VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM, KARNATAKA

PROJECT REPORT

ON

Implementation of automotive system reduce bandwidth usage in real time video system

Submitted in partial fulfillment of the requirement for the award of the degree of

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IN

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Submitted by

USN	NAME
2SD18CS015	Ananth Dayakar Hegde
2SD18CS016	Ankit Anand
2SD18CS130	S Varun
2SD18CS059	Mohammed Usman E Gani

Under the Guidance of

Dr. Umakant P Kulkarni

Dept. of CSE, SDMCET, Dharwad

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

S.D.M. COLLEGE OF ENGINEERING & TECHNOLOGY,

DHARWAD-580002

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S.D.M COLLEGE OF ENGINEERING & TECHNOLOGY, DHARWAD –580002

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

CERTIFICATE

Certified that the project work and presentation entitled **"Implementation of automotive system reduce bandwidth usage in real time video system"** *is a bonafide work carried out by* **Ananth Dayakar Hegde (2SD18CS015), Ankit Anand (2SD18CS016), S Varun (2SD18CS130), and Mohammed Usman E Gani (2SD18CS059),** *students of S. D. M. College of Engineering & Technology, Dharwad, in partial fulfillment for the award of* **Bachelor of Engineering in Computer Science and Engineering of** ***Visvesvaraya Technological University, Belgaum****, during the year 2021-202. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report deposited in the department library. The Project has been approved, as it satisfies the academic requirements in respect of project report prescribed for the said degree.*

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Dr. Umakant P Kulkarni — **Dr. S. M. Joshi**

Project Guide — HoD-CSE

External Viva

Name of Examiners — Signature with date

1. ______________________
2. ______________________

ABSTRACT

The project is titled "Implementation of automotive system reduce bandwidth usage in real time video system".

Wireless sensor networks (WSN) connect small devices, each of which has its own sensing computation and communication components and power sources. The task of such networks which are distributed and adhoc is generally to monitor the environment and collect specific data such as temperature, pressure, and humidity. But such sensors generate a limited amount of information which can be insufficient for many applications even if large sensors are deployed. Hence the need arises for WSNs with multi-dimensional data sensors such as camera sensors to which are referred as visual sensor networks (VSNs). With recent advances in imaging technologies, producing small, low-power, low-cost image/video capture devices at a large scale may be within reach in the foreseeable future.

Thus this project's main aim is to reduce network traffic when using real time video services such as video conferencing or surveillance. This can allow for businesses and people to reduce costs and lead a more sustainable and green economy even while using high energy services.

The project contains 2 main components, mainly, the client-side reconstruction library and the server-side differentiating and parsing engine. Both will be integrated into the final software.

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CHAPTER 1
PROBLEM STATEMENT AND INTRODUCTION

1.1 PROBLEM STATMENT

Implementation of automotive system reduce bandwidth usage in real time video system

1.2 INTRODUCTION

Wireless sensor networks (WSNs) have attracted significant interest from both academia and industry on applications in security, medical, military, environment, industrial and transportation fields. A typical architecture of a WSN consists of distributed sensors that capture, process, transmit and receive data to collaboratively serve users via the base station, which usually works as a gateway and helps coordinate the network. As one of the most recent advances of WSNs, wireless visual sensor networks (WVSNs) further expand the capacities of such networks with cameras mounted on sensor nodes that allow the recording and processing of images and/or videos. This unique feature makes WVSNs different from traditional WSNs in several ways and renders the solutions proposed for traditional WSN deployment inapplicable to solve the WVSN deployment problem. Wireless sensor networks (WSN) connect small devices, each of which has its own sensing computation and communication components and power sources. The task of such networks which are distributed and adhoc is generally to monitor the environment and collect specific data such as temperature, pressure, and humidity. But such sensors generate a limited amount of information which can be insufficient for many applications even if large sensors are deployed. Hence the need arises for WSNs with multi-dimensional data sensors such as camera sensors to which are referred as visual sensor networks(VSNs). With recent advances in imaging technologies, producing small, low-power, low-cost image/video capture devices at a large scale may be within reach in the foreseeable future. The extensive research has been done in the many directions that contribute to the visual sensor networks.

However, the real potential of these networks can be reached through a cross-disciplinary research approach that considers all the various aspects of visual sensor networks: vision processing, networking, sensor management, and hardware design.

However, in many cases of the existing work there is no coherence between the different aspects of visual sensor networks. For example, networking protocols used in visual sensor networks are mainly adapted from the routing protocols used in traditional wireless sensor networks, and thus do not provide sufficient support for the data-hungry, time-constrained, collaborative communication of visual sensor networks. Similarly, embedded vision processing algorithms used in visual sensor networks are based on existing computer vision algorithms, and thus they rarely consider the constraints imposed by the underlying wireless network.

Thus, future efforts should be directed toward finding ways to minimize the amount of data that has to be communicated, by finding ways to describe captured events with the least amount of data. Additionally, the processing should be lightweight—information rich descriptors of objects/scenes are not an option. Hence, the choice of the "right" feature set, as well as support for real-time communication will play a major role in a successfully operated task.

Hence this project focuses on developing a prototype of a system that tries to automatically reduce the bandwidth usage in real time video processing systems.

CHAPTER 2
LITERATURE SURVEY

Wireless sensor networks (WSNs) are an important research area that has attracted considerable attention. Most of this attention, however, has been concentrated on WSNs that collect scalar data such as temperature and vibration. Scalar data can be insufficient for many applications such as automated surveillance and traffic monitoring.

