TECHNICAL ANALYSIS OF REMOTE 3D VISUALIZATION ON MOBILE DEVICES

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ABSTRACT

Considering the limitations of mobile devices like low bandwidth, less computation power, minimum storage capacity etc it is not possible to store whole data for 3D visualization on mobile devices. Therefore to minimize the load of mobile devices there is use of server in case of remote 3D visualization on mobile devices (clients). For 3D visualization on mobile devices various techniques are used at server side as well as at mobile side for different purpose. Some techniques directly provides 3D visualization and some techniques are indirectly responsible for 3D visualization on mobile devices. Remote visualization on mobile devices includes various parameters and aspects in different techniques.

KEYWORDS

Client, server, remote visualization, mobile devices

1. INTRODUCTION

Remote 3D visualization is used in wide areas such as complex urban environments, navigation, illustration, education such as for Cultural Heritage and rendering of large cities etc. As the mobile devices have so many limitations therefore 3D visualization of such wide area on mobile is a tedious task. This tedious task is made easier by server by providing various facilities with the help of various techniques at server side. Techniques are used at remote side (server) such as data compression, preprocessing, asynchronous adaptation etc and then pictures has been transferred to mobile devices for 3D visualization via wireless network. As it is a concept of wireless network, remote communication etc therefore it includes various aspects such as transmission delay, bandwidth, frame rates, catch, throughputs etc.

2. AREAS FOR REMOTE 3D VISUALIZATION ON MOBILE DEVICES

3D remote visualization is useful for earth maps or small patch of geographic area on mobile devices [1]. 3D remote visualization for scenery features of cities such as terrain, building, road etc [2]. 3D visualization of complex stream based data like video games etc. and visualization of 3D models like vehicle at remote side [3, 5]. The main goal is to access ambient intelligent environment by implementing, and evaluating a 3D-based user interface. Previously there were so many problems like interaction with small devices without there own user interfaces, finding and accessing devices in an invisible and unfamiliar environment etc. So with the help of 3D visualization and 3D UI a logical link has been created between physical devices and performs virtual representation on mobile devices [6]. To perform 3D visualization on mobile devices of outdoor environment GPS tracing system is used. This system may use with 2D visualization but it gives very poor sight as compare to 3D. Here authors focus on 3D visualization for real time indoor location tracing system on mobile devices [7]. Software architecture is capable to

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support the execution of agent-based participatory simulation activities and to provide them in a 3D virtual environment on mobile devices. Simulation and agent based modeling are the scientific methodology. This is also known as Agent Based Modeling Simulation (ABMS) technology. The main part of this system is to represent visual simulation using 3D visualization engine on mobile devices [8]. The main objective is to view 3D virtual reality data on mobile devices. Today's mobiles are more powerful however there is a need to reduce the content and need of processing data. Here Markus Feibt and Andreas Christ concentrate on most famous technology data compression. To achieve this, data has been first pre process at server side. As the mobiles which are at client side have so many limitations so to display 3D virtual reality data, concentration is only on device specific properties. To provide 3D virtual reality there is use of VRML. As the wireless connection via wireless network is not more reliable due to their limited bandwidth therefore 3D virtual reality has been optimized before going towards wireless network [9]. Here the focus is on remote 3D visualization of large cities using expressive or non-photorealistic rendering (NPR). To perform such rendering client server system and preprocessing optimization technique has been introduced. Here buildings are considered as simple texture blocks which are photographs of real building frontage. It also implements pipelines from real building frontage in prototype system which has been sent to remote clients [10]. As the mobile devices have so many limitations therefore 3D rendering on mobile is a challenging task because it requires huge network band width and computing resources. To solve this problem there is use of real time remote rendering of 3D video with the help of proxy based structure. Proxy server performs the rendering of complete 3D video and then transfers the render picture on mobile via wireless network [11]. It is possible to visualize image data at client side from server at remote side. Server is a web server which provides images to client on its demand [12].

By considering the limitations of mobile devices Fabrizio, Lamberty and Andrea Sanna provides the remote computing technique for the visualization on mobile devices [13]. It generates GUI events and transmits it to mobile applications.

City map visualization is possible through wireless network and GPS. It is also possible to create real time rendered mobile virtual environment with direct one to one mapping as 3D [14]. It also provides 3D optimization with dynamic entity.

A system has been developed which provides information about location to users and also navigate though mobile images [15]. The focus is on indoor environment. System uses client server approach for the location and direction in indoor environment.

Here [16] provide system which provides on line and offline data visualization for tourist in the tourist region. This system put together satellite images, GPS data, GIS and other information. All this information is used to implement visualization on mobile devices. This tourism information system handles large information which then used to provide guidance of desired destination.

Scalable processing provides in [19] for moving location query as location tracking request. It monitors the location of mobile object using optimization technique and this approach is MobiEyes. Direct benefit of MobiEyes is to reduce server load and communication band width. Various optimization techniques are used to reduce the computation at mobile side.

To visualize complex virtual 3D scenes and navigate those on mobile devices a novel approach is proposed. This approach is based on geographic web services. Client-server approach is also proposed in which servers dynamically generate the 3D scenes in provisions of the navigation commands and the result is sent to the mobile client like video-encoded image stream [20].

Generally a mobile device has limited hardware so it's difficult to create high constancy graphics in realistic time. Therefore to minimize this time there is used of remote server along with mobile device to render high constancy graphics. Here client server framework has been used to reduce rendering time using cost function [22].

