A 3-D MODEL OF AN INSTITUTIONAL LOCATION NAVIGATION SYSTEM (NAVILOC) (A CASE STUDY OF COVENANT UNIVERSITY)

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ABSTRACT

Covenant University location navigation system (CU Naviloc) built on the Android platform is a mobile based system which can be easily accessed from an android mobile device across any location, downloadable on Google play store and deployable anywhere in the world. In this study,Computer-aided design as well as building Information modelling (CAD/BIM) system applications were introduced to the simulation of Covenant University, a smart and compact campus whose edifice elaborates the need for the development of a three dimensional (3D) virtual model of locations as an advancement over the existing 2D model representation of maps on the Google map and Google Earth platform. Therefore, this research work outlays the development of three dimensional models (CU NAViLoc Model) for details of information at Covenant University as well as the requirements for its development and implementation for cooperate representation of the institution. A three dimensional map of CU was packaged into a location navigation system and was implemented using Unreal Engine, Trimble SketchUp and Revit to effect a user friendly, smarter and multi-dimensional viewable user interface. CU Naviloc explore the advantage of the rich benefits of building information models and geographic information systems to build a free-roam navigator, based on a well-updated model of Covenant University location map. The benefits of this system is not limited to 3D capability, real time similarity, portability, no downtime on access, and progressive scalability with zero or little loss of data. The usage of the CU Naviloc system requires free download and installation of the app and internet presence.

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1. INTRODUCTION

Covenant University is a private Christian University founded by Bishop David Oyedepo with a landmass of over 7,000 hectare hosting over 10, 000 housing units with about 13, 000 people residing at Covenant University campus. The University was commissioned in October 21, 2002 [1]. The proportioned land mass of the University, which has capacity for inclusion of over two hundred separate building structures and a very complex road network.

The needs for 3D city models are growing and expanding rapidly in a variety of fields. In a steady shift from traditional 2D-Geographic Information System (GIS) toward 3D-GIS, a great amount of accurate 3D city models have become necessary within a short period of time and made available widely to free market [2],[3]. Yet, the increasing proportion of people living in towns and cities has caused expansion of urban areas, with recent surveys suggesting that urbanization is increasing worldwide. This occurrence fuels the need for the development of urban maps not just in the two dimensional (x, y) plane but also introducing the z factor which necessitates the need to implement three dimensional (x, y, z) space [4].

Computer-aided design (CAD) in combination with Building Information Model (BIM) systems have been phenomenal in the fields of Architecture for effective development of building locations. In recent times, there arises the need for these CAD/BIM systems to support even wider locations than mere single building locations.

Autodesk [5], define BIM systems as essentially the interception between two critical ideas:

- Recording of critical design information in digital form makes it easier to update and share and more valuable to the firms creating and using it.

- Creating real-time, consistent relationships between digital design data—with innovative parametric building modeling technology—can save significant amounts of time and money and increase project productivity and quality.

CAD systems are rather more subtle; it is a software and hardware package which utilizes interactive computer graphics to assist in the creation, modification, presentation and analysis of designs [6]. This definition brings to light, the characteristic feature of CAD as software packages designed to aid manual design without changing the design process.

A conclusion can be safely made that the extension of three dimensional models to cover various cities requires that BIM systems be fully incorporated with CAD systems. However, a platform for the acquisition and assurance of data is required.

2. DATA ACQUISITION

The design process of the CU Naviloc model entailed data acquisition from multiple sources complementing each other in the detailed description of the Covenant University map. These data components inherently describe the geographic and building information systems by providing details of such building which includes building data components, road networks,

