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Research paper

Interactive 3D Wi-Fi Display Miracast System using Back Channel Input

B S Raghunatha Reddy*[1], Dr. P Ramana Reddy[2]

[1]Research Scholar, JNTUA, Ananthapur
[2]Head of the Dept, ECE, JNTUA, Ananthapur
**Corresponding author E-mail:rag.bsr@gmail.com*

Abstract

With advances in multimedia technology, 3D video is driving lot of attention these days. Delivery of 3D video over communication networks poses additional technical challenges by virtue of having multiple video views and the perception of depth. In this paper, we present an interactive multi-view video 3D Wi-Fi Display Miracast system that enables adaptive transmission of ongoing 3D video content based on user's input, fed from the back channel, in real time. Proposed solution enables 3D video transmission of desired views only. Solution gives the viewers the best 3D experience by way of selective sharing the suitable views, yet with significant reduction in bandwidth and power consumption requirements.

Keywords: *3D Video, Multi-view video coding (MVC), 3D video communication, Adaptive video streaming, Wi-Fi Display Miracast,*

1. Introduction

Streaming of traditional 2D video content involves multiple challenges in terms of network bandwidth variations, bit rate adaptation, switching latencies, transmission delays, computing power and capabilities of the client devices and the underlying communication transport mechanism. These challenges have been researched for quite number of years from past and 2D video streaming is a very wide in spread these days.

The emergence of 3D content over the last decade has drawn lot of attention & enthusiasm in the entertainment segment and 3D video is projected to be one of the top technology trends of the current era. 3D TV, 3D movie, 3D games are the popular 3D applications in the entertainment segment. In the video communication filed, with data rates coming down drastically, 3D video streaming has seen a remarkable market growth and it is popularly used by many users.

Stereoscopic 3D video is one of the early coding standards used for the 3D representation. It presents two slightly different images of the same scene to the left and right eye in order to provide a sense of illusion to the user. Stereoscopic 3D video is already in use largely in Movie & TV broadcasting industries.

Yet another popular 3D video coding technology is Multi-view Video Coding (MVC, also known as MVC 3D) where multiple i.e. more than two view video sequences are captured simultaneously from multiple cameras to form a single video stream. As shown in Fig.1, multiple sensors are positioned at certain distant locations around the scene to be able to cover wide range of angles possible in order to achieve high quality 3D content experience.

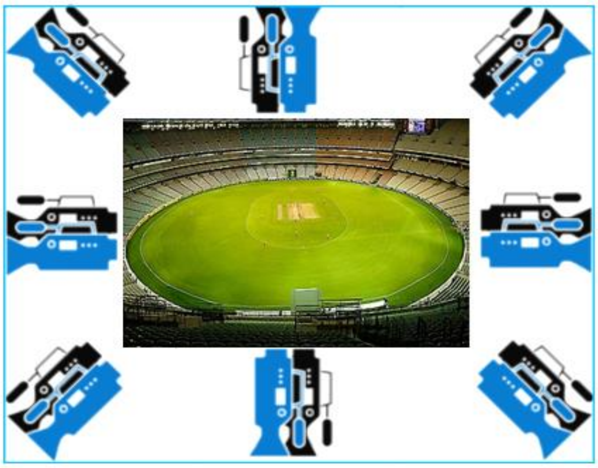

Fig. 1: Multi-Camera 3D Recording System

Though multi-view video (MVV) scores better than the Stereoscopic video in terms of video quality, it suffers from the limitation of large data size because of the multiple views coming from multiple sensors. MVC codec addresses the increased data size problem by means of efficient compression. MVC video coding standard enables efficient encoding of the multi-view content captured from multiple sensors on to a single video stream. Apart from the temporal redundancy, since various sensors are capturing the same scene, MVV leads to a high amount of interview statistical redundancy. Further, MVV requires high bandwidth to carry multiple views.

MVC is as an extension of H.264/AVC, which exploits multi view correlation across MVV frames. Fig 2 illustrates the typical MVV sequence coding with temporal reference frames shown in black and interview predicted reference pictures in blue.

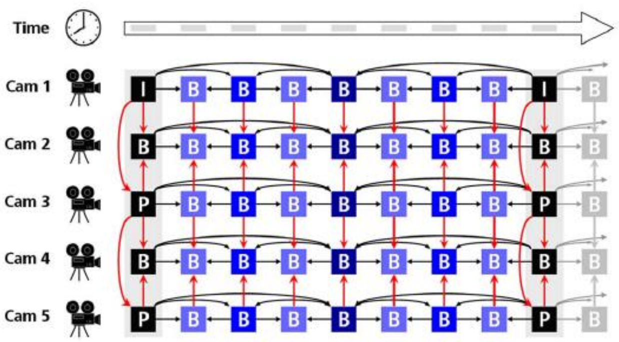

Fig. 2: MVC Prediction Structure with N=5

Adaptive three-dimensional video is a new technology development, with a user driven interactive approach, in the field of 3D video communication. It allows the user to switch the viewing angle selectively and share only the required views in order to gain the best 3D viewing experience with less number of views. In this approach, multiple views, captured by various sensors from different angles, are made available at the source device. Interactivity is attained via client device, by means feeding the user input back to the source device, which in turn, selects the best suitable videos and transmits to sink display device.