A system is proposed by [23] having controller which automatically controls streaming parameters and increases quality of service in remote visualization. This is possible after designing control algorithm. While designing controller it is necessary to have sensitivity to feedback measures, robustness to non-linearity, freedom to the network quality and best handling of available resources.

A general architecture is developed for the visualization and navigation through 3D views on mobile devices by developing 3D museum applications. By means of which various mobile clients can interact with each others [24].

Gianluca Paravati et al. focus on Quality of Experience aspect in remote visualization on mobile device. Even the remote visualization through network provides quality of service but if it doesn't satisfy users then there is not quality of experience [26].

Here in [27] focus is on visualization of medical data on thin mobile client device by means of grid computing. This allows the mobile client to interact flexibly in grid environment.

3. IMPORTANT ISSUES TO BE CONSIDERED FOR REMOTE AND MOBILE SIDE FOR 3D VISUALIZATION ON MOBILE DEVICES

Following are the important issues to be considered for the remote 3D visualization on mobile devices:

1. Roaming step length control, motion blur, and triangle strips division
2. TIN-based vertex generation method
3. Cluster based rendering
4. Interactive generic algorithm
5. Ambient control and The Dynamic User Interface Creator
6. Culling algorithm and RSSI (received signal strength indicator) algorithm
7. Agent Based Modeling Simulation (ABMS) Technology
8. Data compression algorithm and dynamic optimization technique
9. Non-photorealistic rendering (NPR) and preprocessing optimization technique
10. Image based approach with 3D wrapping technique
11. Image Tilling, Multi-resolution Streaming, zoom and rotation
12. GUI with Segmentation, Optical character recognition and Pattern matching techniques
13. Image Segmentation and Matching technique
14. 3D Multimedia Visualization with interactive navigation
15. Multi-resolution, view frustum culling, occlusion culling, imposter techniques, and scene-graph optimizations
16. Adoptive and model view Control System
17. Volume and Iso-surface rendering methods

Remote concept plays an important role for 3D visualization on mobile devices. It makes complex data visualization easier because it supports client server approach having wireless connection. There is no limit of distance between mobile client and server. To visualize complex data from remote side on mobile devices includes various methods, parameters and aspects. Remote visualization on mobile devices is used in different applications for different types of complex data like earth maps, geographic area [1], terrain building, road [2], video games [3,5], ambient intelligent environment [6], 3D virtual reality data [9], outdoor and indoor environment [15], tourist region [16], medical data [27], 3D museum applications [24] etc. As the mobile devices doesn't have so much memory or storage capacity, therefore this complex data comes from server side to visualize on mobile clients with help of some methods at server side and client side.

4. SERVER SIDE METHODOLOGIES

4.1 Roaming step length control, motion blur, and triangle strips division, data scheduling

There are different techniques to improve the efficiency of 3D rendering with smooth roaming function in 3D environment, on the intelligent mobile devices. This rendering occurs through wireless data transmission. Different techniques to improve the 3D rendering are roaming step length control, motion blur, and triangle strips division. Roaming step length means minimized change of view. To achieve this view, in roaming step length control the rendering process would not be executed until the actions of operations have exceeded the limit. It has been found that roaming step length of operations directly reflects the correctness of user's operations.

It is clear that when the roaming step length is short, the globe would rotate accurately, and if the step length is long, the globe would rotate in a rough manner. Dynamic adjustment rules are set for the smoothness of real-time operation and to reduce the actual frequency of rendering.

Motion blur is used to improve the system rendering speed i.e. when the small patch of geographic picture is render in the procedure of dynamic roaming operation it extract the reduced pictures. To reduce the 3D representation time there is division of landscape meshes of each patch into triangle strips [1].

To manage data on wireless network data scheduling is also required.

4.2 Cluster based rendering

The focus is on remote visualization in [3, 4] and for that three tired architecture is proposed. In this architecture clients or mobile devices has been connected to the remote visualization server (RVS) which manages the communication between the 3D graphics application in a distributed environment. Also the visualization interface is organized on mobile devices. OPENGL applications are also used at server side whose callback functions adjust the rendering and mapping parameters. Also the cluster based rendering subsystem has been organized using Chromium which follows client-server paradigm by which OPENGL directives are intercepted. One s/w module is implemented i.e. SPU (steam processing unit) as a dynamically loadable library. It supports graphics context subdivision in tiles, distributing computing workloads to cluster nodes, performing actual rendering, returning the result to Chromium clients, and reassembling image tiles.

4.3 Interactive generic algorithm and controller

In [5], interactive generic algorithm has been produced to improve the performance which allows high quality graphics contents on site by linking set of 3D model. This system also allows user to design 3D graphics content on mobile devices for real time visualization. As the mobile device has less computing power for real time visualization so it provides client server architecture to manage computing load.

In interactive generic algorithm the numbers of steps are creation of initial generation, find out optimum solution, check the model and specify rates, execution of GA operation to produce new pair of models and last step is the visualization of new models as shown in fig. 1. Server side also includes controller to manage interaction with user.

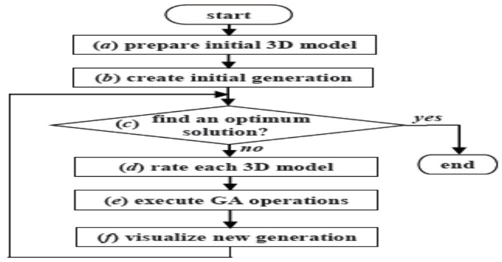

Fig. 1: Flowchart of iGA-Based 3D modeling.