partitioning, passages, walk ways and land topology. Figure 1 depicts the data acquisition pipeline of this work, which includes the instance of separating the data collected and collated into both primary and secondary data. Developing a good BIM for Covenant University is essential for the correct virtual simulation of the Covenant University model. Therefore, this section presents the various sites of data acquisition sourced for the development of the CU Naviloc project.
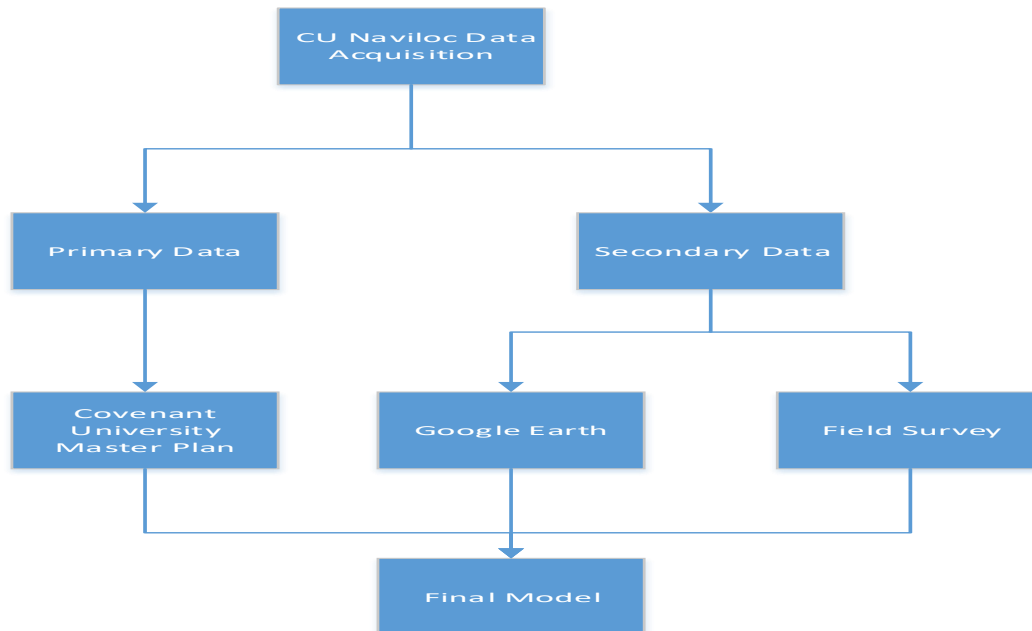

Figure 1 Chart describing processes of data acquisition towards development of the CU   Naviloc model

2.1. Covenant University Master Plan

A master plan of a site is the orderly planning of the system's future managements. It is the initial step before the development and implementation of the building process [7]. It is a thorough and comprehensive plan of action that gives an overall guidance.

The Covenant University master plan was acquired following the due process from the Department of Architecture, Covenant University in January 2016. The master plan acquired was well featured with much details pertaining to urban management and it consist of building distributions and major land marks, road networks, walk ways and partitioning. This was a huge advancement over the situation from the first draft of the same plan obtained from Covenant University Physical Planning Department (PPD) in October 2015.

The master plan (blueprint) was delivered as an electronic CAD file for better efficiency on a computer. CAD files are electronic Computer Aided Design master plan of buildings. The CAD files were provided in AutoCAD drawing format (.dwg).This format works best in AutoCAD and its other technology's modelling environment. Nonetheless, it was directly imported into our Autodesk Revit toolkit. Revit is an architectural development software/ tool used by architects to develop building information systems, road network, and various kinds of aesthetics. In other words, it is designed to develop and design master plans [8].

2.2. Google Map/ Google Earth

The Google map/ google earth application platform provided solution to the problem of out-dated university master plan collected from the architectural department. Google maps is a

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web-based mapping software that allows users to see any part of the world in different views, specific pictures such as road map or satellite view.whereas, Google earth is a three dimensional mapping software that allows for the identification of urban areas, road networks and other smaller within a captured armlets, villages, towns or cities. Such locations even include buildings. When viewing the dynamic nature of Google maps, it gives the idea of some magical touch behind the scenes, in which web design tools such as Hypertext Mark-up language (HTML) and Cascading Style Sheet (CSS), to mention but a few were deployed to deliver. [9].

To be able to properly situate the need for a robust android mobile app which was developed in this work, some limitations of Google map is worth mentioning, and are listed below.

