3D Graphics Visualization for Interactive Mobile Users Navigation

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Abstract: - 3D map visual navigation comes into being as a result of the drawbacks in two-dimensional map-exhibit navigation approaches, which are the most commonly available. The information provided for user in 2D are mostly limited with insufficient presentation and lack of interaction. However, applying 3D techniques surely yield realistic navigation fields. At first glance, it may seem like dealing with 3D map in mobile devices for navigation only present a single particular context (that is user's location). This initial perception fails to take into account other context like visualization, navigation and interactive technological capabilities. Thus, previous attempts at implementing realistic solutions to the visualization of complex 3D scene in mobile devices' interactivity of more than two user's navigation within a scene at the same time were faced with so many obstacles, which unfortunately were left unsolved, despite the enormous ongoing research. This paper aimed at providing solutions to the functional mobile 3D visual navigation system, in particular, one in which mobile devices' users will navigate within an environment and interact among themselves while tracking their position in real-time. The solutions will be provided through implementing an efficient, scalable dynamic entity navigation solution by means of Bi-A* pathfinding algorithm. As a result, a 3D model of a real place in a mobile device will be produced, for user's navigation which will makes it easier to perceive proportions, distances, and recognize landmarks, at the same time interacting with other users.

Key-Words: - 3D Model, 3D map, 3D walk-space, 3D Visualization, 3D Navigation, Bi-A* Pathfinding

1 Introduction

The main goal of using most of the mobile devices is for voice communications, however, upon technological advancement, it becomes more useful in many more ways. Among these ways is mobile 3D visual navigation system. 3D visual navigation comes in to being as a result of the drawbacks in conventional navigation and tour planning in two-dimensional map-exhibit approach, which are the most commonly available. The information provided for user in 2D are mostly limited with insufficient presentation, and lack of interaction. However, applying 3D techniques surely will yield realistic visualizations [1, 2] into navigation fields and more convenient using mobile device [3].

What's now called a smart mobile, Smartphone or pocket PC was once called a PDA it was a Personal Digital Assistant and comes from Psion's first attempt in 1984. Thus, Mobile devices have made undreamed progress in enhanced input, computing power, memory, storage, and equipped with graphical hardware for function of displaying. Moreover, combined with an increasing wireless networking capabilities and Global Positioning System (GPS) receiver, the mobile devices offers an opportunity to interact with a map display showing the current location and orientation, A "mobile 3D map" is expected to be at least electronic, navigable interactive and real-time rendered, running on a PDA or smart phone. There are other related systems, which may claim to be 3D maps, but where the representation of the environment is restricted or has no 3D components at all [4]. For example, car navigation systems commonly support perspective 2D projection, which creates an illusion of three dimensionality through the perspective view, while the actual data is purely two-dimensional. Mobile systems are expected to be physically small, to fit in the pocket, and independent of external power sources. In this sense, a device embedded permanently in a car is therefore not considered mobile [5].

At first glance, it may seem like dealing with 3D map in mobile devices for navigation only present a single particular context (that is user's location). This initial perception fails to take into account other context, like visualization, and intera-ctivity capabilities. However, there were so many pr evious attempts at providing reliable interactivity in 3D mobile navigation system; unfortunately, there are still faced many obstacles, which were left unsolved. This paper imperative thought is to solve the problems of 3D visualization for mobile user navigation and the interactivity among users. It will

be achieved with 3D model, suited for mobile devices with users' realistic perception.
The remaining part of this paper is organized as follows; Section 2 discusses about related work, and Section 3 provide the system structure, and Section 4 discusses the proposed architectural framework of this study, while Section 5 described the modelling and section 6 is the pre-processing while section 7 discuss on Runtime processing and section 8 describe the result and the paper closed with conclusion in Section 10.

2. Related work

Mobile devices with 3D map model allow human being (the user) to understand a new world by using the computed path. The main interaction is between the mobile device and the users. The development of mobile 3D applications was long hindered by the lack of efficient mobile platforms, but even more by the lack of 3D rendering interfaces. Modern Graphics processing unit (GPU) perform floating-point calculations much faster than most CPUs due to their highly parallel structure which makes them more effective than general-purpose CPU [6, 7, 8, 9, 10, 11, 12, 13], and found its way into various fields. However, mobile devices have developed to the point where direct 3D rendering at interactive rates is feasible for viewing 3D models.

The problems within visualization come from viewing scene. Kamada and Kawai (1988) consider the direction as a good point of view if it minimizes the number of degenerate images are an image where more than one edges belong to the same straight line [14]. In our design this consideration was adopted. However, Colin (1988) has proposed a method for direct approximate viewpoint calculation, which was initially developed for scene modeled by octress [15], equally this paper have adopted the implementation in order ascertain the appropriate viewpoint of the entire environment.

Early work on visual navigation started by Herman, et al. (2000) survey on graph visualization and navigation techniques [16], as used in information visualization which has been adopted in their work. While, Raposo et al. (1997) performed the early experiment which visualized 3D vector graphics, using small VRML animations and other multimedia on mobile data terminals so that it will be transmitted over GSM network [17]. Brachtl et al. (2001) established an approach on 3D modelling techniques in which a full 3D model is created to generate the illusion of movement in 3D space [18], in our design only the potential view set of the scene are to be rendered for navigation. This will ensure fast rendering speed [19, 20, 21, 22].