4.4 Ambient control and The Dynamic User Interface Creator

Ambient control (AMCo) is implemented which uses automatic created 3D visualization model of environment and also built integrated user interface at server side. This identifies new devices and also can access identified devices. AMCo also have windows icon menu and pointing to access video, music, slides documents and also provides drag and drop facility. On a mobile device the Interaction Appliance (IA) runs, this makes available the AMCO client and the user interface. The Dynamic User Interface Creator (DUIC) has been implemented as a built-in component of the Environment Manager for the dynamic 3D-Visualization. Environment manager has so many functions like device access, dynamic user interface creation, and context retrieval, interaction synchronization etc. In case of DUIC environment manager illustrate the current position of environment with the help of XML file in 3D user interface. Interaction synchronization manages simultaneous access to the current environment [6].

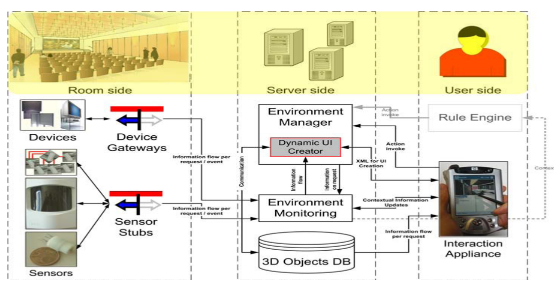

Fig. 2: The system runs on several distributed machines and subsystems.

4.5 Agent Based Modeling Simulation (ABMS) Technology

In system architecture of ABMS consist of Request manager, state updater, and snapshot creator at server side. In this system initially users from there system issues set of orders to the set of organized agents. This order is taken by Agent manager which is further send to Request manager. After that there is state updater, who creates new states, Snapshot Creator makes a text based image for the newly created state. This is all carry out on wireless network and this is all done under ABMS platform. Main goal of [8] is to provide 3D visualization using visual engine on wireless devices.

4.6 Data compression algorithm and dynamic optimization technique

Optimization of 3D virtual reality data is done by two ways i.e. static and dynamic optimization. In static optimization conditions are not changed during execution. In case of static optimization data compression is either done by software or hardware to reduce data transmission rate. Hardware compression algorithm may use for software compression but it never change for different types of clients. In other case software compression algorithm may used for lower clients to use a lower compression rate as well as powerful devices for higher and more data compression. If preload and catching technique is used at client sides then it requires clients with more storage capacity. So to avoid this problem same techniques are used at server (VRML proxy) side. When clients wants to connect to server they have to infer to server about device capacity, processing power, sound resolution etc then server removes unwanted contents according to the client i.e. mobile device requirement.

In case of dynamic optimization, incremental data transmission is used which transfer only minimum needed data. Data processing is done at VRML proxy server side rather than client side.

For VRML proxy there is use of java programming language.

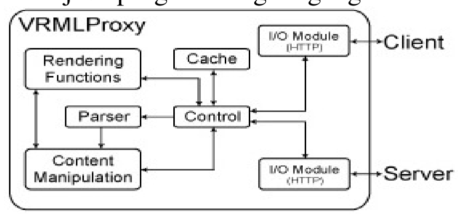

Fig 3: VRML Proxy view.

Here I/O module provides communication between client and server shown in fig.3. Content manipulation reduces the unwanted contents to mobile [9].

Common optimization provides static view while the dynamic optimization provides real time rendering of dynamic entities. Culling algorithm is also used to manage dynamic entities by initially deleting them and then adding them into new position. To ensure the scalability of system take out positioning information from client and due to parallel conflicting there is no need to validate client states at server side. Server manages entities by registering subscription. Dynamic entity updates are distributed by fast entities servers using entity proxies [14, 18].

Pietro Zanuttigh et al [21, 31, 32, 38] provide predictive compression method for the visualization of 3D model at remote side. This method reduces the download time and control the flow of 3D data. Main goal of predictive schema is to compress and transmit prediction error. For the compression of transmitted data it is necessary to packed scatter pixels of data in an array. Author presents various algorithms for the remote visualization of 3D models.

Matt Aranha et al. [22] discuss technique which minimizes computation and time for the rendering of more graphics on mobile devices. Ray tracing is one of the techniques which doesn't need more pixel as compare to desktop. As it uses client server concept so first it establish the communication between client and server using TCP/IP, then data has been compress at server side to reduce amount of transmitted data and decompress at client side. It also uses cost function to reduce rendering time of pixel on mobile device.

Robert Sisneros et al. [25] developed architecture having two aspects caching and pre-fetching for remote visualization. Caching aspect uses adoptive optimization technique for remote visualization to minimize average fetch time.

QoE is related to user observation in remote visualization on mobile devices through network. Actually QoE can move towards applications without network structure. Here in [26] focus is on QoE in remote visualization so it relates to the parameters frame rates, image resolution, compression quality and bandwidth.

Here authors [27] propose visualization pipeline having various components. One of the components is data service to bring and send data, other is filter service to receive data from data service and it uses data compression method to reduce size of data file.

To visualize and manipulate remote large data in real time on mobile devices M. Panka et al. [28] proposed a remote interactive visualization on mobile devices with the help of distributed system. All data are rendered on given servers of this system and compress while transmission using video codec. This compress data is send to mobile client as single video stream of good quality with high frame rates.

Pradeep Sen et al. perform ray tracing rendering to utilize wavelet based final image using compression algorithm. But in low sampling density compressive rendering fails [37].