One of the main differences between visual sensor networks and other types of sensor networks lies in the nature of how the image sensors perceive information from the environment. Most sensors provide measurements as 1D data signals. However, the image sensor provides a 2D set of data points, which we see as an image. The additional dimensionality of the data set results in richer information content as well as in a higher complexity of data processing and analysis.

Hence these camera sensors collect visual data which are rich in information and thus offers tremendous potential when used in WSNs.

Thus, Wireless visual sensor networks (WVSNs) provide great opportunities to use a large number of low-cost low-resolution camera-equipped sensor nodes to monitor the areas of interest thanks to the rapid development of sensor technology

with cost reduction. As compared to traditional wireless sensor networks (WSNs) that can only provide scalar data (e.g., temperature, light, sound, pressure, vibration, etc.), visual data (e.g., image/video) can provide much richer sensing and

monitoring information, enabling more applications such as security, military, industrial, medical and environmental monitoring.

Hence Visual sensor networks have emerged as an important class of sensor-based distributed intelligent systems, with unique performance, complexity, and quality of service challenges. Consisting of a large number of low-power camera nodes, visual sensor networks support a great number of novel vision-based applications.

The camera nodes provide information from a monitored site, performing distributed and collaborative processing of their collected data. Using multiple cameras in the network provides different views of the scene, which enhances the reliability of the captured events. However, the large amount of image data produced by the cameras combined with the network's resource constraints require exploring new means for data processing, communication, and sensor management. Visual sensor networks are in many ways unique and more challenging compared to other types of wireless sensor networks.

One of the major characteristics of the visual sensor networks is local processing of the data. Local (on-board) processing of the image data reduces the total amount of data that needs to be communicated through the network. Local processing can involve simple image processing algorithms (such as background subtraction for motion/object detection, and edge detection) as well as more complex image/vision processing algorithms (such as feature extraction, object classification, scene reasoning).

Thus, depending on the application, the camera nodes may provide different levels of intelligence, as determined by the complexity of the processing algorithms they use. For example, low-level processing algorithms (such as frame differencing for motion detection or edge detection algorithms) can provide a camera node with the basic information about the environment, and help it decide whether it is necessary to transmit the captured image or whether it should continue processing the image at a higher level. More complex vision algorithms (such as object feature extraction, object classification, etc.) enable cameras to reason about the captured phenomena, such as to provide basic classification of the captured object. Furthermore, the cameras can collaborate by exchanging the detected object features, enabling further processing to collectively reason about the object's appearance or behavior.

At this point the visual sensor network becomes a user-independent, intelligent system of distributed cameras that provides only relevant information about the monitored

phenomena. Therefore, the increased complexity of vision processing algorithms results in highly intelligent camera systems that are oftentimes called smart camera networks.

Most applications of visual sensor networks require real-time data from the camera nodes, which imposes strict boundaries on maximum allowable delays of data from the sources (cameras) to the user (sink). The real-time performance of a visual sensor network is affected by the time required for image data processing and for the transmission of the processed data throughout the network. Constrained by limited energy resources and by the processing speed of embedded processors, most camera nodes have processors that support only lightweight processing algorithms. On the network side, the real-time performance of a visual sensor network is constrained by the wireless channel limitations (available bandwidth, modulation, data rate), employed wireless standard, and by the current network condition. For example, upon detection of an event, the camera nodes can suddenly inject large amounts of data in the network, which can cause data congestion and increase data delays. Different error protection schemes can affect the real-time transmission of image data through the network as well. Commonly used error protection schemes, such as automated-repeat-request (ARQ) and forward-error-correction (FEC) have been investigated in order to increase the reliability of wireless data transmissions. However, due to the tight delay constraints, methods such as ARQ are not suitable to be used in visual sensor networks. On the other hand, FEC schemes usually require long blocks in order to perform well, which again can jeopardize delay constraints.

The cameras generate large amounts of data over time, which in some cases should be stored for later analysis. An example is monitoring of remote areas by a group of camera nodes, where the frequent transmission of captured image data to a remote sink would quickly exhaust the cameras' energy resources. Thus, in these cases the camera nodes

should be equipped with memories of larger capacity to store the data. To minimize the amount of data that requires storage, the camera node should classify the data according to its importance by using spatiotemporal analysis of image frames, and decide which data should have priority to be stored. For example, if an application is interested in information about some particular object, then the background can be highly compressed and stored, or even completely discarded.

But however, they raise new challenges such as the transmission of visual data with huge computational and bandwidth requirements in mainly low-power visual sensors networks. It is largely agreed on the following points of VSNs

1. Streaming all data is impractical due to server energy and bandwidth constraints. In order to keep communication between cameras or camera and the base station to minimal, the cameras need to have the ability to estimate whether the information they provide contributes to the monitoring task.
2. Processing cost is significantly lower than communications cost. Thus, it is necessary to determine network architecture and the numbers of different types of sensors that should be used in a particular application, so that all of the sensors are optimally utilized while at the same time the cost of the network is kept low.
3. It makes sense to reduce the size of data before sending

4. Visual data processing is computationally expensive
5. No easy answer to the question of how and where visual data should be managed
   1. where ➜ at the node at Base station or at all
   2. How ➜ compression, fusing and filtering, etc.
6. VSNs are focused on particular application goals.
7. Field of View (FOV) i.e., coverage, and connectivity are coupled issues.
8. Coverage optimization is more complex, but the optimization mechanism must have low complexity
9. It is challenging to design interaction and communication protocols.
10. Correlation of data among adjacent camera sensors is the major challenge.
11. Need for a protocol that supports vertical inter-tier and horizontal intra-tier collaboration.
12. Reliability of sending data is crucial

Hence based on the survey it is evident that current research trends in visual sensor networks are divided into two directions. The first direction leads toward the development of visual sensor networks where cameras have large processing capabilities, which makes them suitable for use in a number of high-level reasoning applications. Research in this area is directed toward exploring ways to implement existing vision processing algorithm onto embedded processors. Oftentimes, the networking and sensor management aspects are not considered in this approach. The second direction in visual sensor networks research is motivated by the existing research in wireless sensor networks. Thus, it is directed toward exploring the methods that will enable the network to provide small amounts of data from the camera nodes that are constrained by resource limitations, such as remaining energy and available bandwidth. Thus, such visual sensor networks are designed with the idea of having data provided by the network of cameras for long periods of time.

