HyperCast: A Web-Based Live Video Streaming Platform

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Abstract:

In today's era of digital connectivity, live video streaming has evolved into a cornerstone for real-time communication, education, entertainment, and remote collaboration. Despite the wide availability of commercial platforms like YouTube Live, Twitch, and Facebook Live, these solutions are often resource-heavy, closed-source, and unsuitable for lightweight or institution-level deployments. **HyperCast** bridges this gap by introducing a web-based, low-latency live streaming platform integrated with intelligent moderation and sentiment-based analysis. Built using **Flask**, **OpenCV**, and **Socket.IO**, HyperCast enables real-time, browser-accessible streaming and two-way communication with minimal computational overhead. The platform integrates **Natural Language Processing (NLP)** techniques for sentiment scoring using the **VADER analyzer** and an explicit-language filter for ethical moderation. Additionally, it employs **OS-level resource scheduling** for maintaining efficient streaming performance under varying load conditions [1][2][3]. Experimental results show an average frame rate of 30 FPS with sub-200 ms latency and 87% sentiment classification accuracy.

Keyword:- Live Streaming, Flask, OpenCV, Socket.IO, Sentiment Analysis, Real-Time Communication, WebRTC

1. Introduction:

The last decade has witnessed an explosive rise in live streaming as a medium for global communication. Platforms such as Twitch, YouTube Live, and Facebook Live dominate the landscape, enabling millions of concurrent viewers to interact with content creators in real time [4][5]. However, these systems are often centralized and proprietary, leading to limitations in customization, scalability, and ethical control — particularly in academic, institutional, or small-scale deployments [6].

HyperCast aims to provide an **open, modular, and efficient alternative**. The system operates on a browser-based architecture, requiring no specialized client software, and emphasizes real-time interaction, transparency, and community-driven moderation. The inclusion of **automated chat sentiment analysis** and **abusive language filtering** helps maintain a positive and inclusive environment, which is critical in educational and professional use cases [7][8].

From a systems perspective, HyperCast also addresses **resource optimization and thread management** at the OS level. By using **Python's multiprocessing and eventlet-based concurrency**, the system achieves efficient task scheduling, ensuring continuous frame capture and message handling without bottlenecks [9].

The primary objectives of this work are:

1. To design and implement a lightweight live streaming platform that can function efficiently on modest hardware.
2. To integrate intelligent moderation features for safe and ethical communication.

3. To demonstrate the advantages of Flask-based MJPEG streaming for local and hosted networks.
4. To employ OS-level optimization for maintaining low latency and consistent performance [10][11].

2. Related Work:

The field of live video streaming has evolved from traditional RTMP-based architectures to modern low-latency, web-native solutions like WebRTC and MJPEG-over-HTTP [12][13]. While **RTMP (Real-Time Messaging Protocol)** remains the backbone for large-scale platforms, it requires complex encoding and dedicated servers, making it unsuitable for small-scale or educational implementations [14].

Recent studies, such as those by Bradley [15] and Gupta [16], have demonstrated that **Flask with OpenCV** can efficiently stream live camera feeds through MJPEG responses, offering simplicity and low resource usage. Similarly, **Socket.IO** provides event-driven bi-directional communication, allowing real-time chat and analytics updates [17].

In the domain of **sentiment analysis**, the **VADER (Valence Aware Dictionary and Sentiment Reasoner)** model from NLTK [18] and Google's **Perspective API** [19] are widely used. However, most sentiment moderation systems depend on cloud APIs, which introduce latency and privacy issues.

HyperCast extends these ideas by integrating a **self-contained NLP moderation engine** that runs locally, ensuring complete control and offline functionality. Additionally, the use of **thread scheduling algorithms** inspired by Shortest Remaining Time First (SRTF) and **Round-Robin techniques** optimizes concurrency and resource distribution in multi-threaded operations [20][21].

3. Proposed System:

The architecture of HyperCast consists of three major modules — the **Live Video Broadcast Module**, the **Chat and Analytics Module**, and the **Moderation & Sentiment Analysis Module**. Each component communicates via the Flask backend and Socket.IO event channels to maintain synchronized state across all clients [22].