4.7 Non-photorealistic rendering (NPR) and preprocessing optimization technique

The very first part of this system is to perform modeling and optimization of 3D representation of texture blocks of real building frontage. Pipe lines are extracted from real building frontage using edge detector. In case of edge detector image is smoothen by Gaussian convolution and also calculate gradient with the help of kernels and then obtain a pixel which is very well superiority of line extraction. To obtain poly lines, pixel chain has been obtained by finding pixel neighbors. To find polygonal approximation each pixel has been process which is vectorization process. To correct the errors occurs due to vectorization and initial noise there are different steps like suppression of segments, junction merging, straight line detector, vertical and horizontal line fittings. After vectorization last process is rendering process. In rendering process lines of real building frontage has been used as image. There is also another way in which lines are represented by geometric primitive on the surface of building. It has been found that texture rendering is faster than image rendering. This technique uses client server approach in which render data has been store on server such data then optimize for remote visualization on client like mobile device, PDA etc. Optimization technique has been used due to the fewer configurations of clients [10].

MobiEyes system is divided into two parts i.e. server side processing and client side processing. In server side processing server stores information of mobile object in focal object table, data of spatial queries in moving query table. Also the reserve query index matrix stores the identifier of the queries and static grid cell to base station mapping. Client (mobile) side stores the local query table having data about moving query and Boolean variable. Server side processing handles moving location query installation request from mobile side and make mediation at both side. Mobile side processing checks whether mobile object is within monitoring area of the moving query and query's filter is satisfied or not. If both answers are true then it registers the query into local query table. Author provides several optimization techniques for efficient and reliable processing of moving query. Those are lazy query propagation, query grouping and safe period which reduce the processing load at mobile side and also reduce the messaging cost of whole system [19].

4.8 Image based approach with 3D wrapping technique

By considering the limits of mobile devices, author presents the proxy based structure for remote rendering on mobile. Here proxy is a powerful server on which whole 3D video is available and then it sends render pictures on mobile device (client) according to there request. Proxy contents different modules like rendering module, motion module, output and input stream interface. Gateway server communicates with input stream interface and send 3D video stream to proxy. User interface is managed by motion module. Client i.e. mobile device receive image from output stream interface of proxy and display it. When the client requests for new rendering then interaction delay may occur due to network traffic. This interaction delay is reduced with the help of image based approach.

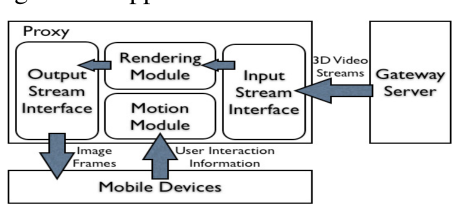

Fig 4: proxy based framework.

Image based approach uses 3D wrapping technique to reduce interaction delay. 3D wrapping algorithm needs camera parameters and pixel depth value. In case of OPENGL the camera parameters receive from model view and projection matrix, and the pixel depth values are stored in z-buffer. Wrapping is computed by following formula,

$$(u_2, v_2) = \left(\frac{u_1 a + v_1 b + c + \partial_1 d}{u_1 + v_1 j + k + \partial_1 l}, \frac{u_1 e + v_1 f + g + \partial_1 h}{u_1 i + v_1 j + k + \partial_1 l} \right)$$

In this algorithm next coordinates (u_2, v2) are calculated from the input pixel of its previous coordinate's u_1, v_1. It also uses depth value of pixel u_1, v_1. This algorithm computes each pixel only once. Therefore the complexity of the whole algorithm is proportional to the image resolution. Input image has no pixel to reference when drawing new image, such problem is exposure problem. This problem is overcome by selecting two reference image frames and 3D wrapping is used for both frames [11].

In [36] Sylvain Faisan et al. proposed 3D binary image warping technique in accordance with continuous and one to one mapping. Warping is nothing but an image transformation process, in which warping image M can transform to image T by means of two ways, considering each point of M whose coordinates in T and other considering each point of T and whose coordinates in M. It is time consuming and expensive.

4.9 Image Tilling, Multi-resolution Streaming

Photographs or images are accepted by system as input. These images are preprocessed by an encoder to produce new subdivided (tile) multi resolution images. All streaming and encoding information is store into map and catalog files produce by encoder [12]. This is done at server side.

4.10 GUI with Segmentation, Optical character recognition and Pattern matching techniques

Fabrizio Lamberty et al. [13] provide client server frame work. Server side provides GUI to the mobile devices with four elements. Those are parser, classifier and descriptor. Parser examines the interfacing. Classifier categorizes each element to place them together. Descriptor is used to convert each information into user interface description language, which holds entire interface description and GUI brokers connects to mobile to access the request and send the parses description to mobile to present to user. Each GUI uses some techniques for various purposes. GUI parser uses frame buffer for interfacing with user, ad hoc algorithm to interact with OS. GUI classifier uses segmentation to segment image onto sub blocks, optical character recognition to recognize text in bounding box and the pattern matching technique to checks character shapes and attributes. XML user interface is used by GUI descriptor which is helpful for remote interfacing.

4.11 Image Segmentation and Matching technique

To provide location and positioning in indoor environment along with information, a system [15, 18] has been developed on the basis of client server approach. In this system sends the images to server using wireless signals. Server extract applicable feature in the images to match to base plane. These feature detect method is based on image segmentation which finds segment by selecting search area and lines trace. After finding feature it should match with floor plane so the matching is occur using Ransac algorithm in which one to one correspondence is occur between left and right side of floor plane and image feature. Then it computes camera pose and send information overlay to mobile client to visualize indoor location. Here all techniques are used at server side.