Navigation tools can be classified as being egocentric (moving a viewpoint through the world) or exocentric (moving the world in front of a viewpoint) [23]. These attribute were also classified in terms of general movement (exploratory), targeted movement, specified coordinate movement and specified trajectory movement. The main idea is to provide visual feedback of the user position [24, 25]. The simplest feedback scheme is to permanently display the 3D coordinate position of the user. This solution is not of great help especially because the position only has a meaning if the user already has an in-depth knowledge of the environment. More elaborated solutions are based on the display of a global simplified view of the world added in the user's field of view [26]. Hence, our design goes aligned with this idea. A* pathfinding expands node with the smallest possible lowest cost to navigate to the target, consequently, Cazenave presents three methods and the associated data structures used to find the best open node [27]. The first method is using a list of open nodes (Maintaining a list). The second method is widely used and implements the open list as a priority queue (Maintaining a priority queue). The third method is faster than the two others and uses an array of stacks (Maintaining an array of stacks), However, we adopt the third method in our implementation of Bi-A* pathfinding to ensure the vital interactive mobile user navigation

3. Overview of the System Structure

The system structure present the 3D mobile user navigation resources and activities in a 3D space, which encompass of: Satellites (GPS signal source), inter-connection of GPS receivers 'node and the links between the nodes as the client part, and the servers side that host the 3D model as shown in Fig 1. The Global Positioning System (GPS) is a satellite-based radio-navigation system, which provides specially coded satellite signals that can be processed in a GPS receiver, enabling the receiver to compute position, velocity and time [28]. The system utilizes the concept of one-way time of arrival ranging. Satellite transmissions are referenced to highly accurate atomic frequency standards onboard the satellites, it are in synchronism with a GPS time base. There are three major components of GPS system: The space segment, control segment and the user segment. The space segment consists of the GPS satellites, which transmit signals on two phase modulated frequencies. GPS satellite are 24 (32 satellites are now in orbit) distributed in 6 equally spaced circular orbital planes with an inclination of 55^0 (relative to the equator) and an approximate radio of 22,200 kilometers [28, 29]. The control/monitoring segment monitors the health and status of the satellites, it includes: 1 master control, 6 monitor stations and 4 ground antennas spread all over the globe [30]. The master control station, located at Colorado Springs collects the tracking data of the monitoring stations and calculates the satellite's orbit and clock parameters using a Kalman estimator. The user segment simply stands for the total user community. The user will typically observe and record the transmissions of several satellites and will apply solution algorithms to obtain position, velocity, and time.

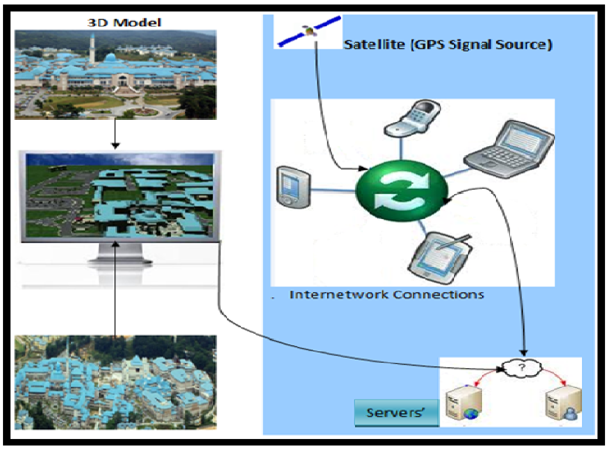

Fig. 1, Structure of the System

The inter-connection of GPS receivers' device at different node and the links between the nodes in the client part; hence the servers' side host the 3D model. As a result, the system is based on client/server architecture and design under wireless remote rendering of the 3D model on low bandwidth networks consideration, particularly considering using GPRS to transmit the GPS data since most of the available mobile devices these days are GPRS enabled.

The servers' are interacting together at the server processing section mutually as shown in Fig 1. Client's requests are processed at the servers' side and the feedback generated is send back to the clients.

4. Architectural Framework

The architectural framework as shown in Fig 2, is adopted from [24] with some modification of a few processes in visualization application processes, and addition of a number of processes in 3D workspace processing. The framework is divided into 3 layers: visualization application, 3D workspace processing and users interaction, thus the user interaction is the implementation whole processes. Although certain processes were undergone in the pre-processing stage while others in runtime processing stage.

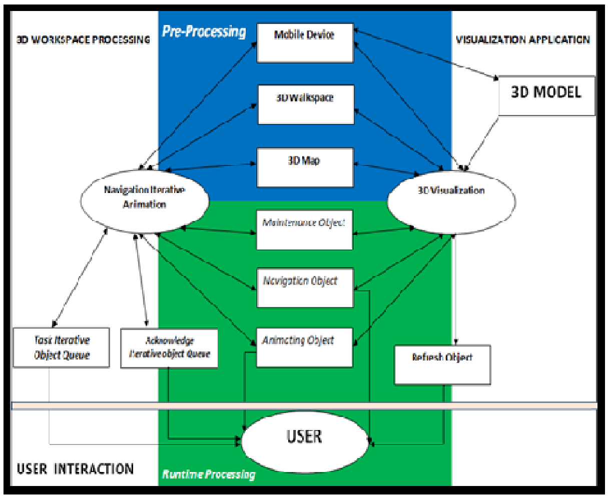

Fig. 2, Architechtural framework

The 3D workspace processing layer describes the main structure of controlled processes in the 3D engine for visualization application of the 3D visualization. Moreover, within the 3D visualization application there are other sub-processes such as the Navigation object, Maintenance object, and Animation object, meant to provide prompt channel in the 3D walk space, using the 3D map of 3D workspace. There also other sub-processes like, Iterative animation, Queue and Acknowledge Iterative Object Queue which interact with the main processes.

