Compression Techniques for Remote Visualization on Mobile Platforms

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ABSTRACT
While transmission of complex data through wireless network for visualization on mobile devices various aspects can be consider such as bandwidth, frame rates, latency and screen resolution of mobile device. As the mobile devices are of low configuration as compared to desktop therefore remote visualization of complex data on mobile takes lot of efforts. Because of low bandwidth low frame rates may generates on mobile device. In such situations compression techniques plays a vital role for the 3D visualization on mobile device to generate maximum frame rates. In this paper focus is given on most efficient and valuable compression techniques used while transmission of data from server to mobile for 3D visualization on mobile devices.

Keywords
Mobile devices, client-server approach, local and remote visualization, compression techniques.

1. INTRODUCTION
Compression techniques are more important to generate maximum frame rates on mobile devices from remote side with various aspects like bandwidth, transmission delay etc. Most probably compression technique is used by server side in remote visualization but some times it may use by clients also. Compression technique can use for any type of data like textual, image or 3D video etc. Mostly compression applies on images or photorealistic data because while transmission image data packets may lose and also transmission delay may occur. Due to the packets losses while transmission; quality of data visualization on mobile devices may reduce.

2. CLIENT SERVER APPROACH FOR COMPLEX DATA VISUALIZATION ON MOBILE PLATFORM
Visualization can be client based only, that can be recognized as local visualization. In case of client based visualization data is store at client and such data then visualized with the help of various techniques. But for local visualization client must have vast storage capacity. However the mobile clients are adversary to this. Therefore remote visualization plays an important role in complex data visualization. Remote visualization can be client-server based or proxy based visualization. Proxy is an intermediary between client and server [1, 2].
In previous client server system proposed in [3, 4] does not mention any function like image quality, frame rates etc. Therefore Ross Mitchell et al. [5] proposed a client server for current generation smart phone i.e. iPhone, iPad, Itouch device etc. to get a sufficient functionality, image quality and frame rates in remote visualization. In client server system images are not directly transfer to client mobile but the server load and render the image and then transmit render frame to remote mobile device. Communication between client and server is done through standard protocol. Due to limitation of mobile advance visualization methods are not occurs on remote mobile device hence it is done by server.

3. LOCAL AND REMOTE VISUALIZATION ON MOBILE DEVICES
3.1 Local visualization
When the data is store on mobile device and such store data then visualized on mobile device with the help of some visualization techniques on mobile device. For local visualization mobile devices must have large storage capacity.

3.2 Remote visualization
When the data is come from server and such data then visualized on mobile devices by using some visualization techniques

4 COMPRESSION TECHNIQUES

4.1 Compression using context modeling and residue packing
To efficiently compress the depth view and to improve the compression context modeling and residue packing techniques are used.

In context modeling and residue packing the complete residual or depth image is represented by array of integers i.e. I[x, y]. Encoder also find prediction $\hat{I}[x, y]$ of next pixel value then encode the prediction residue value as

$$e[x, y] = I[x, y] - \hat{I}[x, y]$$

and in non hole area this value would be zero because their all context almost are zero. Therefore this prediction residue can pack to give the compacted sequence of residue i.e. $\{e_i\}$ in the holes [6].

4.2 Predictive Compression
Pietro Zanuttigh et al. proposed predictive compression technique which provides the depth visualization of 3D model with high quality on mobile device from distant server [7]. In the proposed structure client sends the demand to server then by using graphical engine, server renders the image, compress it and sends to the client. 3D warping was the image based rendering method which finds new predicted view from previous images with the help of z-buffer information. After comparing server render image with predicted view remaining difference is sent to the client. With the help of this difference client reimburse its prediction whose complexity is depended on image resolution. In image based rendering scheme (IBR),

$L_1(x)$ is current view of 3D model which communicate to the position of the user's camera (V_1) where $x \varepsilon Q_1 = [0, W_1] \times [0, H_1]$.

$x\,[x; y]^T$ is the pixel of L_1 whose 3D position is $X = [x; y; Z(x; y)]^T$ where $Z(x; y)$ is the z buffer content at x.

$L_2(x')$ indicates the next view located at V_2, $x' \varepsilon Q_2 = [0, W_1] \times [0, H_1]$. Therefore position $X' = [x'; y'; Z(x'; y')]^t$. 3D projective transformation is also obtained in homogeneous coordinates. The IBR prediction of is denoted by $\hat{L2}(x,y)$, z-buffer is denoted as Z(x, y).