4.12 Multi-resolution, view frustum culling, occlusion culling, imposter techniques, and scene-graph optimizations

To perform 3D visualization of complex virtual environment on mobile devices there are different visualization techniques, including discrete and continuous multi-resolution geometry and texture representations, progressive and hierarchical representation with client-server architecture, view frustum culling, occlusion culling, imposter techniques, and scene-graph optimizations. But 3D navigation applications go through short of data values and flexible distribution techniques. So the data can only be used for visualization purpose but not for higher-level functionality such as simulations, analysis tasks etc.

This application uses general techniques those are Quad-tree, BSP (Binary Space Partitioning) tree and Octree to divide and arrange data with multi-resolution by means of pyramid mode into hierarchical structure. It also uses mipmap texture for higher resolution, interpolation between original source images [20].

4.13 Adoptive and model view Control System

Control system considers the theoretical bandwidth occupation, device throughputs. Bandwidth error considers the increase between visualization flow created by server and the flow process by mobile client. Throughput is depends on both network and mobile capabilities. If the throughput is lower than bandwidth then it means that mobile is not capable to receive, decode and visualize all flow sent by server. Therefore controller is implemented at server side which decreases the encoding parameters to reduce the wasting of bandwidth. Target frame rate is also used for the external control of parameters. So the target frame rate is always comparing with actual frame rate of client and the controller always tried to reduce this difference. Controller also changes the parameters of the flow of images to reach the preferred frame rate to use minimum bandwidth of network and client processing capability. To manage the instability of bandwidth and device throughput the adoptive control approach can be used. The optimization technique is used with proposed controller to rearrange the resolution, frame rate and quality that are mentioned in [33]. In overall simulation initially target frame rates was15 fps in time t1 after that it becomes 25 in time t2. To get a higher frame rates even though resolution and quality decreases but it doesn't provides stable value due to nonstop fluctuation [23].

The developed architecture is based on Model View Controller which consist of views like local and remote, device controller and M3G. M3G controls data and performance of the 3D graphical object. M3G model also check and responds on the collision of graphical objects. Graphics are mapped on device display with help of local and remote views. Remote view is responsible to render on remote mobile devices. Device controller act as interpreter between mobile devices and 3G model so that device users can interact with applications. Communication layer acts as data communicator with server. Once the connection is established server receive images from other devices in the ad hoc network and sends it to current mobile device. Therefore navigation and interaction is occurs in between multiple mobile clients. Author [24] developed architecture to deal with fault tolerant aspect. This architecture is tolerant to failure to communicate with server by allowing 3D scene to be loaded from nearer device.

For the optimal decomposition and adoptive mapping of visualization pipeline over distributed network Mengxia Zhu et al. proposes various aspects of remote visualization system. Visualization pipeline is developed to reduce the total delay and to increase frame rates because this pipeline is arranged into group of modules which is allocated to various network nodes. While in distributed visualization system visualization pipeline is decomposed into groups and then mapping is occurs in between these groups and computing nodes distributed over transport network [29, 30].

Here in [34] the discussion is on integration of two techniques i.e. web content adaptation and dynamic content catching. To display dynamic content on mobile devices content adaptation is employed which uses page adaptation method. Content adaptation helps for dynamic visualization and catching increases speed of content transmission. The proposed adaptation algorithm is modified by consisting of two parts semantic block detection and semantic block partition. Enhance fragment catching strategy increase the dynamic content adaptation and it solve both transmission and adaptation cost.

When the visualization on mobile is performed through wireless network from remote side, a lot of problems may occurs relates to data transmission, bandwidth, frame rates etc. like these energy utilization may also be the problem. Therefore adoptive synchronization method is proposed in [35] which solve the problem of energy consumption and increase transmission speed.

Milos Bogdanovic et al. proposes context service architecture for adoptive geospatial data visualization. Detail visualization of spatial data on mobile through web is a time consuming task [39].

4.14 Volume and Iso-surface rendering methods

Aboamama .A. Ahmed et al. propose visualization pipeline with various components. With the help of this it is possible for the mobile client to interact in distributed network environment. Visualization pipe line contains various components such data service to bring and send data, filter service to receive data from data service. It also use data compression method to reduce size of data file, mapping service converts the data in geometric format using volume and iso-surface rendering methods. Render service render the geometric data into image to transfer towards visualization agent via presentation service. Render service acts on network bandwidth to receive request from visualization agent which is implemented in Java 3D and xml [27].

5. CLIENT SIDE METHODOLOGIES

5.1 Asynchronous adaptation, progressive refreshment, roaming, rendering

To release the burden of data catch there is the adaptation of asynchronous and progressive refreshment strategy. To render data in 3D form on mobile 3D rendering is used. Implementation is done on the platform of PDA with the help of OPENGL ES 3D programming package and VC language [1].

5.2 TIN-based vertex generation method

This application focuses on the geographic information processing and visualization on mobile 3D and web 3D. Main motivation is on system architecture and prototype implementation for mobile and web 3D. For dynamic 3D terrain rendering system using high resolution satellite metaphors, some techniques and algorithms were applied and implemented by using graphic pipeline of OPENGL ES API. Those are TIN-based vertex generation with regular spacing elevation data for generating 3D terrain surface, image tiling for LOD, image-vertex texturing in order to resolve limited resource of mobile devices.