5. Modelling

This paper uses 3D polygonal model for the modelling of the scene. In computer graphics the most popular method for representing an object is the polygon mesh model [31]. Object can be represented in the list of points in three dimensional spaces. This is done by representing the surface of an object as a set of connected planar polygons where each polygon is a list of points and consists of a structure of vertices [32]. Thus, polygonal surface approximation is an essential preprocessing step in applications such as scientific visualization [33, 34], digital terrain modelling [35] and 3D model-based video coding [36]. Polygon mesh representation is formally called a boundary representation or B rep because it is a geometric and topological description of the boundary or surface of the object.

5.1 Designing the 3D Model

Modelling complex 3D structures like IIUM Gombak Campus will lead to serious repercussions in modelling cost, storage and rendering cost and quality. The IIUM Gombak campus is nestled in a valley in the rustic district of Gombak, a suburb of the capital city of Kuala Lumpur. It covers 700 acres, (2.8 km²) in terms of landmass, with elegant Islamic-style buildings surrounded by green-forested limestone hills, The campus houses all the facilities that a modern community needs, including a mosque, sports complexes, library, clinic, banks, post office, restaurants, bookshops and grocery stores.

The design of the 3D model was carried out through the following stages: 1) Preparation. 2) Using the reference descriptions (Image or video or sketches). 3) Initial Modelling. 4) Refinement of the Model and final smoothing. At the preparation stage, we plan to manually design a simplified lightweight 3D model based on the calculations of the pre-processing visibility information acquired from the visibility algorithm implemented, and the consideration of the least level of detail for the potential visible sets, so that it will be use more intuitive in mobile devices. The 3D application used for the design is Autodesk 3DsMax 2010 and the final 3D model is exported to VRML 2.0 through the VRML exporter.

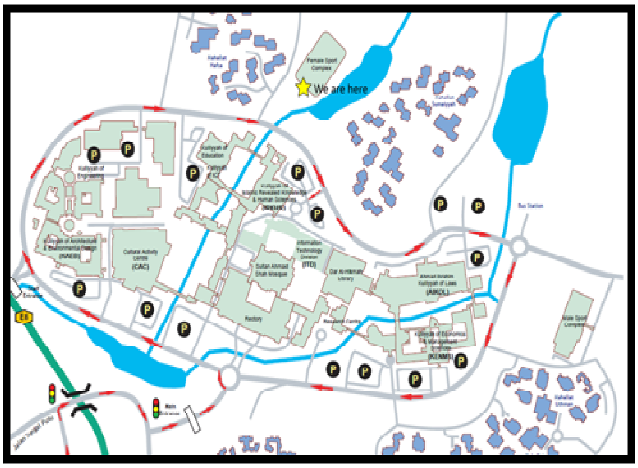

Fig.3, Zone A to D of IIUM Gombak campus

The reference description of the model is a layout map and video file of the sample area, which is the zone A to zone D of IIUM Gombak campus, and lay within the administrative and academic area of the campus as shown in an enclose red arrows in Fig. 3.

The layout image is then imported into Autodesk 3DsMax and placed as a flat plane texture in the program as reference description images to the pre-existing grids. The initial modelling was carried out using polygonal modelling as describe in section 5. The reference image layout was extruded by momentary looking at the reference video and constructs the accurate design of the scene with least level of detail. After the basic shapes of the initial model was completed, the final model was then refined by adjusting points and edges of the model and make it smoother and ensured that it works well when the shape needs to move.

About seventy percent of the model comes from spline line which where extruded to gain the buildings. Splines means flexible, describes as curves in construction to ease accuracy of evaluation capacity to approximate complex shapes through curve fitting and interactive curve design. However, as the buildings are complex in structure, that is not regular shape or straight structures, that is why spline approach is used for the construction of the model. By using line drawn from the top view, Boolean property is applied to cut an object to form the required shape of the structure. The 3D model is shown in Fig 4, and compresses of the following components: Mesh Total (vertices = 94645, Faces = 147568), Scene Totals = 379, (Objects = 338, Shapes = 11, Lights = 5, Cameras = 6, Helpers = 16, External Dependencies = 8 texture images).

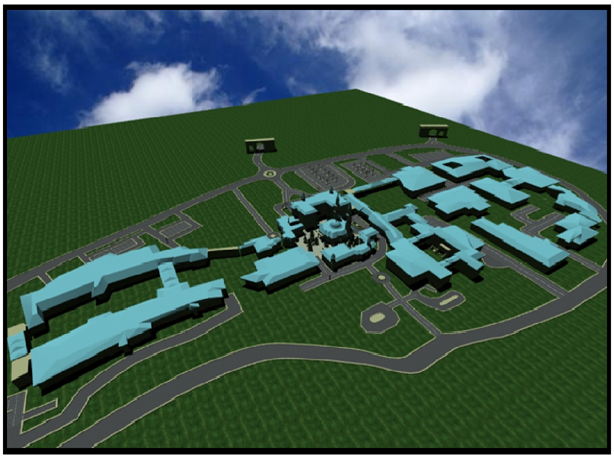

Fig. 4, 3D model of Zone A to Zone D

6. Pre-processing

The main purpose of pre-processing is to prepare all the necessary optimizations techniques that will be used in the runtime processing, such as, visualization approximation through identifying and marking out the subset of the 3D model (spatial data) into potentially visible set (PVS) in order to reduce the data redundancy and enhance the rendering efficiency at the runtime processing. In our approach, we transformed the 3D map model into regular space grids partitioning data structure and then subdivided it into regular grid of $2^n + 1$; where n = 1, 2…,n grids on each side as shown in Fig. 5.