CHAPTER 3
DETAILED DESIGN

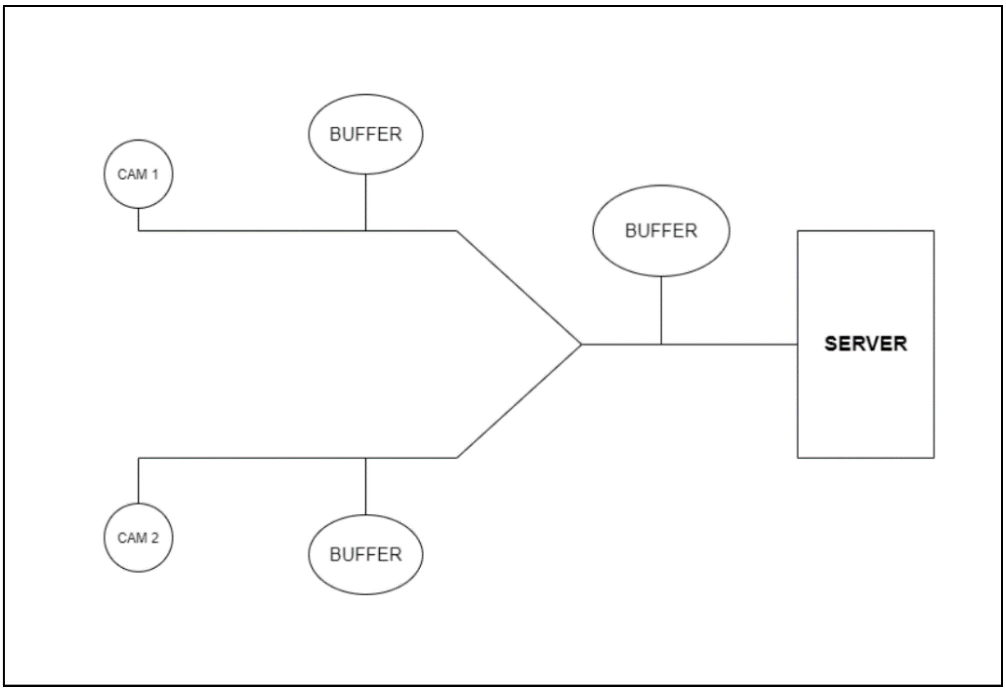

Fig: 3.1 Architecture Diagram

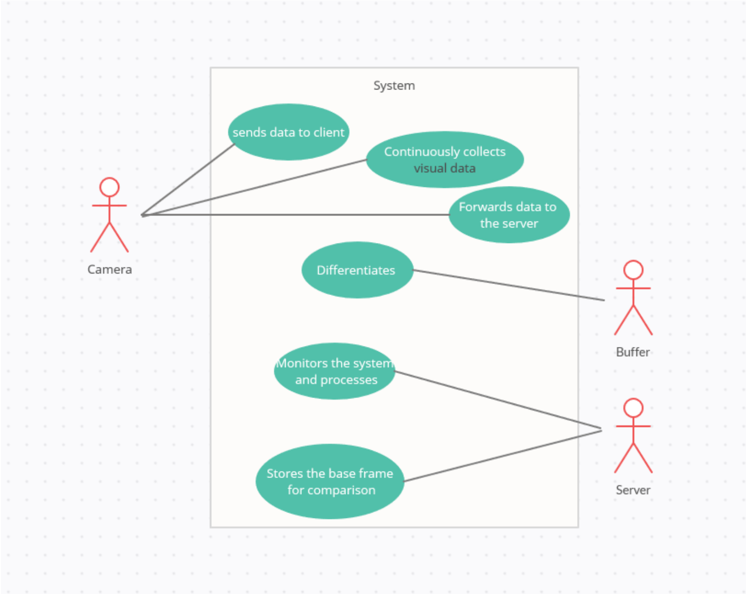

Fig: 3.2 Use Case Diagram

1. An interface to capture images from a webcam, continuously and also extract selected frames for processing
2. Client-server model where multiple clients (WEBCAM) send data to the server for display (Continuous).
3. Measurement of Quality if the image at the server
4. Processing of image at server-side and integrating the algorithm to compare with previous frame captured and management of associated image accordingly.
5. Customer environment: Elegant User Interface for surveillance.

CHAPTER 4
PROJECT SPECIFIC REQUIREMENTS

The project specific requirements are as below:

1. To Understand the technologies to be used in the implementation of the project.
2. Design of test bed (Virtual sandbox for experimentation) and optimization of the algorithm. The test bed is used for experimentation and optimization of the protocol and algorithm.
3. Development of test bed, where the test bed is supposed to show all the clients that are currently connected to the particular room, while also providing basic metrics like latency, frame per sec, bandwidth saved.
4. Development of image differentiating and reconstruction suites.
5. On the server, the differentiating engine acts as a pre-processor, comparing the previous frame to the current frame and sending the differences and reconstructs the video. On the client side, the frame is then reconstructed based on the data received.
6. Integration of above-mentioned engines with the testbed.

