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Analyzing Impact of Video Codec, Encapsulation Methods and Streaming Protocols on the Quality of Video Streaming

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Abstract—**There are various factors involved in the transmission of video over internet. These factors have direct impact on the quality of the transmitted video. The underlying video codec, encapsulation method and protocol are the key players which affect the quality of video transmission on a network. Up to our knowledge various research studies have been carried out to analyze the impact of these factors independently on the quality of video transmission however their combined effect on video transmission is not yet done. In this paper we characterize the impact of video codec, encapsulation methods and transmission protocols of video streaming setup, while keeping in view the percent frame loss as the main investigating parameter. The results obtained from the experiments carried out for the key investigating factor are presented in the results section of this paper. To be more precise, it was observed that the wmv1, mpeg2, m-jpeg codecs, asf encapsulation and rtp protocol performs best.**

Keyword—Codec; Encapsulation; Protocol; VideoLAN Client; Video Streaming; Percent Frame Loss;

I. INTRODUCTION

In earlier days data used for communication was only in textual form. But with the advancement in technology, the transmission of multimedia data became more striking option and data like animation, pictures, voice and video became more fashionable on internet. Now there are more multimedia networking applications like internet telecommunication, internet protocol TV (IPTV) and video conferencing that are used in health, education and many other sectors [1,2,3].

These multimedia internetworking involve two modes of media transmission - the download mode and the streaming mode. In the **download mode**, a user downloads the entire video file and then plays back the video file, while in **streaming mode**, the video content need not be downloaded in full, but is being played out while parts of the content are being received and decoded [4, 5]. Among other internetworking scenarios video streaming over the Internet has been experiencing dramatic growth due to the increase in bandwidth and computing power [6, 7].

Video streaming depends on quite a lot of factors and these factors may be network dependant (e.g. bandwidth, throughput, loss etc) or independent (e.g. compression, decompression, encapsulation etc) [8]. Some of these factors that were used in our experimental setup are Frame loss, streaming server, protocols (e.g. udp, http, rtp, and mms [9]), codec (e.g. dirac, divx2, divx3, h.264, mjpeg, mpeg1, mpeg2, wmv1, wmv2), encapsulation methods (e.g. avi, ps, ogg, asf, raw, ts), resolution, bit rate, frame rate and media caching etc. A short explanation to these factors is given below.

A. *Protocols*

Protocols play an important role in streaming videos. There are various protocols available for data communication but the most commonly used protocols for video streaming include Hypertext Transfer Protocol (HTTP)[10], Universal Datagram Protocol (UDP)[11], Real Time Protocol (RTP)[12], Real Time Streaming Protocol (RTSP)[13] etc [4]. The Hypertext Transfer Protocol (HTTP) was originally designed by Tim Berners-Lee. This protocol is used by servers for communication. It is generic, stateless, object oriented protocol used for many tasks [5, 14, 15] such as name servers and distributed object management systems, typing of data representation and communication between user agents and proxies/gateways to other Internet protocols [10]. The User Datagram Protocol (UDP) is transport layer protocol. UDP provides a connectionless but unreliable datagram service over the network [3, 11]. Real time Transport Protocol (RTP) is IP based transport protocol for real time data, primarily designed for multicasting data but can also be used in unicasting [3, 5, 15]. Microsoft Media Server (MMS) Protocol is Microsoft's real time streaming protocol that uses TCP and UDP [9].

B. *Codec*

Codec is a compression algorithm used to compress the size of the media stream. There are many video codec e.g. dirac [16, 17], divx2, divx3 [18], h.264 [19], mjpeg [20, 21],

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Investigating the impact of Group Mobility Models over the On-Demand Routing Protocol in MANETs

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***Abstract*—Due to the high mobility and frequently changing network topology, the choice of suitable mobility model and routing protocol has a significant impact on the performance of Ad-hoc networks, when deployed in unmanageable and hostile mobility environments. In this paper, the performance of various Group mobility models such as RPGM, Column, Nomadic and Pursue are evaluated and examined over the On-demand routing protocol (DSR) in the realistic scenarios using performance metrics like packet delivery ratio, average delay and normalized routing load. For the implementation, Linux (Fedora) Operating System is considered as a platform for the research work that is reliable and compatible with Network Simulator (NS-2) and the mobility scenario generation tool BENCHManet. The recommendations of the research will provide better understanding of the On-demand routing protocol, Mobility Models and their use in the real world applications such as rescue and relief operations, military operations, scanning and searching, tracking and surveillance operations and many more.**

***Keywords*—MANET; DSR; RPGM; NS-2; BENCHManet.**

I. INTRODUCTION

In the past few years, the growth and development in the field of portable and mobile communication has increased sharply. The nature of computation has changed from personal computing to ubiquitous computing due to the need of such wireless and portable devices (i.e. laptop, smart phones and wearable devices).In Mobile Ad-hoc Networks the group of mobile and wireless nodes communicate with each other in a decentralized manner and without any permanent communication structure [1].The Wireless Mobile Ad-hoc Networks are impermanent network, which could be installed in no-time, anywhere, anytime. The nodes operate and communicate in decentralized fashion as a host as well as a router [2]. The Ad-hoc Network has numerous and countless applications [3]; such as rescue and relief operations, military tactical operations, scanning and searching, tracking and surveillance operations etc.