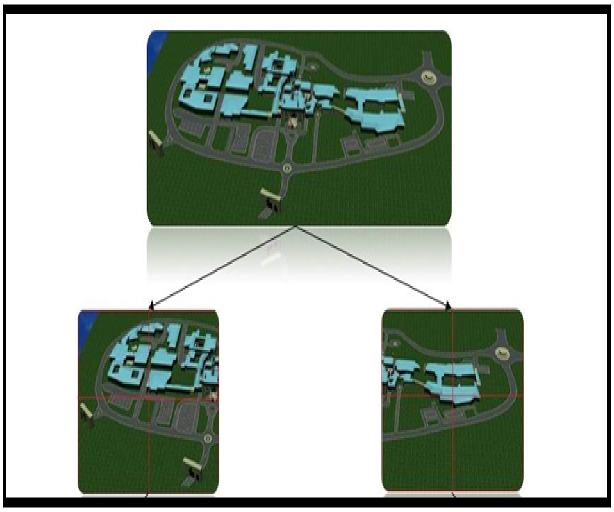

Fig. 5, Spatial subdivision

The regular grids containing actual 3D scene are determine at the pre-processing stage. During run-time, each grid containing the 3D scene pass through based on the dynamic location of the users' within the view frustum as shown in Fig. 6. If an adjacent grid is found completely outside the frustum it's discarded, while the grid with 3D scene will be computed and stored in grids buffers. Visual complexity at any given point is an optimization parameter at pre-processing stage; it is a quantity which depends on:

- The number of surfaces visible from all the point of views of the 3D scene;
- The area of visible part of each surface of the scene from all the point of views of the 3D scene;
- The orientation of each (partially) visible surface according to the all point of views of the 3D scene;
- The distance of each (partially) visible surface from all the point of views of the 3D scene.

The visual complexity of a scene from a given viewpoint can be computed by the following formula [34]:

$$C(V) = \frac{\sum_{i=1}^{n}\left[\frac{P_i(V)}{P_i(V)+1}\right]}{n} + \frac{\sum_{i=1}^{n} P_i(V)}{r} \quad (1)$$

Where:

- C(V) is the visual complexity of the scene from the view point V,
- $P_i(V)$ is the number of pixels corresponding to the polygon number I in the image obtained from the view point V
- r is the total number of pixels of the image (resolution of the image)
- n is the total number of polygons of the scene

Most pre-process visibility culling methods calculate the visibilities independently of the possible runtime viewing direction [2, 3]. View frustum culling is performed to all sets of potential visibility sets of nodes as shown in Fig. 6.

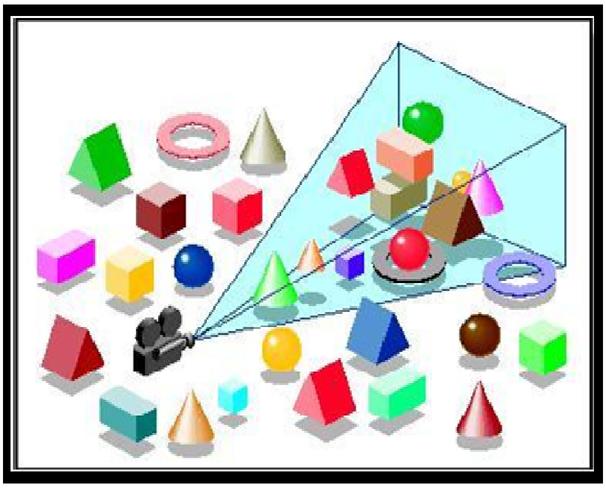

Fig. 6, View frustrum for a given scene.

In addition view frustum culling methods further exclude polygons not directly in the viewpoint as shown in Fig 6. The level of detail selection is performed depending on a given polygon budget and data availability which allows for a constant frame rate control [4]. The quad-tree and the view-frustum test is computed for each tile in the buffer [4, 14, 16].

7. Runtime Processing

The runtime processing is implemented based on remote rendering on client-server architecture through 3D graphic Pipeline to the mobile devices' 3D API. The server is responsible for handling requests sent from the clients through sequence of long series of 3D transformations calculations of the 3D frames. The client request processed by the server, are send through the 3D graphic pipeline for rendering to the client mobile devices via NMEA sentence. The graphic pipeline, which acts as a state machine, desires to be restarted when a state change is issued.

Remote rendering is describe as remote out-of-core rendering [37], that is client server situation where the rendering is performed remotely and final frames sent to the clients. By implementing server-side pre-processing state where all the necessary optimizations techniques are carried out, network usage can be strongly decreased by sending only visible objects to the client. The real-time server-side computation of the visibility set can be pre-computed for all view scene that form a partition of the regular grids [3]. This is possible when the potential visibility sets have been pre-computed for all view scene of the viewpoint space. Mobile device clients can sends their viewpoint changes to the server that locates the corresponding view scene and then updates the client data according to the associated potential-visibility-scene [38,39]. However, the mobile device needs to contain the 3D application (3D engine) in order for the mobile users to be able to make a requests, and receive a message of all the potential visible sets within the 3D dataset that are resolved and computed by the server using the pre-process information. To ensure memory management, only the current view grid needs to have its visibility list open in memory, that is, to hold in memory for only the currently needed scene with the lowest level of detail.