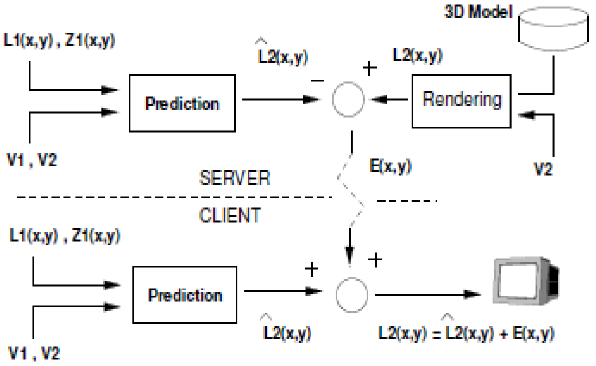

Fig. 1: Predictive compression scheme.

Prediction schemes main theme is to compress and transfer prediction error E(x, y). If the predicted view moves extra as compared to beginning view then prediction error is larger. If the prediction error is reset to zero, then full view and relative z-buffer can be sent. The sum of data of prediction residual and compress image is compare by server and when such ratio overcomes fixed threshold then new complete image is sent to the client. At the client side decompression is performed to visualize the compress image.

Compression gives the best efficiency with respect to visual quality. Compression with depth comparison and pixel packing is done with the image of resolution 300x260 pixels. Depth based residual selection and packing presents the good quality image for required bandwidth. This is an old predictive compression technique which does not support multiple frames [8].

4.3 Image compression and streaming with scheduling and QoE

Dr. A. Sanna et al. [9] proposed remote rendering approach. This remote rendering service is divided into two sides i.e. server side and client side. Number of applications given at server side is an event scheduler, 3D rendering module, QoE manager, JPEG encoder, and steaming module. While client side includes event generator, QoE manager, JPEG decoder, stream receiver and frame buffer viewer. Remote visualization framework covers three parameters resolution, image quality and frame rates but these parameters may change due to network level i.e. bandwidth.

Server side 3D rendering module uses OpenGL for rendering; event scheduler manages command from user sides. QoE increases the resolution and compression quality. JPEG chose the right sight within frame buffer and generates compressed image. Steaming module is responsible to perform image stream which is created by packets having compressed graphics data. Image stream is packet made up by rendered images having good resolution and compressed quality

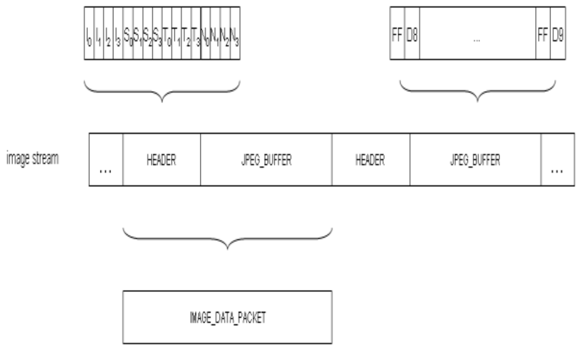

Fig. 2: Image steam

I0-I_4 are different packets, then there is image size given by S, T is a temporary information about delivery of packets i.e. T_0-T_4, N indicates sequence of number of fields.

Authors [9] find the motion smoothness and reliability of 3D visualization modules according to number of polygons using and without using QoE. To find this performance authors consider maximum resolution 320x240 pixels and higher compress quality of JPEG set to 100. Rendering server contains a set of 12 resolutions ranging from 224x168 to 400x300.

$$S_R = \left\{ \begin{matrix} 224\text{x}168 & 240\text{x}180 & 256\text{x}192 \\ 272\text{x}\,204 & 288\text{x}\,216 & 304\text{x}\,228 \\ 320\text{x}\,240 & 336\text{x}\,252 & 352\text{x}\,264 \\ 368\text{x}\,276 & 384\text{x}\,288 & 400\text{x}\,300 \end{matrix} \right\}$$

From the result it is found that using QoE manager, got more frame rates to increase compression quality and moving smoothness. It is also found that as the number of polygons increases, the compression and smoothness moving capability reduces.

4.4 Data compression in static optimization

To minimize the data transmission rates, unrelated and unnecessary data, data compression technique is used. Data compression algorithm can made for hardware but it may work as software module such as V.42bis, which is not a benefit. Data compression algorithm create for software can lower compression rates for low processing power devices and high compression rates for high power devices [10].

4.5 Interactive video streaming with Compression and decompression

To visualize and manipulate remote large data in real time on mobile devices M. Panka et al. [11] 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 wile transmission using video codec. This compress data is send to mobile client as single video stream of good quality with high frame rates. Data can be 2D, 3D and animated 3D. In distributed system server accept input from client, process and encode it, send compress data to client. Client take compress data decompress it and visualize on mobile screen. This system is also responsible to decrease network latency for interactive visualization on mobile devices.