With the help of GML model and its schema components, users can describe the geographic types such as real or conceptual, which are used within their application domain. X3D supports 3D functions such as polygonal geometry, parametric geometry, hierarchical transformations, lighting, materials, multi-pass or multi-stage texture mapping, pixel and vertex shading, and hardware acceleration in [2].

5.3. Interaction/ Interfacing:, event generator and frame decoder

At client side mobile devices uses mobile 3D viewer application for the visualization. At client side to handle user interaction with mobile view there is use of interfacing and users occurrences are also handle at this side with the help of event generator. Frame decoder is also used to extract synchronies data, decode it and put it into visualization buffer. Frame buffer is also used to mange packet losses. This application also supports Gtk+ 1.2 and X11 graphics libraries under Linux [3].

With the help of 3D based user interface the room metaphor has been developed. Therefore the user can selects and identify devices based on position, orientation and form without having a technical knowledge. 3D user interface has so many advantages which allow the visualization of environment and its devices and create a direct correspondence between the physical objects and their 3D representations within the user interface. On a mobile device the Interaction Appliance (IA) runs this makes available the AMCO client and the user interface [6].

5.4 Web Browser, 3D viewer

At the client side of this application uses compact 3D viewer in JAVA and web browser to browse and rate 3D model. Viewer performs zooming function [5].

5.5 Culling algorithm and RSSI (received signal strength indicator) algorithm

Virtual Reality Modeling language is used for constructing 3D indoor building maps. 3D models are divided into two cells (rooms) and nodes (objects). These nodes are located in cell. To make a system more flexible and scalable, designer 2D map also been used.

Culling algorithm is implemented with the help of script presented in VRML. It developed three types of visibility cell to cell, cell to object and eye to object. When the VRML script is activated, cell is loaded where the user is present with the help of cell to cell visibility algorithm. When that cell is loaded only current cells objects are visible and at the end all the objects that are viewed by user are visible. Therefore in culling algorithm there is use of IsCellVisible and IsObjectVisible functions. Culling algorithm is more useful to minimize rendering time. With the help of RSSI smoothing algorithm distances are calculated between reference and blind objects. It also estimates user's location with the help of CC2431 location engine in 3D virtual reality environment. For the final experiment reference objects are located at each corners of ceiling in one cell for proper location tracking [7].

Mobile device like PDA are not allow large 3D model at acceptable frame rates due to their limitation. Therefore author proposed two culling algorithms i.e. hierarchical frustum culling and portal culling for interaction of large 3D model of building on mobile device. Large 3D model is subdivided into cells and portals having Meta data in X3D file [40].

5.6 3D rendering and navigation in virtual environment

For the execution of ABMS (Agent Based Modeling Simulation) system author [8] design a client server architecture shown in fig.5 and also provides 3D rendering on wireless devices like mobiles, laptops etc.

Fig. 5: ABMS rendering on different devices

3D visualizer at client side consist of three software components snapshot manager, virtual word creator and rendering engine. Snapshot Manager manages the succeeding activity of data decompression, and checks for their integrity. Virtual word creator takes data from queue and creates 3D virtual environment and the rendering engine perform 3D rendering of virtual environment on wireless devices.

Here authors [14, 18] provide system which provides 3D navigation on mobile.

Local 3D rendering is most probably done at client side to perform 3D visualization on mobile devices [27].

5.7 Data compression and optimization technique

Data compression also used at client side which is also called as software compression. Optimization of 3D virtual reality data is done by two way i.e. static and dynamic optimization. In static optimization conditions are not changed during execution. In case of static optimization data compression is either done by software or hardware to reduce data transmission rate. Hardware compression algorithm may use for software compression but it never change for different types of clients. In other case software compression algorithm may used for lower clients to use a lower compression rate as well as powerful devices for higher and more data compression. When clients wants to connect to server they have to infer to server about device capacity, processing power, sound resolution etc then server removes unwanted contents according to the client i.e. mobile device requirement.

In case of dynamic optimization, incremental data transmission is used which transfer only minimum needed data. Data processing is done at VRML proxy server side rather than client side. Content manipulation reduces the unwanted contents to mobile [9].

5.8 Data Decompression

Along with compression method decompression is also used at client side to decompress the compressed data which comes from server side. Data has been compress at server side to reduce the transmission rate of complex data. After decompression mobile users gets the view of whole data [10, 21, 22, 28].

5.9 Zooming and rotation

Zooming and rotation is performed at client side to navigate through 3D video [11, 28]. Zooming technique is also used by visualizer of ABMS [8].

Tile images visualized at client side with the help of view operations like zoom, rotations etc. Client also supports multi threaded pull model for multiple tiles [12].

5.10 3D Multimedia Visualization with interactive navigation

Multimedia objects are generated after survey of tourist information and preprocessing of remote sensing data. While preprocessing digital elevation model (DEM) is required for geo-coding of remote sensing data and it is also important for 3D visualization. In the process of geo-coding, bi-cubic convolution re-sampling is useful to get an optimum visual representation. 3D views are calculated from the combination of RGB images and DEM and generally view in animation software. Multimedia objects can integrate with different applications on mobile [16].