During initialization, the set of grids within the potential visibility set of the view frustum are loaded first, followed by the other sets within the next view frustum, In order to improve speed and memory management, data fetching from server will be pre-fetched and stored base on the predicted user next movement from the current position. However, when movement stops, the system starts loading predicted next movement data, thus when rendering is required due to user interaction or for updating dynamic components, the system respond promptly

7.1. Bi- A*Pathfinding Algorithm

Way finding with the Bi-directional A* pathfinding algorithm alternates between running the forward and reverse version of Dijkstra's algorithm. This is refers to as the forward and the reverse search, respectively. Bi-directional A* path-finding algorithm search from source to the target and in the same time the target also moves to the source as shown in Fig 7. The searching process will stop when the two directions search meet each other in a 3D walk-space. In most cases, the complexity of the bi-directional A* algorithm will be the heuristic function h that can be defined as the following [19]:

$$|h(x) - h^*(x)| = O((\log h^*(x))/2) \quad (2)$$

where x is the current user location and h^* is the optimal heuristic, the exact time/distance to get from current user location (x) to the target.

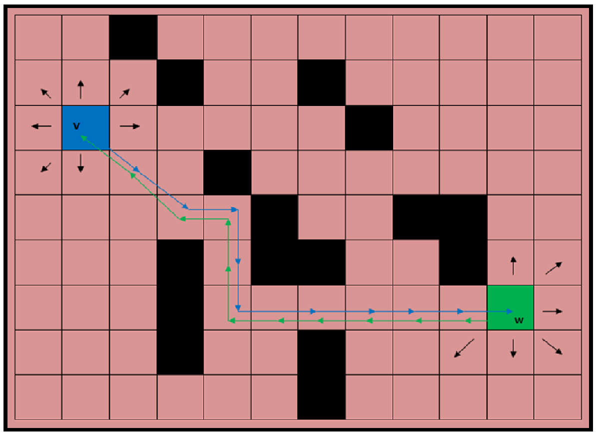

Fig. 7, Bi-A* Pathfinding algorithm

The Bi-A* pathfinding implementation scenario is explain in section 8, while the example of the algorithm is shown in Fig 7, for two users, user blue (v) and user green (w). The algorithm will ensure that User blue moves to user green's location and at the same time, user green moves to user blue's location. The entire search area is divided into a square grid; this will simplify the search area to a simple two dimensional array. Each item in the array represents one of the squares on the grid, and its status is recorded with eight arrows, four to the sides and four to the diagonals as either walkable or un-walkable. The path is found by figuring out which squares it takes to get from green to blue and vice versa. The cost of movement from each square node to another square node going through the sides of the square is less than the cost of movement of the square node moving through the diagonal by square root of 2, or roughly 1.414 the cost of moving sides ward. During initialization, the search started in both directions maintains the length of the shortest path, until both meet. The algorithm terminates when the target reachable from both direction meet.

8. Results.

The experiment carried out to determine the efficient interactive navigation among users based on client server implementation and GPS signal over network transmission was found to be proficient. However, the datasets transfers with the lightweight 3D model and least Level of details improves the rendering speed and does not affect the download time, the scene is remotely rendered in sequences to the mobile clients and the frame rate was sufficient for conducting the navigation within an environment. Users in a 3D walk-space are able to navigate using the shortest path to meet at a certain point and at the same time sees their whereabouts in 3D projection mapped on the their mobile devices' screen.

The experiment is represented in a scenario for two-way direction of users navigation in the following: there are three users involved, user blue, user green and user red as shown in Fig.8, they are in different position within the environment and they make an appointment to meet face to face in a single location.

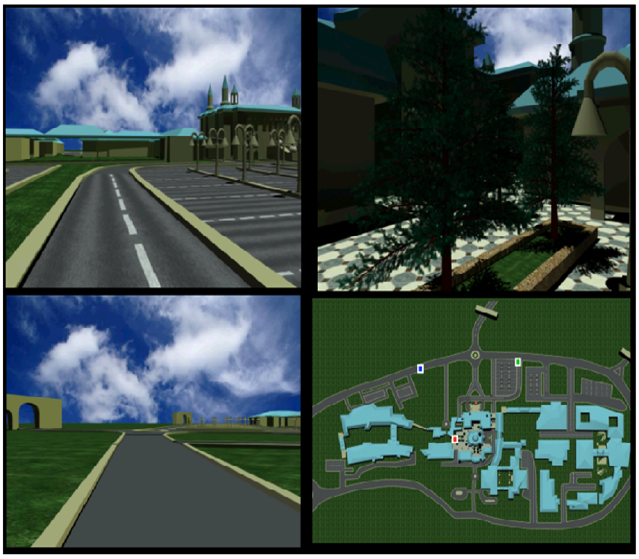

Fig. 8, Bi-A*Pathfinding Navigation Scenario.

Each user being aware of his position will also sees his current front view together with the current location of each other (as dot colour) in 3D projection mapped on the same mobile devices' screen as shown in Fig 9, 10, and Fig. 11, respectively. Based on the algorithms explained, the applications is designed and installed on each of the user's mobile device.

Fig. 9, Green user's view and projected 3D map

Fig. 10, Red user's view and projected 3D map

Fig. 11, Blue user's view and projected 3D map

The application is designed so that the colour dots in the scenario represent the users at the same time the Global Positioning System's information, and also to implement Bi-A* pathfinding algorithm based on remote rendering under client-server framework. First, all the clients sends their viewpoint changes to the server that locates the corresponding view node and second the server updates the client data according to the associated potential visibility sets based on remote rendering, which is meant to provide the rendering services at the server side.