- Information provided by the Google Maps API for some locations may be inaccurate or out-of-date. Walking and cycling directions, in particular, may suggest routes that are missing sidewalks, pedestrian paths or cycling paths.

- Depending on the country and location of interest, some of the entire buildings are blurred out in street view, in the satellite view, certain areas may be displayed using older imagery or blurred out altogether (This feature has however been improved for corporate areas like Covenant University).

- Images used on Google maps Street view are sometimes inappropriate. Photographs taken for the Street View feature may show people in compromising positions that would be inappropriate for the general public.

Google Earth is an existing system used for 3D virtualization of geographic areas. But, it suffers a limitation that this research work aims to address. The Google Earth platform as described only features correct 3D virtualizations of popular cities, roads and building structures. It provides impressive detail of this locations and captured their satellite image with very high resolution, but lacks the ability to provide accurate 3D representations of local and rural areas which in this case- lots of Nigerian hamlets, villages, towns and even some cities are included. The three dimensional representation of this locations are described as two dimensional pictures with three dimensional descriptions; it is not sufficient to give 3D terrain views of the locations. These images are not downloadable, but zoom-able and expandable [10].

Since Covenant University is the case study of this research work, the Google map platform was utilized to provide 2D descriptions of positions not represented in the masterplan. Moreover, a rigorous and in depth field work was incorporated into Google Earth to provide an accurate three dimensional representations of the smart campus, Covenant University.

3. METHODS
This session describes briefly the various tools used in this work.

3.1. Sketchup
SketchUp, formally Google SketchUp which is currently owned by Trimble Navigation, a mapping, surveying, and navigation company is a three Dimensional (3D) modelling computer program that makes possible the creation, viewing and manipulation of 3D objects [11].

It is available for both Windows and Mac operating systems; it looks and works about the same way on both systems. There is also SketchUp 3D warehouse where users share their

designs, and can be downloaded and used by anyone. SketchUp Pro can export models to many other professional grade 3D software packages such as Blender, AutoDesk products – Revit, AutoCAD and so on [12]. Everything in SketchUp is made up of one of two kinds of features, Edges and Facesforms the basic building blocks of every model ever made using SketchUp. Collectively, the edges and faces in models are called Geometry. Other modelling programs like Blender may have other kinds of geometry, but SketchUp is pretty simple because there is less to keep track of [13].

3.2. Autodesk Revit

Revit is architectural development software used by architects to develop building information systems, road network, and various kinds of aesthetics. In other words, it is designed to craft master plans.

3.3. Simulation Tool

Game simulation tool refer to game engine necessitated by the introduction of CAD systems, BIM systems and 3D Urban mapping into the implementation of geographic information systems (GIS) on a three dimensional game simulation of a certain geographical area.

Game Engines refer to a set of tools that help the developers to create games a lot faster and easier, using commands that used to require a lot of coding through plug-in or asset provider of the game engine. Game engines are utilized by developers to create simulations, games and 3D terrain visualization of Geographic information system (GIS) data for mobile devices, personal computers and consoles. 3D terrain visualization is a technique used to visualize terrain information from GIS data [14].

The selection of process of the Game simulation software engaged in the CU Naviloc project was processed based on various factors. These factors include:

- Learning curve

- 3D capabilities

- Modeling capacity

- Rendering capacity

This criterion was used to deploy Unreal Engine, which is considered to be best suited for the project. This recommendation was based on efficiency and clarity rather than preference.

3.2. Unreal Engine

Unreal engine is the game engine platform selected for the development of the CU NAViLoc system. It is dynamic open source software which became freely downloadable / accessible in March, 2015. Unreal engine will be used as it is better suited than unity in terms of broader 3d functionalities, modelling and rendering capabilities. For the purpose of the modelling of CU NAViLoc system, unreal engine 4.10 was downloaded in February 2016 and deployed for the project development. The development of the CU NAViLoc system following the designed methods labelled earlier was adhered to sequentially. This implies that the game simulation of CU NAViLoc system was dependent on the results of the previous phases of CU modelling.