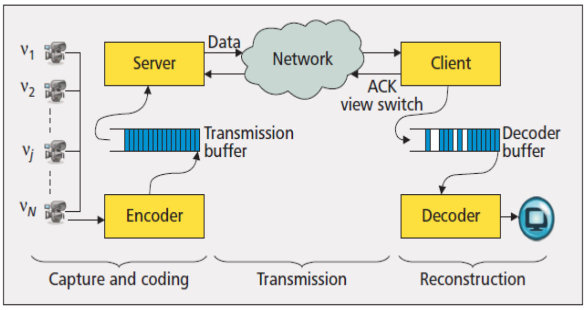

Fig. 3: Multi-view video delivery system architecture

Fig.3 depicts the typical multi-view video system architecture. There are multiple challenges and opportunities pertaining to adaptive streaming [1] at various stages of a streaming system such as source coding, channel transmission and reconstruction. [2] explains a client driven selective streaming approach for 3D TV over internet. [3] presents a typical Peer-to-Peer architecture for streaming the 3D content adaptively. [4] presents a user centric interactive 3D streaming over present day networks based on user's head position. My article reviews and presents one such system in the context of Wi-Fi Display Miracast specification.

Miracast is a Wi-Fi Display (WFD) standard [5], by Wi-Fi Alliance, enabling seamless display of multimedia content between miracast certified devices. It allows users to share content from certified source devices such as laptops; smartphones to sink displays such as PC monitors and TVs. Miracast enables either to do screen casting or to share the multimedia content wirelessly from source to the sink. It is as an alternative to HDMI replacing the cable from the device to the display. All the devices that achieve Miracast certification by Wi-Fi Alliance can communicate with each other. Non-Miracast devices can connect to a Miracast device via adapters/dongles that plug into HDMI or USB ports.

2. System Description

A typical approach of a 3D MVV video transmission system is to transmit all the encoded streams to the client device. Receiver decodes all the views and makes it ready for the sink device to display the best-suited views. Selection of the view can either be arbitrary selection by the user by means of trial and error or it can be based on the user's viewing angle as well [4].

Unlike traditional internet based streaming transport methods, in Wi-Fi Display Miracast case, bandwidth is not a major limitation as it's governed by the underlying Wi-Fi technology. Modern day Wi-Fi devices are capable of supporting up to 50-100 mbps practically while theoretically it promises up to 600 mbps. Hence, with no bandwidth limitation pertaining to Miracast 3D Wi-Fi Display, it should be an easy approach to transmit all the views.

However, there are few concerning factors such as large computation power and the corresponding batter life statistics of the device(s) under the communication.Apart from the battery consumption, sharing of multiple views lead to higher bit rates and additional pocket losses. Therefore, adapting the interactive streaming approach to the Miracast system still holds well and it is expected to be a viable & beneficial solution given the importance of battery life to the user of the Miracast device (e.g. Smart phone.)

This study presents steps to build a viewer driven interactive 3D Miracast Wi-Fi display video system, in which, the source device is equipped with 3D MVV video content that contains view data of multi-view video and at the remote side, user's input is fed back in real time to the source device. Based on the user's feedback, source device selects the two best suitable video streams and shares to the sink device. Therefore, by way of sharing only the desired streams across the Wi-Fi channel, under given bandwidth conditions, the proposed solution is capable of providing the same 3D experience to the user, however with far less computational power consumption statistics.

Fig.4 gives high-level overview of the proposal. System can be realized with traditional Wi-Fi Display system with source and sink server model. There are two entities: Source (e.g. a smart phone device with 3D MVC video content in its internal storage) & Sink (say a TV, connected to a Wi-Fi enabled Dongle).

In principle, each view of MVV is encoded independently, multiplexed, packaged on to a single stream and stored as file on the source device. At the sink side, user input information is constantly fed back the source device. Source, in turn, determines respective access points related to the best matched views from the original source file content and shares the corresponding video stream to the remote side.