Regardless of the numerous applications, MANETs are exposed to several challenges and issues [4].In the wireless Ad-hoc network, mobile nodes has limited bandwidth and battery power hence need a routing protocol which could produce a low overhead, so in most of the situations the on-demand routing protocol provide better results[5,6], rather than pro-active routing protocol. In the on-demand routing protocol [7] the routes are discovered when needed, so the choice of suitable routing protocol has a significant impact on the performance of Ad-hoc networks.

Such networks also have another issue of frequently changing topology and uncertainty with high mobility situations. The mobility model [8] designed for movement patters must closely match the real time situation to produce better results. Such mobility models could be divided into two groups. In the entity mobility model, the nodes are independent of the movement of other mobile nodes, whereas in group mobility model, the mobile nodes are dependent on the movement of whole group.

The related work of Harris Simaremare et al. [9] evaluated the performance of modified AODV using RWP and RPGM models. Chrisy Samara et al. [10] worked on the performance comparison of three MANET routing protocols AODV, DSDV and OLSR using the real life scenarios. Arindrajit Pal et al. [11] studied the impact of traffic patterns over the on-demand routing protocols AODV and DSR for the RPGM model. Fahim and Nauman [12] analyzed the effect of MANET routing protocol AODV, DSR, DYMO, OLSR and DSDV against the three mobility models RWP, RPGM and CMM. K. Amjad [13] examined the impact of group leader's mobility using the RPGM model over the Dynamic Source Routing (DSR) Protocol in MANETs. S. R. Biradar et al. [14] analyzed the performance evaluation of on-demand routing protocols AODV and DSR using Group mobility model. Geetha Jayakumar and Gopinath Ganapathi [15] evaluated the performance comparison of reactive routing protocol AODV and DSR over the RWP and RPGM models.

The intention of the research is to evaluate the impact of group mobility models[16,17] such as RPGM, Column, Nomadic and Pursue over the on-demand routing protocol i.e. Dynamic Source Routing Protocol[18,19] in the realistic environment scenarios using performance metrics like packet delivery ratio (PDR), average delay (AD) and normalized routing load (NRL).

The rest of the paper is managed as; Section II describes the overall methodology and system design. Section III depicts the simulation environment based on realistic scenarios. Section IV contains the results and detailed discussion. Section V comprises of conclusion and future work.

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Parallel Phase Unwrapping In 3D Shape Measurement Using Digital Fringe Projection Technique

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***Abstract*—Phase unwrapping is used to get absolute phase from the wrapped phase image and remove 2π discontinuities. It is computational extensive process. It requires a lot of iterations, first in one dimension of the image and then in the other dimension, to unwrap the phase. The primary limitation of the phase unwrapping is that it is a path dependant process which can only be executed sequentially. In this paper we have developed a new method for the parallel processing of path dependant phase unwrapping. In this proposed method different blocks of image are executed parallely by separate threads independent of each other. The algorithm used in this paper is Itoh for phase unwrapping. The results achieved by parallel processing of phase unwrapping are 99% better as compared to the sequential processing.**

***Index Terms*—3D shape measurement, Parallel phase unwrapping, Itoh's algorithm.**

I. Introduction

Phase unwrapping algorithms are utilized for the removal of 2π discontinuities and for obtaining continuous phase map. It is highly computational process in which phase unwrapping is done in the wrapped phase image first in one dimension and then in the other dimension. The main challenging task of making this sequential phase unwrapping process to parallel is that it is path dependant. Phase unwrapping is applied in digital fringe projection technique to obtain 3D shape measurement. Efficient algorithms for phase unwrapping are required to speedup this process. Image based methods include stereo vision [2], photogrammetry, shape from focus defocus [3,4] shape from shading [5], structured light techniques using laser scanning [6], binary coding, multi-level gray coding, intensity ratio, time or color-coded structured light [7,8,9], wave optics-based techniques include optical interferometry, Moire contouring, digital fringe projection.

Real time 3D shape measurement can be done by using single fringe image. This single frame based 3D shape measurement speed can be done as fast as the image acquisition. To obtain the phase with the help of single fringe image is referred to as the Fourier method [10]. In [11] Guo and Huang propose a technique which obtains phase through frequency domain using two fringe images.