The mobile devices' GPS receivers support a protocol called NMEA0183, which is a standard protocol to transfer geographical location information from GPS to GPS receiver's devices. Our application is configured to connect through the communication port to the library of the protocol. The location information which is referred by NMEA as sentence is used by the mobile device GPS receiver through the 3D application connecting the protocol. The protocol consists of several sentences. $GPGGA sentence was used, which stand for Global Positioning System Fix Data.

The Bi A* pathfinding algorithm implemented in the 3D application integrate with the $GPGGA sentence to determine the starting and dynamic nodes for navigation within the environment. However, the navigation within the environment was carried out based on the wireless remote rendering on low bandwidth networks thought, particularly considering using GPRS since most of the available mobile devices these days are GPRS enabled.

Each mobile user is required to enrol for the access to the navigation information to get a user name and ID. The mobile device whose GPS receiver support NMEA 0183 protocol is required to send requests to the server, the server identify the request through the $GPGGA sentence and the user's ID. The calculation of Potential Visibility Sets, Least level of detail and Visibility culling is undertaken in the server side. By implementing server-side visibility culling, network usage can be strongly decreased by sending only visible objects to the client [3]. The real-time server-side computation of the visibility set can be pre-computed for all view sets that form a partition of the viewpoint. This is possible when the potential visibility sets have been pre computed for all view sets of the viewpoint space.

At the initial navigation orientation all the users sees their view points and the locations of the each other in the projected 3D map. As all the users constantly moves and manoeuvres the environment based on the shortest path distance, so also they sees the movement of the colour dots in the projected 3D map in the same mobile devices' screen and at the same time their value of the GPS coordinates changes and the rendering is highly sufficient with good visible scene. The Navigation information of all the users under the experiment was obtained.

Table 2, Navigation Information of User Red

Paths No.	Paths Description	GPS Location: Longitude and Latitude	Decimal Longitude and Latitude	Altitude (ft)	Data, Download rate (kbps)	Rendering rate(fps)
1	Starting point	3^{0}15'06.84"N, 101^{0}44'09.29"E	3.2519N 101.735914E	297	13 - 70	20 – 25
2	Initial orientation	3^{0}15'06.81"N, 101^{0}44'09.29"E	3.251892N 101.735914E	297	13 – 110	30 – 38
3	Early Maneuvering	3^{0}15'05.20"N, 101^{0}44'09.57"E	3.251444N 101.735992E	295	13 – 400	30 – 40
4	Maneuvering	3^{0}15'04.14"N, 101^{0}44'08.12"E	3.25115N 101.735589E	294	13 – 550	30 – 40
5	Maintaining orientation	3^{0}15'03.60"N, 101^{0}44'06.81"E	3.251N 101.735225E	294	13 – 450	30 – 40
6	Recognizing the target	3^{0}15'02.49"N, 101^{0}44'04.91"E	3.250692N 101.734697E	293	13 – 500	30 – 40
7	At the target.	3^{0}15'01.18"N, 101^{0}44'04.44"E	3.250328N 101.734567E	282	13 - 500	30 - 40

8.1 Red User Navigation Information

Navigation task is divided into four main stages [34], which are: the Initial orientation, manoeuvring, maintaining orientation, and recognizing the target, during the experiment of this work, the navigation task follow this stage, the orientation of each step along the paths were traced when the red user moves, it's found out that each change in the orientation of movement either to the north, south, east, or west is traced by latitude and longitude respectively which is represented by the red dot, thus the elevation along the path was also traced. The rendering speed was sufficient for navigation and the network speed (download rate) was also reliable, all the results of the entire navigation from the starting point to the destination are represented in Table 2.

The red user shortest path is represented in Fig 14, it's the combination of the latitude changes in Fig 12 and longitude changes in Fig 13 that form the paths taking from the starting point to the destination.

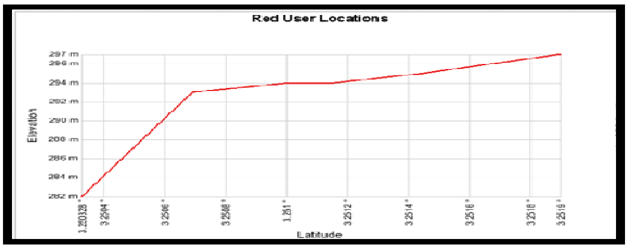

Fig. 12, Navigation orientation of Red user as he move north or south from the starting point in degrees of latitude.

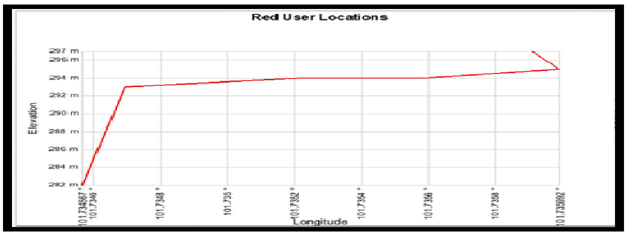

Fig. 13, Navigation orientation of Red user as he move east or west from the starting point in degrees of longitude.

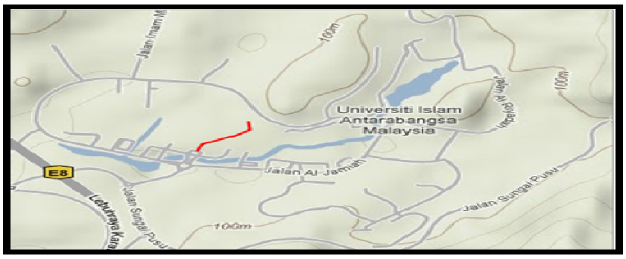

Fig. 14, Navigation orientation of Red user

8.2 Blue User Navigation Information

The navigation task of User blue is the same with that of user red, therefore all the explanation of user red also apply to user blue. However, the result obtained is not the same with user blue. All the results of the entire navigation from the starting point to the destination are represented in Table 3. The Blue user shortest path is represented in Fig 17, it's the combination of the latitude changes in Fig 15 and longitude changes in Fig 16 that form the paths taking from the starting point to the destination.