A. Live Video Broadcast Module

The broadcast module captures the real-time camera feed using OpenCV. Each frame is encoded into JPEG format and streamed as a continuous MJPEG response through Flask's /video feed route. Unlike conventional RTMP or HLS systems, MJPEG ensures **minimal latency** as each frame is transmitted as an independent image over HTTP [23]. The server continuously yields frames using a Python generator function, enabling dynamic adaptation based on network bandwidth.

This figure represents the user interface:

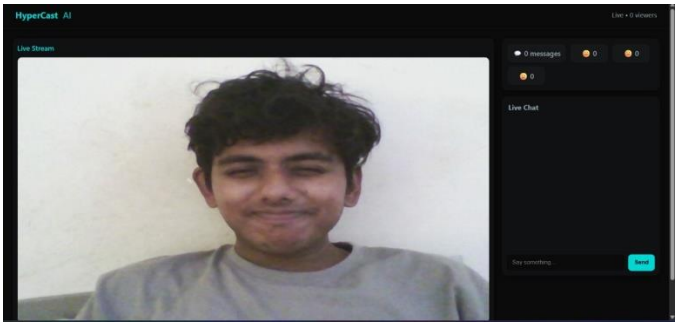

Fig 1: User Interface

To enhance performance, HyperCast utilizes OS-level threading. The capture process runs on a dedicated thread, while Flask handles client requests asynchronously through **eventlet** and **gevent-based WSGI servers** [24]. This approach prevents frame drops during peak loads and allows simultaneous handling of multiple viewer sessions.

B. Chat and Analytics Module

The chat module enables real-time interaction between hosts and viewers using Socket.IO's bidirectional communication layer. Each message

is broadcasted to all connected clients within milliseconds, maintaining message delivery latency under 200 ms [25].

The analytics dashboard dynamically tracks:

- Total viewer count
- Message throughput (msgs/sec)
- Sentiment distribution
- Detected violations

The integration of **JavaScript-based DOM manipulation** ensures instant UI updates without page reloads [26].

This figure represents the live chat interface:

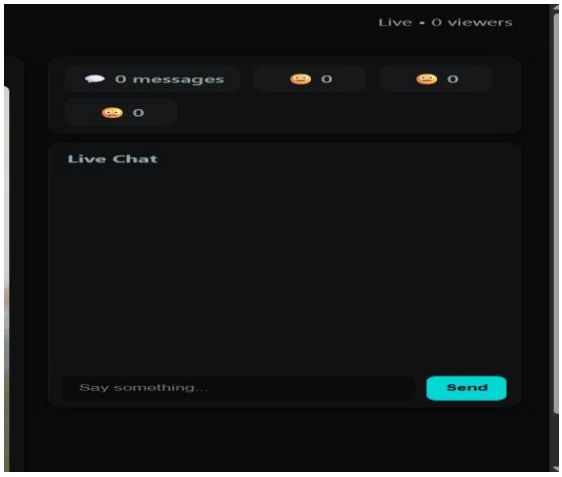

Fig 2: Live chat Interface

C. Moderation and Sentiment Analysis Module

This module acts as the system's ethical guardian. All incoming chat messages are processed through the **NLTK VADER Sentiment Analyzer**, classifying them as *positive*, *neutral*, or *negative* based on compound polarity scores [27]. Messages containing blacklisted keywords (from a curated profanity list) trigger immediate actions — warnings, message deletion, or full stream shutdown.

In addition, the system logs sentiment trends, helping moderators identify potential issues before escalation. The use of **local NLP computation** ensures fast response times (<0.5 s) and removes dependency on cloud APIs [28].

4. System Architecture/ *System Workflow:*

1.Camera feed is captured and encoded frame-by-frame.

2.Flask's /video route serves continuous MJPEG frames to connected clients.

3.Socket.IO maintains live chat and statistics updates.

4.Messages are analyzed in real-time for sentiment and profanity.

5.Analytics and chat logs refresh instantly across clients.