6. ANALYSIS OF VARIOUS TECHNIQUES CONSIDERING (APPLICATIONS, ATTRIBUTES, PAREMETERS AND THEIR ASPECTS)

Applications	Methods	Parameters	Related attributes	Aspects
Geographic data and earth map 3D visualization[1]	Roaming step length control	Roaming step length	Rotation degree, Distance from earth, Time of 3D rendering	Rendering,
	Motion blur	Dynamic roaming, 3D terrain mesh, Geographic scene	Small patches, Reduces triangles	3D visualization, Rendering
	Triangle strips division,	Preprocess 3D meshes, Divide 3D meshes into triangle strip	Reduces 3D rendering time	Rendering
	Data check And transmission	Data updating mechanism, Correctness of data	Spatial indexes, Timestamp of patches	Wireless data transmission
	Asynchronou s refreshment	Data scheduling, Loading rough data before accurate	Release mobiles data catch load, Smooth roaming	Data resolution, Efficiency, Speed, Frequency,
	Dynamic catching	Data loading and organization	Represent Current sense with inferior data	Speed and Space limit, 3D roaming
Terrain, building, road data rendering [2]	TIN based vertex generation	Modeling, editing and manipulating 3D landscape objects, optimizing and rendering of integrates 3D landscape objects, navigation of 3D scene.	Intuitive and user friendly high resolution remote sense images	Data transfer and shearing of 3D urban modeling
Complex stream based data like video games etc. visualization [3,4]	Distributed cluster based rendering and streaming using Chromium framework	Event scheduler, Streaming, Rendering Event generator, Frame decoder	Visualize interface during OPENGL API, Run graphic applications and manages communication	Fast network connectivity, Frame rates, screen resolution, time, stream quality, network traffic
	Interaction/ Interfacing/re ndering	Mobile interaction, handles events Render lines i.e. Boundaries, Ridges, Valleys, Silhouettes	Extract synchronize bitstream, handle packet loses, decode compress frames	Bandwidth, Reduce network traffic , Frame rates, transmission time
3D models like vehicle at remote side[5]	Interactive generic algorithm.	Interactive 3D modeling system and mobile oriented GUI, which increases mobile interactivity and performance.	Good quality mobile 3D visualization from anywhere anytime.	Frame Rate , Image resolution.

	Controller	Manage client server interaction, converts 3D into 2D	Transmission, HTTP protocol	Wireless communication
To access ambient intelligent environment	Ambient control and The Dynamic User Interface Creator[6]	Dynamic 3D visua-lization, user interface creation, and context retrieval, interaction synchronization etc.	Controllability, Document and device access is integrated in same user interface.	Error tolerance, Efficiency, Gateways, Sensor tube.
Indoor environment GPS tracking system	Culling algorithm and RSSI (received signal strength indicator) algorithm[7]:	Reduce 3D rendering time, decrease comput-ing time on mobile devices, and increase the system performance.	Accurate real time rendering in indoor environment, 3D rendering, distance and position estimation.	Location tracking with 3D view, Increase flexibility and scalability using 2D view.
Agent based multimedia simulation in virtual environment[8]	Agent Based Modeling Simulation (ABMS) Technology	Fast 3D visualization using visual engine on wireless devices, perfect synchronization between client and server..	Scientific visualization on mobile in virtual world using simulator, reproduction, compatibility.	Wireless network communication , dynamic rendering, Catching, Fetching
	Zooming	Visualize large image on small display	Visualizer	Dynamic rendering
To view 3D virtual reality data, city map, medical data etc[9, 14, 18, 21, 22, 25, 26, 27]	Data compression algorithm	Requires minimum computation and memory resources at client, Reduces the download time and control the flow of 3D data	Visualization of complex data on mobile device in distributed environment. Low compression rate for slow mobiles and high compression for powerful mobiles	Data transmission rate, Compression quality, Bandwidth.
	Dynamic optimization technique	Manage dynamic entity, provide dynamic view, better performance, and image quality, reduce fetch time, satisfy users with quality of experience, and provide flexible interaction in grid environment.	Improve data transmission on wireless network	Wireless network, GPS, Packed pixel array, Ray tracing, Caching and pre-Fetching, Frame rates, Image resolution, Bandwidth
3D visualization of large cities. Moving location query as	Non-photorealistic rendering (NPR)	Fast line based and high quality rendering, Server load reduction and communication, Feature line extraction from	Location watching on mobile in distributed surrounding, Gradient magnitude and direction. Poly line and graph	Wireless communication, Edge detection, Segment suppression, Pixel chaining, Loading, Pre-fetching,

location tracking and monitoring [10 ,19]		image front	structure., filtering, threshold	
	Preprocessing optimization technique	Fast rendering, Reduce processing load at mobile, filter	focal object, spatial queries, reserve query index matrix, static grid cell	Wireless communication, Bandwidth
Real time remote rendering of 3D video	Image based approach with 3D wrapping, Zooming and rotation [11]	Proxy based structure, Visualization of whole 3D video frame on mobile. Dynamic, real time and temporary frame rendering.	High quality 3D visualization, 3D video stream, gateway server, less computation resources, processing time	Network traffic, Interaction delay, Image resolution, Pixel depth , Rendering performance and quality, Bandwidth
Visualization of image data.	Image Tilling, Multi-resolution Streaming, Zooming and rotation [12]:	Interactive visualization on mobile, encoder, Multi threaded pull model	Interactive visualization using structure, multi-resolution images, tile images, preprocess image.	Internet delivery, Multi-resolution, Streaming, Decoder
Graphical user interfacing on mobile	GUI with Segmentation , Optical character recognition and Pattern matching techniques[13]	Client server framework, image segmentation, parser, classifier, descriptor.	Control the remote requests using GUI., interfacing, categorize elements to put together, convert information into user interface ,image sub blokes, character shapes, bounding box	Frame buffer, Ad hoc network
Location finding of indoor environment and navigate.	Image Segmentation and Matching technique. [15, 18]	Visualization and navigation of indoor environment on mobile, feature extraction and detection	Shows position and direction in indoor environment., find segment, line trace, floor plan	Wireless signals,
Visualization of complex virtual 3D scenes and navigate them on mobile devices	Multi-resolution, view frustum culling, occlusion culling, imposter techniques, and scene-graph optimizations :[20]	Provides web service interfacing, improve the rendering speed of 3D navigation, efficient network transmission. Pyramid with hierarchical quad tree, latitude, longitude	Server generates dynamic 3D view and then send encoded image to mobile client, define data structure, compress spatial data, reduce data redundancy.	GPS location, Video encoder, Network transmission, Frame rates,
Rendering of complex 3D image data on mobile which flows from server, interactive	Adoptive and model view Control	Decrease bandwidth between client and server, increase mobile throughputs, Maintain image quality and	Flow of interactive multimedia over wireless network using controller. High quality 3D visualization. Enhance motion	Wireless network, Bandwidth, Throughputs, Frame rates. Fault tolerant, Ad hoc network, Data communication