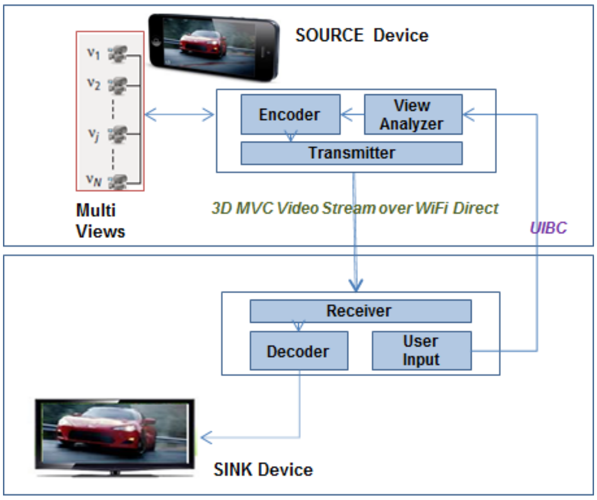

Fig. 4: System Architecture

As depicted in Fig.4, proposed system includes multiple components such as MVV encoder, view analyzer, transmitter, receiver decoder and user input modules. Functional details of the few key components are described in the section below.

2.1. MVC Encoder/Decoder

Key aspect of the multi-view video encoder is the compression efficiency so as to be able to reduce temporal as well as interview statistical dependency across multi views. Multi-view video coding method has become one of the focused research area these days in the field of video coding technology.

Video decoder designed at the sink side should be capable of achieving the backward compatibility so that a non-MVC complaint decoder can decode a single 2D view, discard the rest of the data, whereas a compliant MVC decoder can decode all the views, and generate the 3D video.

2.2. View Analyzer

Important aspect of the proposed interactive 3D Wi-Fi Display system is to switch the views based on the user's input fed back from the client side in real time. Source selectively chooses the two best matched views according to the given input data. Switching criteria of how to select the best-matched streams according to a given position is addressed in [4].

Another important aspect is the method of feeding back the user input of view port information from sink to source device. UIBC (User Input Back Channel) as specified in the WFD specification [5] is used for the purpose.UIBC i.e. User Input Back Channel is an optional WFD feature that facilitates communication of user inputs from the WFD sink display device to the WFD source device. All UIBC user inputs are packetized using a common packet header and transported over TCP/IP. The user input can be specified in two categories i.e. Generic and HIDC [Human Interface Device Class].

Generic is used for communicating the device agnostic user inputs at the application layer. Generic user inputs include generic user inputs such as mouse and keyboard events and the functional inputs such as zoom and scroll. HIDC is used for user inputs generated by HID devices such as remote control, keyboard, etc.

2.3. User Input

A commonly used criterion to change the viewport is the viewing angle based on the position, at which he/she is watching the display device. Methods are described in [2, 4] in which user's viewing angle is determined by tracking the head position of the user by using a camera device fixed on the sink device. These traditional methods suffer from limitations such as complexity & accuracy of the face detection by a mounted camera, unwanted user movements, multiple users watching the content etc.

In the proposed solution, we eliminate the complexities of the traditional methods and present an easy and intuitive UI (user interface) application on the sink display using which user shall be able to change the desired viewing angle. Sink device, in turn, communicates the changed viewing angle information to the source device via UIBC channel as explained in the previous section.

In case of live streaming, user's exercise of inputting 'viewing angle' is an estimation/approximation in real time aligning to the camera positioning at the capturing location. User experience can further be enhanced by means of sharing the 'navigation map with the exact camera positioning' from live location to the display device. End user shall be able to choose the desired viewpoint using the map displayed on the sink device, which in turn, is communicated to the server. Live streaming control using navigation map is beyond the scope of this paper and is a future research topic.

3. System Implementation

This section gives the deployment details considered for realizing the system.

3.1. Source Device

Source device is a smart phone mobile device, which contains the 3D MVC video in its storage. 3D MVV with N=16 (i.e. eight pairs of stereoscopic videos) is MVC encoded, locally stored and streamed using Wi-Fi Display specification. The device is capable of Wi-Fi Direct and is Miracast certified.

3.2. View Analyzer

View analyzer is the software component inside the source device, which is capable of analyzing the MVV views and picking the best suitable views from N-point MVV content present in the device. It receives the viewing angle fed back by the sink device and communicates the same to the encoder. Encoder chooses the two best views as determined by the analyzer module and switches the transmission to these new views for the sink device to display.

3.3. Sink Device

Sink device is a smart TV, which is connected to the Wi-Fi dongle. Dongle is required for the Wi-Fi Direct compatibility between source device and sink device. If the connected TV has in-built Wi-Fi Direct compatible chipset and is Miractast certified, then there is no need of Dongle.

3.4. User Input

In order for the user to input the desired view port angle/information, a simple progress bar like UI application is developed on the sink display device i.e. on the smart TV side, as depicted below.