CHAPTER 5
TECHNOLOGIES USED

5.1. Developing the test bed:

ReactJS is used to develop a testbed ui , it is an open-source, component-based front end library responsible only for the view layer of the application. It is maintained by Facebook. React uses a declarative paradigm that makes it easier to reason about your application and aims to be both efficient and flexible.

5.2. Developing image differentiating library:

a. Programming language: Python is used to develop the image differentiating library.
b. OpenCV: OpenCV is a library of programming functions mainly aimed at real-time computer vision. By using it, one can process images and videos to identify objects, faces, or even handwriting of a human. When it integrated with various libraries, such as NumPy, python can process the OpenCV array structure for analysis.
c. Nodejs: As an asynchronous event-driven JavaScript runtime, Node.js is designed to build scalable network applications. It is an open source development platform for executing JavaScript code server-side. Nodejs is useful for developing applications that require a persistent connection from the browser to the server and is often used for real-time applications such as chat, news feeds and web push notifications

CHAPTER 6
IMPLEMENTATION

6.1. Design of test bed:

a. Two Clients

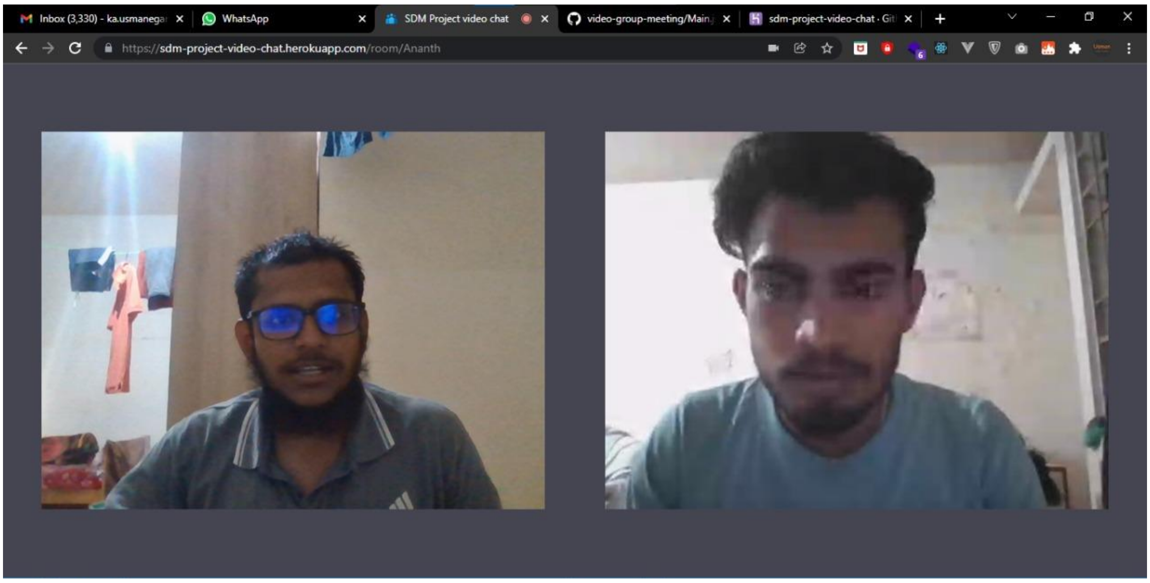

Fig: 6.1.a Two Clients

b. Multiple Clients

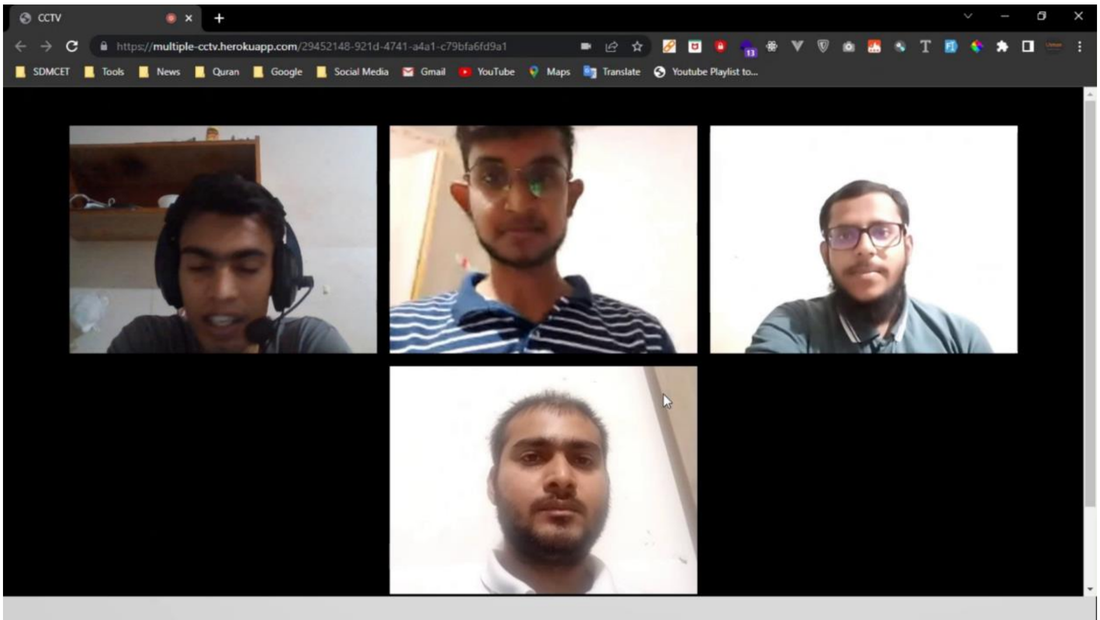

Fig: 6.1.b Multiple Clients

6.2. Frame Processing:

a. Frame Detection

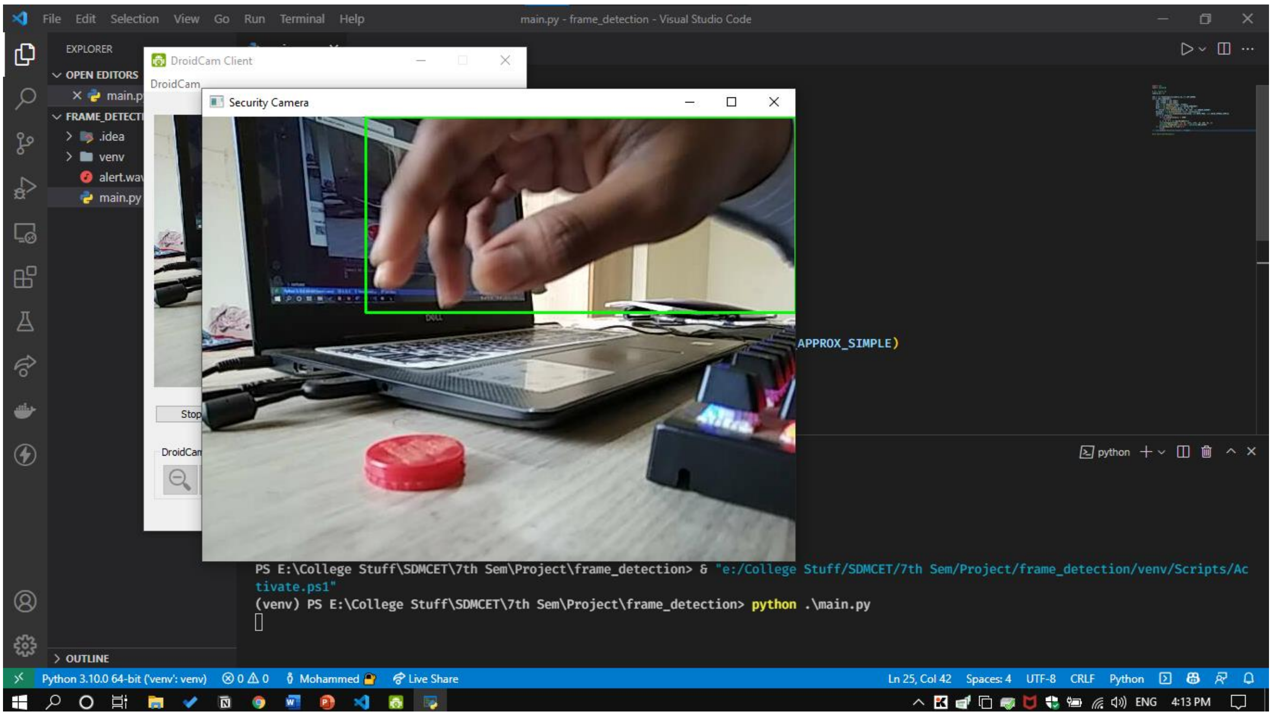

Fig: 6.2.a Frame Detection 1

b. Frame Detection

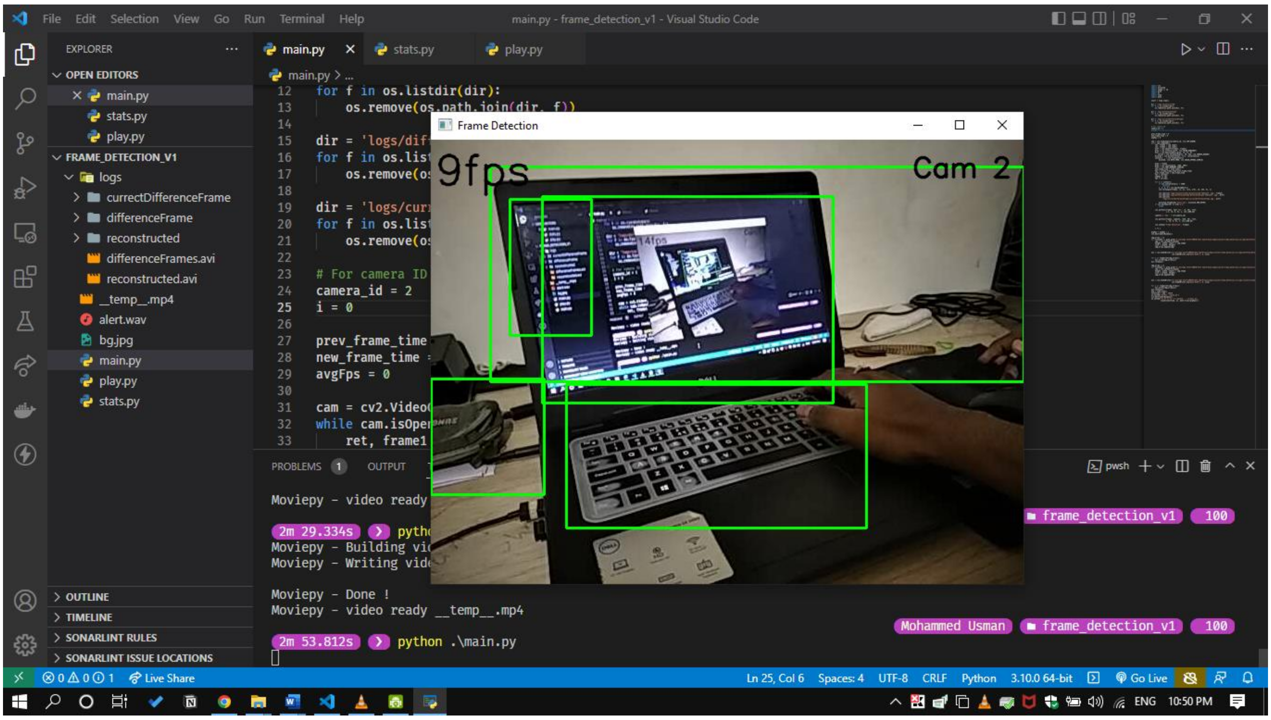

Fig: 6.2.b Frame Detection 2

c. Logs

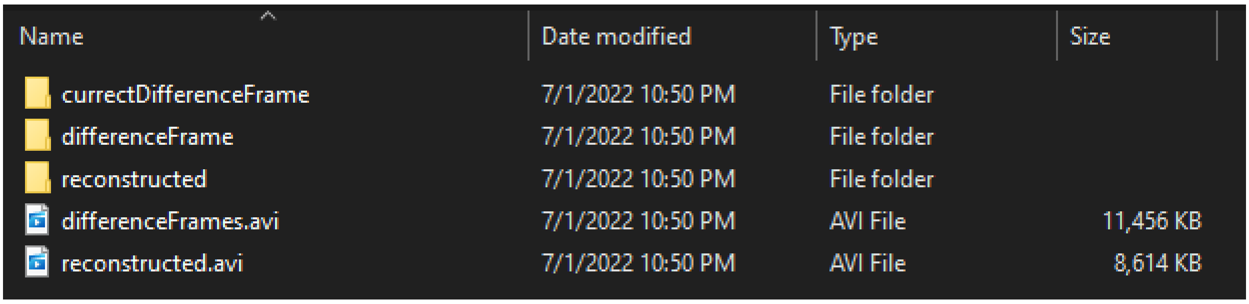

Fig: 6.2.c Logs

d. Logs (differentiating)

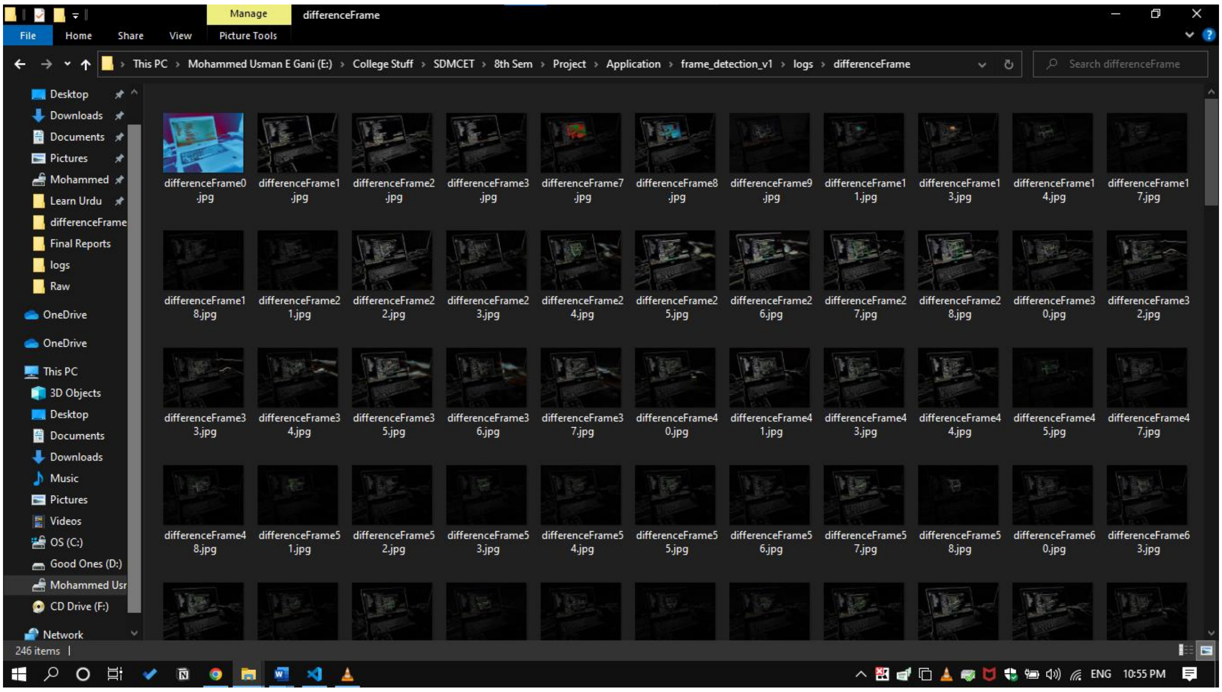

Fig: 6.2.d Logs (Differentiating)