Unreal engine is composed of an editor, which is configured as the viewport which can be used to develop, edit or delete a model. Due to the complexity of the unreal engine and other professionals tool for architectural model developments, a more subtle and precise tool was utilized. This tool is revit and as earlier described, the result from revit is a three dimensional (3d) model of CU as developed from the CU master plan. Unreal engine editor or unreal

editor is used for the actual game simulation of the cu NAViLoc model. The CU master plan is essential to its provision of a featured architectural plan of the institution. Thus, it became very important and was the first prerequisite in the development of the 3D CU NAViLoc model. The CU master plan was tested against the data collected from Google maps and Google Earth to ensure data integrity with regards to building boundaries and the correctness of the road networks.

4. CU NAVILOC SYSTEM

The CU NAViLoc model was basically designed to resolve the problem of lack of accurate 3D model of Covenant University. However, attempts were made to extend the simulation of even wider areas. Figure 2 is a typical outlook of field data plus google map images after merging; this was then incorporated into the Master plan. The game simulator makes it possible for user to navigate into rooms, passages, staircases, walkways, lobbies and corridors within the buildings.

Figure 2 CU halls of residence and Senate building field images embedded into CU Masterplan blueprints and google maps exported to revit, compressed and designed by unreal engine.
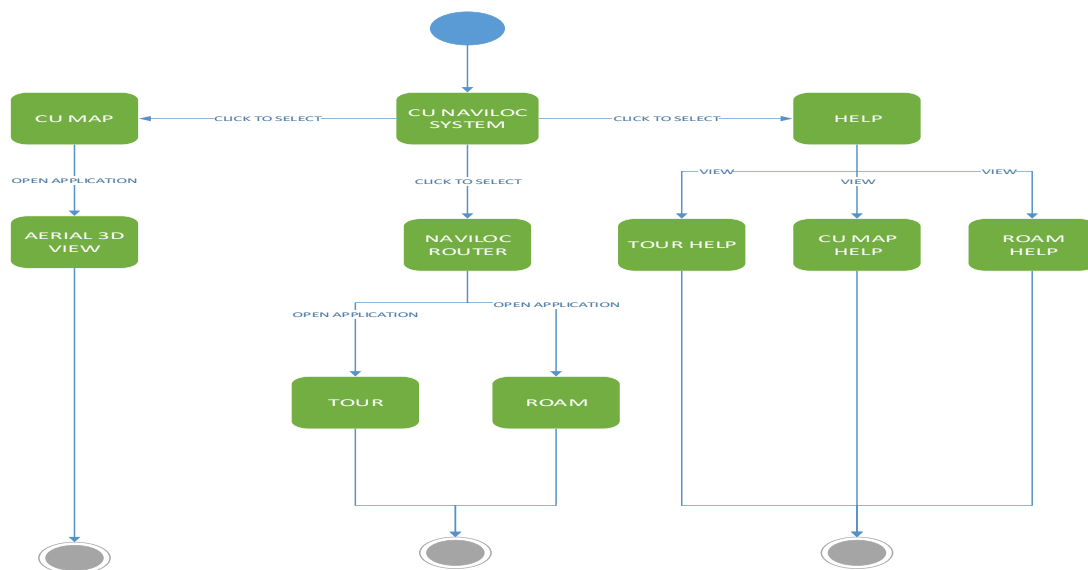
Figure 3 Combined Activity diagram and Functional Decomposition diagram of CU NAViLoc System

All the interfaces within CU NAViLoc system was represented in a combined activity and decomposition diagram in figure 3, the combined activity flow and the top-down functional decomposition of the system and most importantly exposes the system's structure in a simple diagram. The objective of this Functional Decomposition is to reveal the NAViLoc system step by step, beginning with the main/ functional interphase of the system, continuing with the interim levels down to the elementary function level. While activity graphically represents the performance of actions or sub activities, transactions that are triggered by the completion of an action or sub actions is revealed. It is a means of describing the workflow of activities

4.1. System Interface and Modules

The purpose of this section is to discuss the modules, its sub modules and interfaces that are reflected in CU NAViLoc System. The system is built to allow seamless integration of the various modules required for effective utilization of the software. After download and installation of NAViLoc app, smartly clicking on any part of the app icon will link the user to the home the page tagged 'connect'. Figure 4 is the diagram of CU NAViLoc model logo and icon as designed in this work.