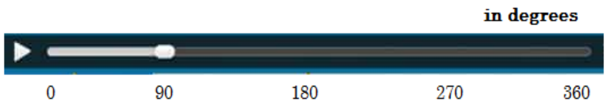

Fig.5: User Input UI app

The app takes the user input and feeds back the data to the source device via UIBC back channel, which in turn analyzes and adaptively selects the best suitable video views.

3.5. Transmitter & Receiver

Transmitter at the source side and the receiver on the remote side are the typical data networking interface modules on either side, which shall be able to communicate using TCP/IP control protocol and RTP/RTCP for media. RTSP streaming protocol is used for the media streaming procedure.

4. Experimental Results

With the above system in place, an end-end 3D Wi-Fi display subsystem is designed and verified for the transmission of the 3D MVC video from source to sink. From the sink device a human interactive i.e. user fed viewing angle is shared to the source side using UIBC-HIDC as explained above. Upon receiving the user input of viewing angle, source device successfully switches the transmission to the best-suited views to display at the sink side. UI application used for changing the viewing angles is simple but very effective & efficient in terms of ease of interaction.

Table 1: Experimental results

Smart phone device spec: H264 video codec; 1280 * 720 Resolution; 30 Fps, 2800 mA battery

No of View (pairs)	Video Bitrate *(mbps)*	Packet Loss	Power Consumption *(mAh)*	Battery Life *(hr)*
8	19.6	8.1	654	4.2
6	15.8	2.8	572	4.8
4	12.96	0.7	496	5.6
2	10.52	0.2	423	6.6
1	8.4	0	345	8.11

Table 1 gives the results of the key parameters such as bit rate, packet loss, power consumption and battery life with different No of views i.e. from N=8 and N=1. While traditional approach of sharing all eight pair(s) drains out the mobile device in 4.2 hrs, with the proposed system, Battery life is doubled, i.e. it allows eight plus hours of continuous streaming, which is a significant improvement from the end user perspective. Below depicted are the graphical representation of variations of video bit rate and batter life with respect to no of views transmitted from source to sink device.

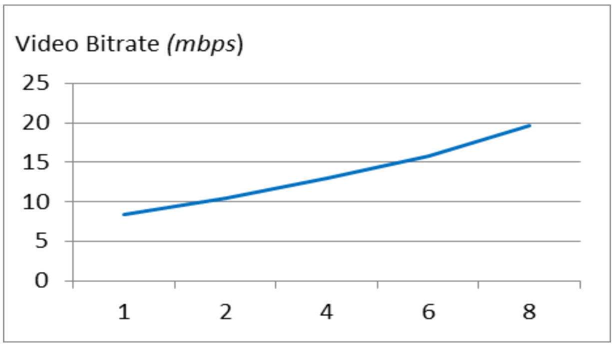

Fig.6: Bit rate vs No of views

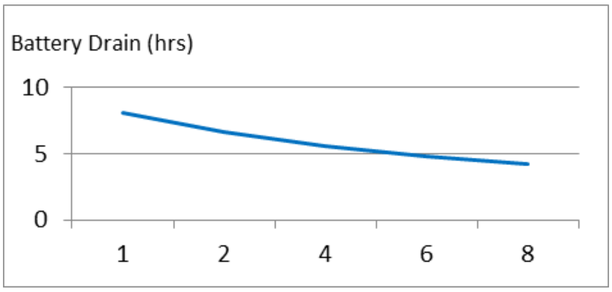

Fig.7: Battery life vs No of views

Apart from the above mentioned Bandwidth gain, Power consumption and battery savings explained above, it is also observed that the prosed system enables 360° span of viewing angle control whereas the traditional camera captured face detection methods have at max coverage of 180° only.

5. Conclusion

In this paper, a viewer-centric interactive 3D video Wi-Fi Display system is proposed. Upon receiving the user input feedback from the sink device, source device transmits only the best matching view data to the users, greatly reducing the bandwidth/bitrate requirements. Key device parameters like power consumption and the battery life are improved significantly while giving the same 3D user experience. Further, a simple and intuitive UI application is presented to ease the user interaction of changing the viewing angle.

Experimental results have shown that the proposed solution enables the user to choose viewing angle freely presenting the viewers with the best suitable views only, thus achieving the better power and performance numbers overall.

Hence, the proposal is proven to be one of the efficient interactive solutions to transmit among the multi view 3D scenes from source to sink device methods.

6. Future Scope

System can be enriched further for better automation, control and realization by way of interconnecting the devices under test using Internet of Things (IoT).IoT is a network of things enabling seamless connection and sharing of information among connected devices, thus facilitating easy means of data exchange across various devices. User interaction among devices is via IoT in this case. Hence, realization of the Wi-Fi display system using IoT technology is the future scope to enhance the proposed system further.

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