The paper structure is organized as follows. Section II discusses digital fringe projection setup and describes the whole process. In section III we described the algorithm for three step phase shifting. Section IV describes the phase unwrapping basic principle. Section V describes the sequential process of Itoh's algorithm. In this paper we have evaluated mathematically the efficient implementation of Itoh's algorithm which have reduced alot of computations and processing speed has been increased which is discussed in Section V(A). Section V(B) compares both the implementation of Itoh's algorithm and computes the computational complexity of both the implementations. The pseudocode of the basic implementation of Itoh's algorithm and that of the efficient implementation is shown in the Section V(B)(i) and V(B)(ii) respectively. Experimental results are shown in the Section VI that includes the processing time of both the implementations. Conclusion is described in Section VII.

II. Digital Fringe Projection System

Digital fringe projection system consists of a charge coupled device (CCD) camera, a projector, a computer for structured patterns generation. In digital fringe projection technique the digital fringes usually the sinusoidal patterns are generated through a computer and these patterns are projected through projector directly on the object surface. A CCD camera is positioned to capture the image of the fringes that are deformed by the object surface.

3D shape measurement with digital fringe projection technique can be summerized in the following steps.

1) Digital Fringe generation using personal computer
2) Projection of digital fringes on the object through projector
3) Images capturing through camera
4) Finding wrapped phase map of the captured images
5) Using phase unwrapping algorithm to obtain the continuous phase map
6) Phase to height transformation

III. Three-step Phase Shifting Algorithm

Phase shifting techniques have high speed measurement, high spatial resolution because phase retrieval and measurement is pixel by pixel and are less sensitive to the variations in the surface reflectance.

Three-step phase shifting algorithm work on three fringe images with phase shifts $0, +2\pi/3, -2\pi/3$. The intensities of the fringe images can be expressed as follows.

$$I_1 = I'(x,y) + I''(x,y)\cos[\emptyset(x,y) - 2\pi/3] \quad (1)$$

$$I_2 = I'(x,y) + I''(x,y)\cos[\emptyset(x,y)] \quad (2)$$

$$I_3 = I'(x,y) + I''(x,y)\cos[\emptyset(x,y) + 2\pi/3] \quad (3)$$

where $I'(x,y)$is the average intensity, $I''(x,y)$is the intensity modulation and $\emptyset(x,y)$ represents the wrapped phase which can be obtained as follows

$$\emptyset(x,y) = tan^{-1}\left(\sqrt{3}(I_1 - I_3)/(2I_2 - I_1 - I_3)\right) \quad (4)$$

IV. Phase Unwrapping

Phase unwrapping is considered to be the main challenge in the fringe pattern analysis. Phase data contains all the information that is required to reconstruct a 3D shape. Many phase unwrapping algorithms exist that obtain the true phase of the object to be measured. The success of the phase unwrapping algorithm lies in its ability to retrieve the true phase of the image fast and accurate. The absolute phase of the image is wrapped

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Efficient Implementation of Itoh's Algorithm in 3D Shape Measurement using Digital Fringe Projection Technique

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***Abstract*—Phase unwrapping is one of the challenging tasks in 3D shape measurement. Phase unwrapping is the computational intensive process which involves adding or subtracting multiples of 2π. In this paper the basic implementation of Itoh's algorithm[1] is shown which involves a lot of computations and unnecessary iterations to solve the phase unwrapping problem. To reduce the number of computations and iterations we have derived another implementation for Itoh's algorithm. In this implementation computational complexity has been reduced and is directly proportional to the number of pixels traversed.**

Keywords—3D shape measurement; 2D phase unwrapping; Itoh's algorithm.

I. INTRODUCTION

Digital fringe projection technique for 3D shape measurement has been used for years due to its speed and accuracy. In order to get the 3D geometric information image based methods, structured light techniques, wave optics-based techniques, time of flight are the existing techniques. Image based methods include stereo vision [2], photogrammetry, shape from shading [3], shape from focus defocus [4,5], structured light techniques include laser scanning [6], binary coding, multi-level gray coding, intensity ratio, time or color-coded structured light [7,8,9], wave optics-based techniques include optical interferometry, Moiré contouring, digital fringe projection. Digital fringe projection is widely used technique in 3D shape measurement. It has a major role in diverse fields that includes Biomedical, industrial, scientific, biometric identification applications, home security and entertainment. 3D shape acquired by the techniques where only one or two fringes patterns are used are called temporal techniques and those where more than two fringe patterns are involved are called spatial techniques. Digital fringe projection technique takes the advantage as its patterns are easily generated and can be easily switched. This technique is less erroneous as compared to the mechanical devices for different pattern generation i.e., phase shifted and multi-frequency patterns.

