 Go8 was employed in the conversion of sound to wave files, while text and photo / images were converted to video clips using Cyber link Photo Director 5. Video clips obtained using Digital camera were downloaded by using ULEAD video studio into the HP Core i7 personal computer. These Video clips and recorded sound after compression were hyper-linked to appropriate locations using incorporated GIS of the multimedia. Photographs from the Digital camera after conversion to video clips were also hyper-linked on the Google map through the same procedure after thorough processing.

The audio were converted from 3gpp format to mp3 format using movavi video suite. They were again reprocessed using an online software called tunestotube and then uploaded to YouTube along with pictures and text information. The video component after preliminary processing using cyberlink software and movavi were also uploaded to YouTube. All the components were uploaded/ hyperlinked. The flow chart of the Methodology is as shown in the fig. below.

Database Creation

Studies have shown that there has been a general lack of a standard database system in operation for handling multimedia GIS and it has been a subject of argument that the relational or hierarchical database models are incompatible for the multimedia GIS (Jonas 1995, Shiffer. 1992). Boone (1992) added that the traditional models (hierarchical, network, relational) do not fit well to the hypermedia environment for at two reasons:

International Journal of Scientific Engineering and Science
Volume 4, Issue 5, pp. 71-76, 2020. ISSN (Online): 2456-7361

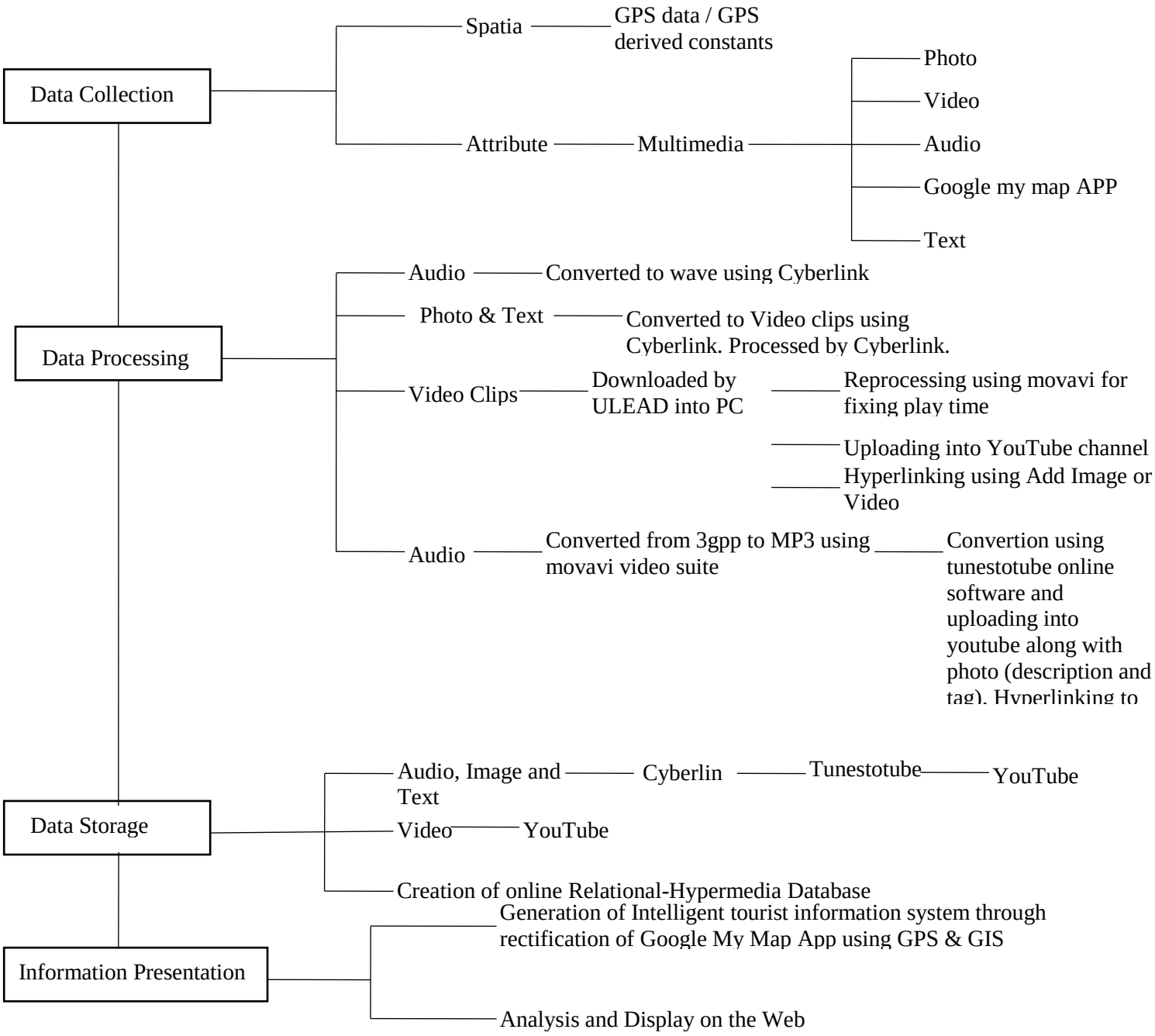

Figure 1: Flow Chart of the Methodology Source: Authors Model

1 Restrictive semantics of the entities and relationships in these models

2 Lack of support for structural abstraction. The class of semantic models probably provides the best fit since it supports constructors for building complex data types (Kim and Lochovsky, 1989).