e. Logs

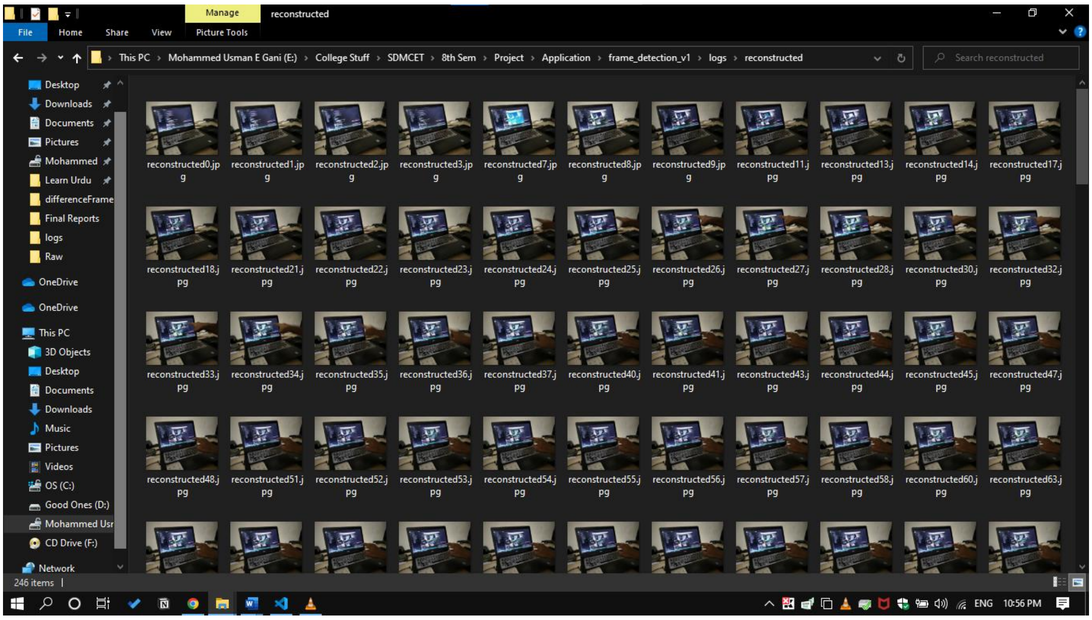

Fig: 6.2.e Logs

f. Comparison

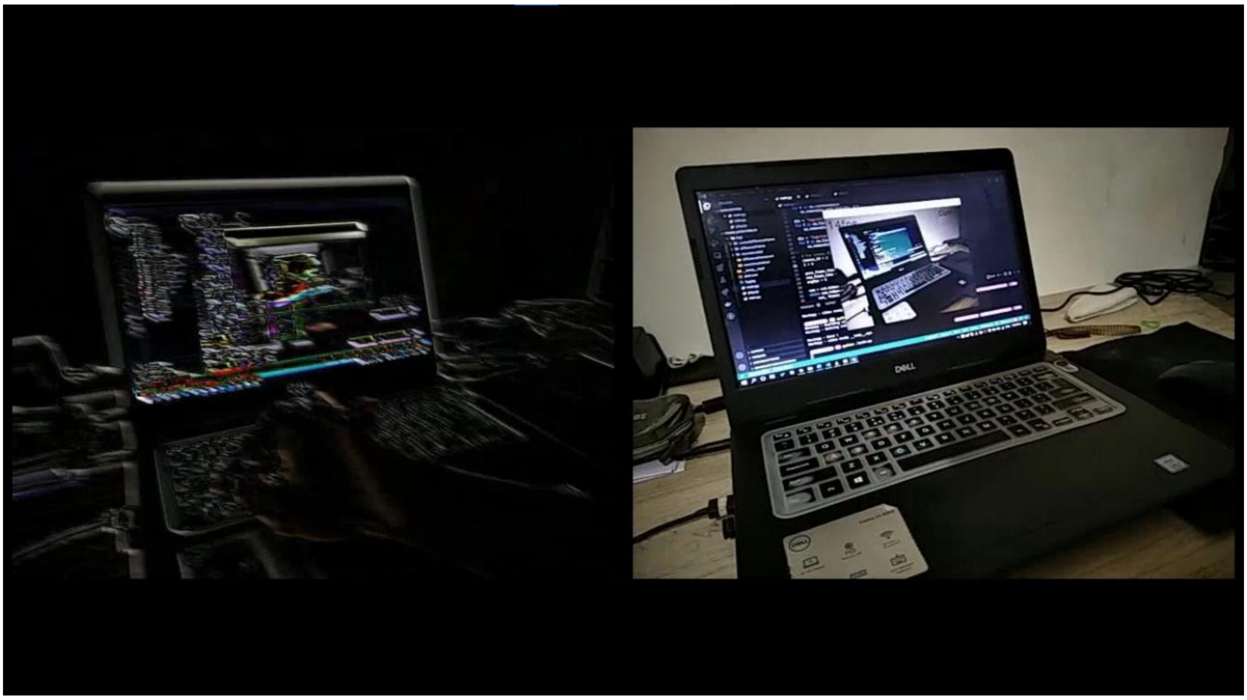

Fig: 6.2.f Comparison

g. Statistics

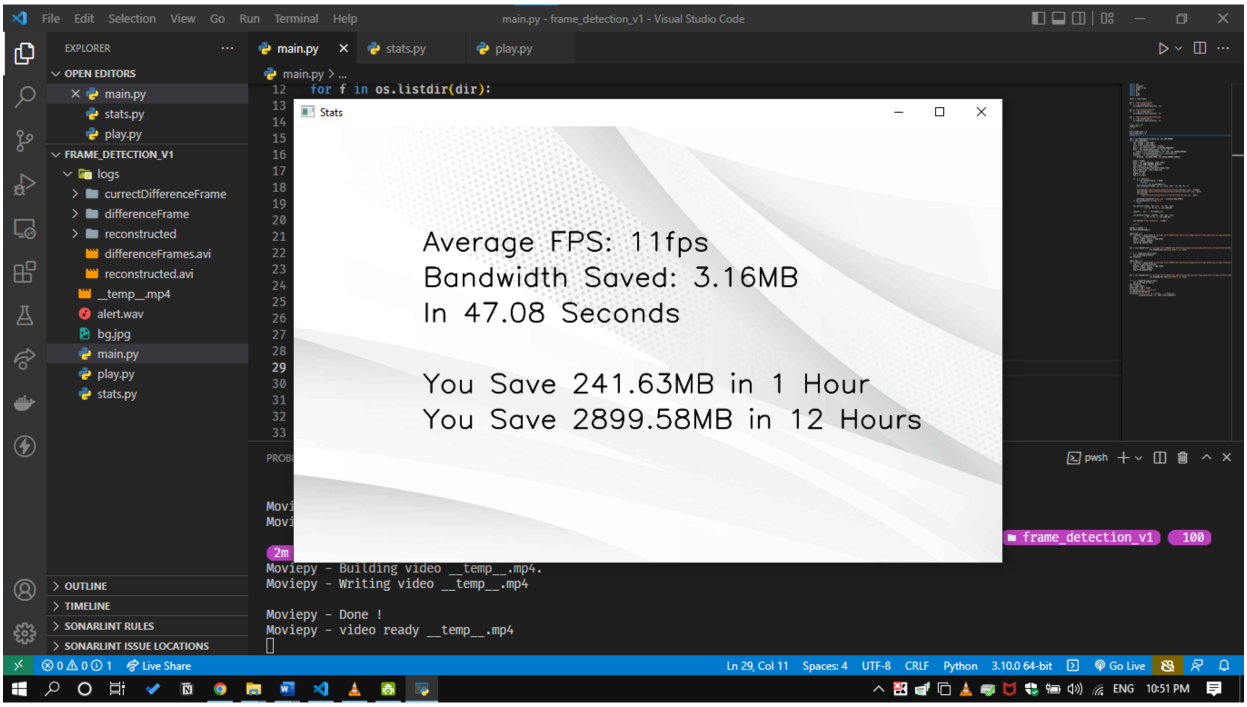

Fig: 6.2.g Statistics

h. Proofs

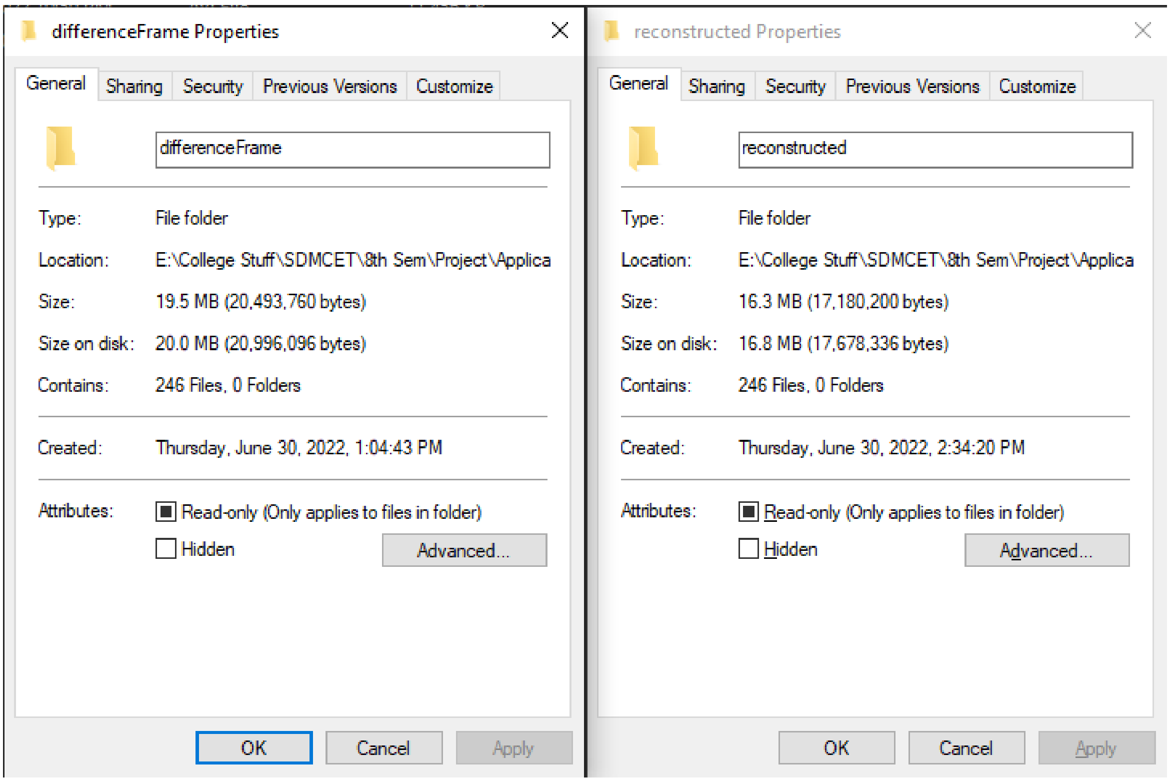

Fig: 6.2.h Proofs

CHAPTER 7
CONCLUSION

1. The team's first approach was to use socket programming to transfer frames and metadata over the client-server architecture, however, the team faced issues with committing multi-client functionality with socket architecture.

2. Then the team decided to implement a well-known library, Web RTC for implementing multi-client architecture. The differentiating library was moved to JavaScript and so was the reconstruction library. Upon using JavaScript, multi-client architecture was implemented, however, due to the synchronous nature of Web RTC, original frames in the buffer were being sent i.e., the Web RTC function was not waiting for the differentiating library to create the frame difference. As a result, the client-side reconstruction library was getting fed full images, resulting in huge amounts of delay in reconstruction.

3. The team then decided to pivot the project into a non-real time software by using it for video compression instead of real time video transport and found a significant improvement in the amount of storage and data used to transport the video files and frames generated.

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