In communication flow of system architecture user requested data receive by session manager module of server, it also manage all activity by users like zooming, moving and rotating. Session manager sends the data to render module which create frames of data and send to encoder using socket communication. Encoder compress frame by video codec and send to client via dedicated stream protocol trough network bandwidth. Quality of video stream, frame rates and stream resolution is adopted with video broadcast in encoder module and also to save network bandwidth last frame is sent with higher bit rates. Client decompresses the data and visualize on screen. It also performs different actions i.e. zooming, rotation and moving.

In case of 2D visualization, some part of image is cropped (shown in fig. 3) according to the user need which is then encoded to view. Due to the crop technique whole image doesn't download and display on mobile. This technique is good for the high resolution image.

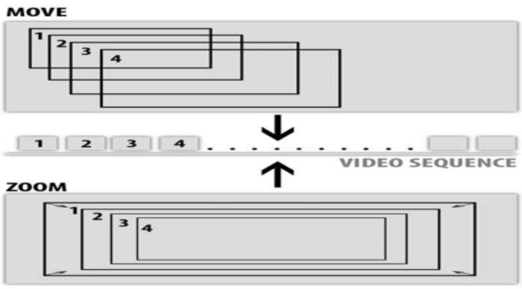

Fig. 3: Crop based on user selection

In 3D visualization instead of zooming and moving, objects are rotate along X and Y axis. Based on user's choice successive frames are dynamically generated in the render module. Animated 3D data visualization also uses zooming, moving and rotation techniques. Here the frames are changed in time. Authors in [11] test the system using multidimensional data for most computational power consuming device i.e. encoding module. Using three different screen resolutions i.e.320x240, 800x480 and 1366x768, system performance is tested for number of users. It is found that though number of simultaneous users connected to single server, compression speed is fast. 320x240, 800x480 is mostly the resolution of mobile devices, provides more than 25 frames per second. Lowest speed is 15 fps. If high resolution video stream is considered then it slow down the server. Client uses zoom, moving, rotation, decompression while server uses compression, cropping techniques.

5. ANALYSIS

5.1 Common aspects required in wireless network for 3D visualization on mobile devices

5.1.1 Bandwidth

Bandwidth in a networking denotes a network levels. As the bandwidth increases frame might be reduced.

5.1.2 Threshold

Threshold indicates the point of outset. It is nothing but a boundaries or given minimum and maximum values. For efficient and accurate filtering it is necessary to set suitable relevance threshold and also for other techniques.

5.1.3 Frame rates/ pixel rates

Frame rates measure the frequency with which an image or a frame can be generated by a visualization system. It is measure of smoothness and fidelity.

5.1.4 Throughput

Throughput denotes the final result or output. It depends on the device capabilities.

5.1.5 Screen and image Resolution

Resolution is a function of image or screen height and width. Considering the mobile device resolution it is difficult to achieve good frame rates and image quality.

5.2 Comparative analysis of various techniques

Various author proposed a number of techniques for 3D visualization, each techniques have some features along with some drawbacks, parameters, attributes and aspects.

Table 1. Comparative analysis of various techniques considering pros, cons, parameters, attributes and their aspects

Most constructive techniques in all categories for 3D visualization	Ordinary pros	Frequent cons	Parameters	Attributes	Aspects
Compression [6, 9, 10, 12, 13, 14]	1. Provides the depth visualization of 3D model with high quality 2Minimum computation and memory resources 3. Best possible tradeoff between the compression ratio and the visual quality 4. Provides residues packing for efficient	1. Increase number of polygons, reduces the compression and smoothness moving capability. 2. Compression algorithm created for hardware can't be change. 3. More polygons may increase transmission rate and cost.	- Residual image, - Image quality, - Encoder, - Translation - image resolution -frame rates -image quality - image stream -remote visualization -distributed network.	- Compress depth view, - Provide image quality - Motion smoothness, - Reliability -motion smoothness - reliability - Increase image quality - high frame	-Frame rates -Image resolution - Bandwidth - Pixels - threshold -broadband connection -screen and image resolution

	compression and provides good quality image for required bandwidth. 5. Good compression quality increases number of frame rates and moving smoothness. 6. View damages compressed better. 7. Create good quality image from compress data. 8. Decreases data transmission rate. 9. For number of simultaneous connected users to single server, compression speed is fast.	4. Predictive compression does not supports multiple frames 5 If high resolution video stream is considered then it slow down the server.		rates - decrease network latency	

6. CONCLUSION

In this paper discussion is on various compression methods mostly used in remote visualization on mobile devices. In case of remote approach it is found that focus is on data transmission from server to client via wireless network. From the above techniques it is observed that compression techniques are generally used at server side because these techniques requires more computations and mobile devices are of low computation power. So the server side compression technique reduces the computation at mobile side.

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