Codd, (1970) developed the relational database model designed to among others accommodate a growing demand for data, structural independence, and for queries. This database system was based on a mathematical abstraction in which relations are shown as tables.

Nelson, (1965) coined the words hypertext and hypermedia. While Hypertext is digital text in which the reader navigate related information using hyperlinks embedded, Hypermedia is used to connote hypertext but does not necessarily mean text, as it include video, map, drawings, sound and audio among others. Hyperlink database therefore can be said to be a computer – based information system which permits a user to have unlimited access to information in multiple formats about any object of interest.

For this research, the database was developed by integrating the Relational and Hypermedia systems developed by Codd (1970) and Nelson (1965) respectively. In a relational

database system, data are stored in tables. Tables in the system contains rows (records) and columns (fields) and data in the system are accessed through the SQL (Structured Query Language). On the other hand, the hypermedia database system is a computer information retrieval system allowing a user to use and work on audio – visual recordings, text, drawings as well as pictures of a stored subject. According to Shiffer, (1992) a responsive multimedia system utilizes the abstractions of interactivity and nonlinear text to organize and display photographs, text, sound and video clips. Existing database structures namely those of relational and hierarchal databases among others are not suitable for multimedia data sets. Therefore, a nonlinear text database system is more appropriate for organizing the multimedia data into the so-called "multimedia database." Usually hypertext system is comprised of hypertext and hyperlinks (Nielsen, 1990). Each hypertext node has pointers, called hyperlinks, the function of which is to redirect any reader to other nodes.

Hence, using relational database system for Multimedia GIS as shown by Ayeni *et al.*, 2003, 2004; Ayeni, 2006; John, 2015 may not acceptable considering the two definitions and principles of operation of the database systems above. In addition, Jonas (1995), was of the view that the database model for multimedia GIS was yet to bet defined. Therefore, this research taking a clue from the PhD thesis developed a combination of the two approaches as University of Nigeria Relational-Hypermedia Database System (UNRHDBS). The integration of Codd – Nelson Models would break the jinx of non-availability of a suitable database system for multimedia GIS.

IV. Results

1. The spatial and attribute data of points of interest [Pols] were acquired using a combination of mobile topographer on an Infinix X572 cell phone and a digital camera The data acquired were processed using a combination of software packages and hyperlinked to their respective locations
2. The University of Nigeria Relational - Hypermedia database system was developed by integrating two database systems namely the Relational Database System and the Hypermedia System.
3. A web – based responsive multimedia system with interactive graphic interface [GUI} that allows easy and quick communication to the internet for spatial and multimedia data was developed using the incorporated GIS of the multimedia, YouTube and other online software.
4. Using the incorporated GIS of the multimedia queries were raised and corresponding answers were generated giving information such as fastest shortest path finding among other

Discussion of Results

The database is more digital format and passes through various channels, namely the Computer hard disk, Cyberlink, Movavi, tunestotube (for only audio), YouTube and finally Google My Map App. The order of entry is in row and column i.e. S/N, location name, coordinates, Photograph, text, audio and video as in relational database but with the hyperlink function for the hypertext components thus justifying the name (see Appendix 1)

On the Google Map My App, the digital photograph/picture can be uploaded using the upload function on the App, to add the text, the edit function is invoked and the text is added; then saved.

To load the video data, they were first uploaded into an account in YouTube dedicated for such purpose or a multipurpose one. The Audio were first converted from their 3gpp format into the MP3 which is compatible to the Google My Map App using the Movavi video suite. The same software was used to time the audio and video components for reasonable play time. When so converted, they are further processed using an online software called tunestotube. Here the audio and picture are uploaded with the tittle, description and tag. After processing, they are automatically uploaded into the YouTube channel earlier mentioned.

For the hyperlinking of the Audio and Video, a click is made on an icon in the Google My Map App choose an image or video,, a dialog box opens as shown below in fig 4.2, a click is made on YouTube URL or more as the case may be with a drop down menu giving other options, the copy link is chosen.

You either play the Audio or video to be sure of it or right click on it while the copy link is shown, this is copied and pasted on the window on the Google My Map APP; they are finally saved.

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