Table 3, Navigation information of User Blue

Paths		Location: Longitude and Latitude	Decimal Longitude and Latitude	Altitude (ft)	Data, Download rate (kbps)	Rendering rate(fps)
No,	Description					
1	Starting point	3°14'57.18"N, 101°44'12.20"E	3.249264N 101.736722E	273	13 - 70	20 – 25
2	Initial orientation	3°14'57.08"N, 101°44'11.64"E	3.249389N 101.735667E	271	13 – 110	30 – 38
3	Early Maneuvering	3°14'54.80"N, 101°44'08.40"E	3.248556N 101.735667E	264	13 – 260	30 – 40
4	Maneuvering	3°14'58.63"N, 101°44'05.88"E	3.249619N 101.734425E	271	13 – 400	30 – 40
5	Maintaining orientation	3°14'59.03"N, 101°44'03.93"E	3.249731N 101.734425E	267	13 – 550	30 – 40
6	Recognizing the target	3°15'00.66"N, 101°44'04.16"E	3.250183N 101.734489E	270	13 – 500	30 – 40
7	At the target.	3°15'01.18"N, 101°44'04.44"E	3.250328N 101.734567E	282	13 - 500	30 - 40

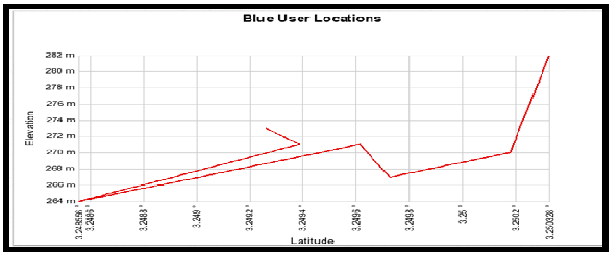

Fig. 15, Navigation orientation of Blue user as he move north or south from the starting point in degrees of latitutude.

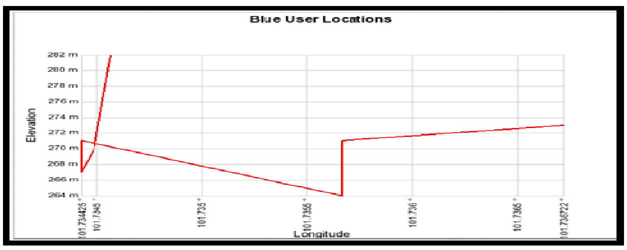

Fig. 16, Navigation orientation of Blue user as he move east or west from the starting point in degrees of longitude.

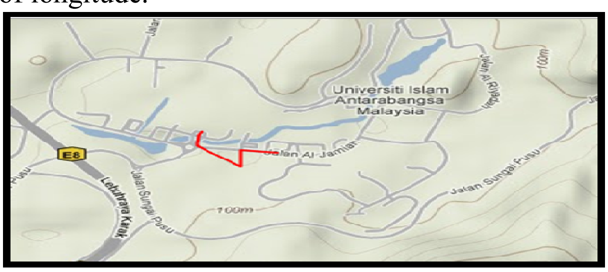

Fig. 17, Navigation orientation of Blue user

8.3 Green User Navigation Information

The navigation task of Green user is the same with the other users, therefore all the explanation of the other users also apply to Green user, However, the result obtained is not the same with the others. All the results of the entire navigation from the starting point to the destination are represented in Table 4. The Green users' shortest path is represented in Fig 20, it's the combination of the latitude changes in Fig 18 and longitude changes in Fig 19 which form the paths taking from the starting point to the destination.

Table 4, Navigation information of Green User

Paths		Location: Longitude and Latitude	Decimal Longitude and Latitude	Altitude (ft)	Data, Download rate (kbps)	Rendering rate(fps)
No,	Description					
1	Starting point	3°15'01.46"N, 101°43'56.76"E	3.250406N 101.732433E	273	13 - 70	20 – 25
2	Initial orientation	3°15'00.12"N, 101°43'58.92"E	3.240033N 101.733033E	271	13 – 110	30 – 38
3	Early Maneuvering	3°14'59.82"N, 101°44'00.35"E	3.24995N 101.733431E	264	13 – 260	30 – 40
4	Maneuvering	3°14'59.48"N, 101°44'01.08"E	3.249856N 101.733633E	271	13 – 400	30 – 40
5	Maintaining orientation	3°14'59.05"N, 101°44'02.95"E	3.249736N 101.734153E	267	13 – 550	30 – 40
6	Recognizing the target	3°15'00.86"N, 101°44'03.61"E	3.250239N 101.734336E	270	13 – 500	30 – 40
7	At the target.	3°15'01.18"N, 101°44'04.44"E	3.250328N 101.734567E	282	13 - 500	30 - 40

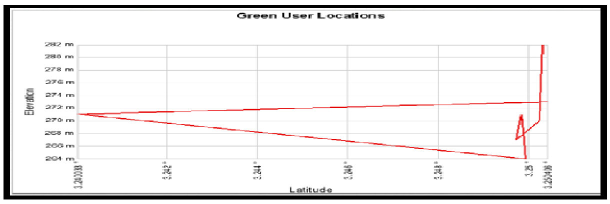

Fig. 18, Navigation orientation of Green user as he move north or south from the starting point in degress of latitude.