Figure 4 CU NAViLoc Model

4.1.1. Connect

This introductory page is the first page displayed to the user, it shows the Connect page and displays option to user to launch fully into the application, either using an account or anonymously.

Using the account option to Connect to the Interface provides the option of connecting to Google play store for consistent in-app action. The most important functionality of the account option is the recognition of the user utilizing the system as well as providing user specific data. These User specific data such as locations learnt, tutorials studied, achievements and various other service content are therefore backed up using Google play game service. This is very efficient as it allows for seamless transfer of operations from one mobile device to another while retaining user data. Whereas using the anonymous option proceeds into the application directly providing slightly reduced functionality. In this case, user specific data is stored locally on the device. This is essential for users going completely offline; however, it poses a challenge of efficient transfer of operations when moving to another mobile device.

4.1.2. Home Page

This is the next Interface after the Connect Interface. It displays the products present in the application. It contains the following modules: Product One (NAViLoc Model), Product Two (CU Naviloc Router) and Help

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4.1.2.1. Product One (NAVILOC Model)

Product one, also known as the Covenant University Naviloc Model is one of the two products of the Covenant University Naviloc project. This model is a module presented in a three dimensional view, It contains all the layers of Geographical Information system (GIS) required as a functional navigable and rotatable model. It includes BIM data, road networks and other spatial data on a completely span enabled interface. CU NAViLoc model module featured the 3D GIS model and a linking interface to the CU Naviloc Router.

4.1.2.2. Product Two (CU NAVILOC Router)

The router identifies and links users to various locations. A good example is Peter, Esther, Mary, Paul and John are male and female halls of residence designated to regular undergraduate fresher, their building information model (BIM) has been designed to be essentially similar and has a path easily links one to the other.

Other male and female halls of residence designated to other undergraduate regular, part-time, graduating, spill over and post graduate students halls are routed/ linked together. This includes Joseph, Daniel, Lydia, Deborah, Dorcas and PG halls. Other building that are linked includes College of Science and Technology (CST), Petroleum and Chemical Engineering, Diamond Bank, Mechanical Engineering, Zenith bank, Animal house, Wave research centre, Automobile workshop, Cafeteria1, Cafeteria2, Centre for Learning Resources (library), Senate, CUCRID, Africa Leadership Development centre (ALDC), CU Guest house, EIE, Mechanical and Civil Engineering block, Centre for Entrepreneur Development Studies (CEDS), College of Business and Social Sciences (CBS), Chapel, Lecture Theatre, Medical Centre, Sports complex. Also, residential complexes and estates that includes; Suits, Old Professors lodge, senior staff quarters, New estate, PG quarters and Mandate estate.