visualization of multimedia data and navigation of 3D view of museum applications.	System: [23, 24]	resolution. QoS. Performs navigation and interaction in between multiple mobile clients, Model view controller	smoothness, Impact on interactivity, Target frame rates maintain resolution and quality Manage 3d graphics, Response to potential geographic collision	
Medical data visualization in grid environment	Volume and Iso-surface rendering methods:[27]	Converts data into geometric form which is then render into , large data flow and steering	Interactive Visualization and precise controlling of large datasets on mobile	Network bandwidth, Image streaming.
Real time multidimensional data	Compression, decompression [28]	Image stream, remote visualization, distributed network.	Increase image quality, high frame rates, decrease network latency	Broadband connection, Screen and image resolution

7. RESULTS AND DISCUSSION

From the above analysis it has been found that most of the techniques are use at server side for remote visualization on mobile devices.

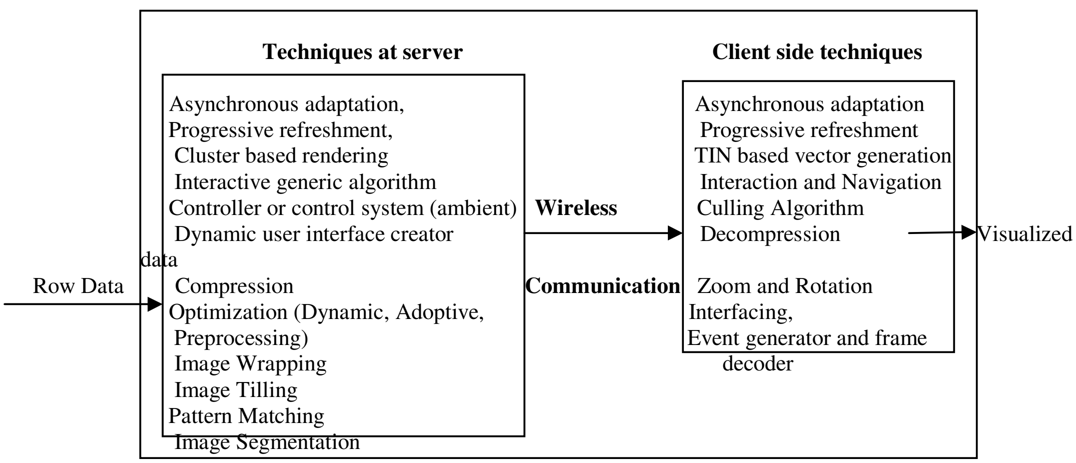

Fig 6: Framework of most probable techniques used at server side and client side

To make 3D visualization of complex data more effective on mobile devices there is use of remote visualization. Actually various reasons are found which build remote visualization on mobile devices more successful.

1. As the data transfer through wireless network therefore when the client requests for new rendering then interaction delay may occur due to network traffic. This interaction delay is reduced with the help of image based approach. Image based approach uses 3D wrapping technique to reduce interaction delay

2. Continuous data catching is not possible due to limited storage capacity of mobile devices this is overcomes by adaptation of asynchronous, progressive refreshment strategy and data compression techniques.

3. Visualization of environment and its devices and create a direct correspondence between the physical objects and their 3D representations within the user interface.
4. As the wireless connection via wireless network is not more reliable due to their limited bandwidth therefore 3D virtual reality has been optimized before going towards wireless network.
5. In case of client server approach render data has been store on server such data then optimize for remote visualization on client like mobile device, PDA etc. Optimization technique has been used due to the fewer configurations of clients.
6. With the help of different techniques such as roaming step length control, motion blur, and triangle strips division it is possible to improve the efficiency of 3D rendering on the intelligent mobile devices via wireless data transmission.

8. CONCLUSIONS

Here the concentration is on different techniques those are responsible for visualization on mobile devices at remote side from server. Most of the techniques are useful for server to send data for visualization to mobile devices. It has been found that optimization and compression methods are more useful for the remote visualization. Also discuss the various advantages of remote visualization on mobile devices.

In this paper discussion is on different techniques in various applications their attributes, parameters and aspects. Remote visualization on mobile devices considers various aspects such wireless connectivity, bandwidth, frame rates, throughputs, fault tolerant, cache, fetch, interaction delay, resolution etc. in different applications with different techniques.

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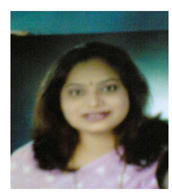

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