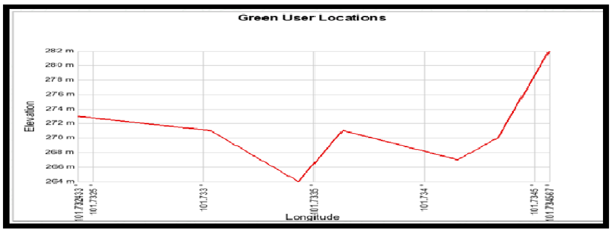

Fig. 19, Navigation orientation of Green user as he move east or west from the starting point in degrees of longitude.

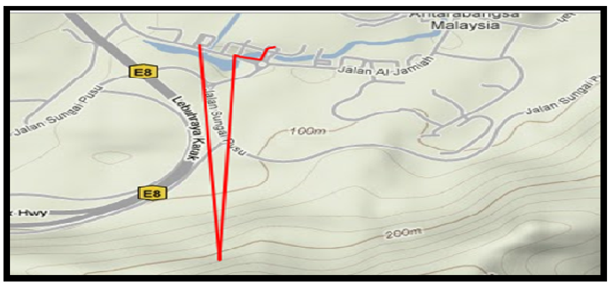

Fig. 20, Navigation orientation of Green user

The initial navigation orientation for all the users sees their view points and the locations of the each other in the projected 3D map. As all the users constantly moves and manoeuvres the environment based on the shortest path distance, so also they sees the movement of the colour dots in the projected 3D map in the same mobile devices' screen and at the same time their value of the GPS coordinates changes and the rendering is highly sufficient with good visible scene. The Navigation information of all the users under the experiment was obtained.

9. Discussion

Interactive navigation scheme implementation based on this paper is the demonstration of feature mobile devices services. Applications with interactive navigation are always be challenged with the user-friendliness of its interface [40]. Anyone will agree that navigating based on map in 2D or especially in 3D world is not a trivial task. Based on the experiment carried-out in this research, it is believed that the efficiency of navigation system would only be possible when several experiments are made. However, the user interface of traditional 3D browsers provides simple navigation tools that allow the user to modify the scene parameters such as orientation, position and focus. Using these tools, it is frequent that, after some movements, the user might need to reorient himself for a new task. When interacting with a 3D world model in mobile device, one of the first requirements is being able to navigate in the world in order to easily access and explore information to allow for judicious decision making for solving eventual problems. Basic navigation requires a lot manoeuvring for the user's movements to be efficient. It is important for the user to have a spatial knowledge of the environment and a clear understanding of his location. In order to enhance the user's navigation, navigation tools have to take into account the user goals and provide tools that help the user accomplish specific tasks.

The experiments carryout in the scenario of section 8 revealed two important points; 1) navigation schemes are more perceptive to the 3D scene and user's tasks when projected 3D map is provided in the same mobile device's screen with the view-front. 2) Navigation is tightly bound to the visual metaphor used and the way the user moves in the virtual world is determined by the metaphor that the same world is based upon. The red, blue, and green users in the experiment navigation adapt to the concept of metaphor-aware navigation. Although the way users navigate in a 3D world is intimately related to the task that need to accomplished, that's reaching to a destination as quickly as possible. The rendering rate and the data download to the mobile devices' of the three users from the starting point of the experiment to initial orientation and early manoeuvring were increasing until when the users recognised the target, at that point users do not make any requires since the target has been reached. The nature of the navigation orientation make-up from point to point of the movement of all the users, either from left to right or back and forward and the elevation at each point was plotted in section 8. The paths that add up the entire navigation orientations where also plotted section 8, it indicates the shortest paths followed by the users to meet at their meeting point.

10. Conclusion

The interactive mobile device visualization and navigation using 3D Maps of a 3D workspaces environment is an ongoing project with more upcoming bits and pieces. This paper discusses the problem of interactive navigation and visualization optimization techniques for mobile 3D application. There are three motivating factors for this study: 1) Mobile devices resources enhancement over the years in computing power, memory, storage, and equipped with graphical hardware for function of displaying. 2) An increasing wireless networking capabilities for mobile device. 3) Global Positioning System (GPS) receiver in most of the mobile devices. This offers the opportunity for the success of research like ours.

Mobile phones embedded with GPS and online maps have already emerged in the market to navigate user on the road. Some devices may also contain a digital compass, inertial sensors, miniature video cameras for position and orientation tracking location context aware, time and visualization of information. Unfortunately all to those devices are not using 3D map. This paper concentrates on solving the problem of visualization and navigation in relations to mobile 3D maps. The main goal is to break the technological drawbacks encountered in the implementation of 3D map visual navigation in mobile devices and proceed towards the potential offered by wireless networking and GPS positioning technologies, including on demand progressive content downloading and scalable near-real time rendering of dynamic entities. The paper uses 3D maps model of IIUM Gombak Campus (within zone A to zone D), the available internet bandwidth in the campus and finally users studies and field experiments as methodology for validating the algorithms of visibility for walkthroughs (View frustum algorithm), Regular grid spatial sub division and Bi-A* pathfinding algorithm. The experimental result confirmed that navigation schemes are more perceptive to the 3D scene and user's tasks when projected 3D map is provided in the same mobile device's screen with the view-front and Navigation is tightly bound to the visual metaphor used. The rendering rate and the data download to the mobile devices' of the 3D scene were sufficient for navigation use. Finally, shortest paths have been found for all the users to follow and to meet at their meeting point.

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