Use case modelling was used to perform requirements analysis in order to understand the core functionalities and usage scenarios associated with the identified requirements. A Use case diagram simply looks at the system from the user's point of view. The system is treated as a black box and one solely identifies what the system is used for. Figure 5 distinctly illustrates that there is only one actor having access to three usable operations which subsequently takes such user to their desired relevant subsystems in the system, for instance, the tour and roam sub systems when router menu is expanded, the help, FAQ and documentation subsystems when help menu is accesses, and the map and aerial view
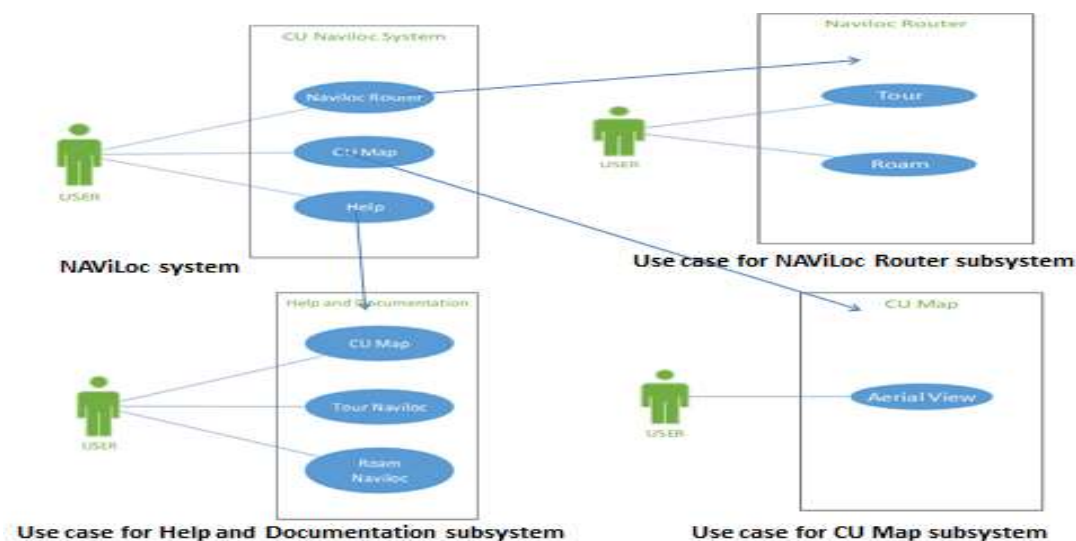

Figure 5 Covenant University NAViLoc System User in relationship with her subsystems (A Use Case Model)

5. DISCUSSIONS

5.1. System Requirements

A requirement is simply a statement of what the system must do or what characteristics it needs to have. The requirements of CU Naviloc are divided into the functional requirement, which defines what the system is doing and the non-functional requirements. This detailed the characteristics the system possesses.

5.1.1. Functional Requirements

CU NAViLoc system enable users to select access to synchronise user specific data with Google Play Games services and permits them access to a separate CU model utilized in the NAViLoc development. Users have access to full utilization of the interactive CU navigation system.

5.1.2. Non-Functional Requirements

Aesthetic Requirements refers to the user interface's design, feel and look. The CU NAViLoc system should be auto installed on the CU branded tablets which is given to every student on completion of registration at 100Level. Interactive options such as icons and buttons are clearly visible to all users, it is compatible across various android devices and working on almost any android-enabled device.

5.2. Usability Requirements

This refers to general usability and learning curve. Thus, it is recommended that CU NAViLoc should present clear usage and ergonomics terms (human/computer interaction), this includes Convenience of use and minimal learning curve.

5.3. Portability Requirements

This refers to the level of program distribution which mandates CU NAViLoc allow user access into multiple devices on a single Google play service account.

6. RECOMMENDATION

Multiple problems ensued in the usage of the digital University master plan provided. This bottleneck ranged from master plan problems, obsolete/ outdated information and insufficient information or building incompleteness to further describe elementary details of the building such as doors, windows, roof pavements and so on. Suggested solution includes; data acquisition from Bing map and Google map, field work development of building information models, proper management of the CU NAViLoc model for inclusion of newer structures, updates on the existing visual graphics and development of a full scale Covenant University Navigation system.

7. CONCLUSIONS

The continuous development of Covenant University has featured the provision of buildings complexes, educational facilities, equipment, furniture, roads, water, electricity, healthcare facilities, and accommodation for faculty, Staff and Students. Primary and secondary schools, worship centre for instance the largest church auditorium in the world with 50,000 sitting capacity… as owned by the same founder of CU and is situated right in d same compound, but academic area is clearly demarcated from the church area.

Various systems have been developed to represents the geographical information systems, some of which were; Google map, Google earth and Bing maps. However, these systems suffer some graphical limitations.

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CU Naviloc model is implemented to cater for the limitations of these popular and elaborate systems by providing an accurate three dimensional plan of Covenant University for better identification, traversing and location of buildings and other infrastructures within the campus are embedded in the geographic information system.

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