Real time 3D imaging can be done using a single fringe image. Here the 3D imaging speed can be as fast as the image acquisition speed. To obtain the phase by using a single fringe image is called the Fourier method proposed by Takeda and Mutoh [10]. Guo and Huang [11] introduced a technique that uses two fringe images in order to obtain phase in the frequency domain. Using two fringe images it becomes difficult to measure complex 3D surfaces where surface changes are faster than the fringe changes. Three fringe images are required to uniquely identify the phase.

Rest of the paper is organized as follows. In section II we discuss digital fringe projection system and described the whole setup of this process. In section III we described the three step phase shifting algorithm. Section IV describes the phase unwrapping basic principle. Section V describes the basic principle of Itoh's algorithm. In this paper we have evaluated mathematically the efficient implementation of Itoh's algorithm which have reduced alot of computations and processing speed has been increased which is discussed in Section V(A). Section V(B) compares both the implementation of Itoh's algorithm and computes the computational complexity of both the implementations. The pseudocode of the basic implementation of Itoh's algorithm and that of the efficient implementation is shown in the Section V(B)(i) and V(B)(ii) respectively. Experimental results are shown in the Section VI that includes the processing time of both the implementations. Conclusion is described in Section VII.

II. DIGITAL FRINGE PROJECTION SYSTEM

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Performance Evaluation of Stack-Protocols, Encapsulation Methods and Video Codecs for Live Video Streaming

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***Abstract*— There are diverse factors involved in the transmission of live video over internet. These factors have direct impact on the quality of the transmitted video. The underlying protocol, encapsulation method and the choice of video codec are the key factors involved in the transmission of video over streaming network. Up to our knowledge various studies have been performed to analyze the impact of these factors individually on the quality of video transmission however their joint impact on video transmission is not yet done. In this paper we characterize the performance of live video streaming setup, while keeping in view the effect of stack-protocol, encapsulation method and the underlying video codec on delay as the key investigating parameter. The results obtained while considering diverse video streaming setups are provided in the results section of this paper. More specifically, it was observed that stack (http, mjpeg, mjpeg) performs best and stack (mms, asf, wmv1) perform worst.**

Keyword—Stack; Protocol; Encapsulation; Codec; VideoLAN Client; Video Streaming;

I. INTRODUCTION

Heterogeneous computer networks exist to connect different types of computers for sharing of data and communication of information. These computers can be on different locations that may be within a city or two different parts of the world. In the old days data carried through these networks was only in textual form. But with the passage of time and advancement in technology, the transmission of multimedia data became more attractive choice and data like animation, pictures, voice and video became more popular on internet. Now these multimedia networking applications like internet telecommunication, internet protocol TV (IPTV) and video conferencing are used in health, education, e-commerce and many other sectors [1].

These multimedia communication scenarios involve two modes of media transmission -the download mode and the streaming mode. In the **download mode**, a user downloads the entire video file and then plays back the video file, while in **streaming mode**, the video content need not be downloaded in full, but is being played out while parts of the content are being received and decoded [2], [8], [9]. Streaming video over the Internet has been experiencing dramatic growth due to the increase in bandwidth and computing power [3].

Video streaming depends on several factors and these factors may be network dependant or independent [4]. The network dependant factors are those factors which are dependent on the network (e.g. bandwidth, throughput, loss etc) while those factors which are not dependent on the network (e.g. compression, decompression, encapsulation etc) are independent factors. Some of these factors that were used in our experimental setup are delay, streaming server, protocols (e.g. udp, http, rtp, and mms), codec (e.g. dirac, divx2, divx3, h.264, mjpeg, mpeg1, mpeg2, wmv1, wmv2), encapsulation methods (e.g. avi, ps, ogg, asf, raw, ts), resolution, bit rate, frame rate and media caching etc.

A brief description of those factors is given below.

A. *Delay*

It is the amount of time taken by a bit to travel from source to destination. It is also called the Latency [5], [6]. In real time video streaming, if video packets are not arrived in time they become useless [2].

B. *Protocols*

Protocols play an important role in streaming videos. Furthermore, transport protocols are also one of the subsystems of the streaming server. There are many protocols available for data transmission but the most widely used protocols for video streaming include Hypertext Transfer Protocol (HTTP), Universal Datagram Protocol (UDP), Real Time Protocol (RTP), Real Time Streaming Protocol (RTSP) etc [2].

The Hypertext Transfer Protocol (HTTP) was originally designed by Tim Berners-Lee. This protocol is used by servers for communication. It is generic, stateless, object oriented protocol used for many tasks [7], [9], [13] such as name servers and distributed object management systems, typing of