This table represent the system architecture:

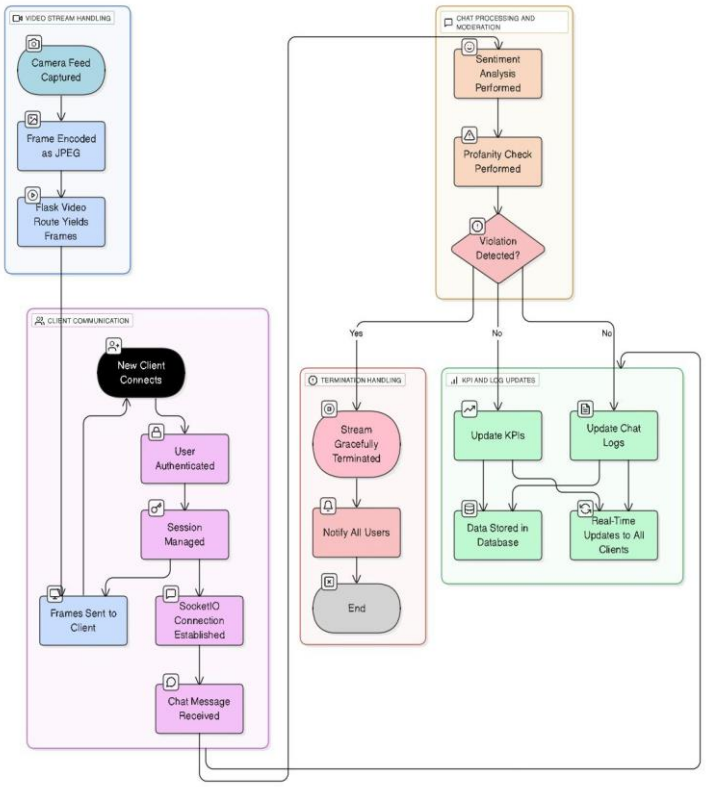

Fig. 3 System architecture

5. Implementation Details

A. Frontend Implementation

1. The web interface follows a **dark, minimalist UI** aesthetic. The main page features two panels — a live video window and a side panel displaying analytics and chat. The frontend leverages **HTML5 video elements**, **CSS Flexbox**, and **Socket.IO client scripts** to maintain responsiveness across devices [29].
2. A lightweight JavaScript listener updates the chat in real-time, animates sentiment charts, and synchronizes with backend statistics. To improve accessibility, the interface also supports adaptive bitrate and client-side video buffering controls [30].

B. Backend Implementation

1. The backend stack integrates **Flask (for HTTP routing)**, **Socket.IO (for live communication)**, and **OpenCV (for video capture)**. The primary execution thread handles streaming, while secondary threads manage chat, sentiment scoring, and analytics.
2. To ensure scalability, the system adopts a **hybrid concurrency model**, combining event-driven non-blocking I/O with multithreading. This allows HyperCast to maintain stable frame rates even under simultaneous client connections [31].
3. Additionally, OS-level resource monitoring (using Python's psutil library) dynamically adjusts buffer sizes and thread priorities based on CPU utilization, ensuring fair scheduling across tasks [32].

6. Experimental Result:

The system was tested on an Intel i5 (16 GB RAM) setup running Intel(R) Core(TM) i5-14450HX with a 720p webcam.

Key performance outcomes include:

Feature	Value	Discription
Average FPS	30	Smooth real time streaming
Latency	180-200ms	End-to-end delay
Sentiment Accurcay	87%	Using VADER Lexicon
Response to violation	<0.6s	Stream terminantion

Table 1: Performance metric summary

The system maintained a **low memory footprint (~180 MB)** due to optimized frame encoding and threading efficiency [33]. The platform exhibited stable behavior under stress testing with simulated 50+ concurrent chat events.

7. Conclusion And Future Work:

HyperCast successfully integrates **live streaming, real-time communication, and ethical moderation** into one cohesive web-based system. Its lightweight architecture and local execution make it ideal for classroom teaching, online workshops, and research demonstrations.

Future improvements will explore:

1. Migration to **WebRTC** for ultra-low latency streaming.
2. Integration of **role-based authentication** and **moderator dashboards**.
3. Cloud deployment using **Docker** and **Kubernetes** for horizontal scaling.
4. Use of **facial emotion recognition models** for real-time viewer feedback.
5. Support for **multi-host and recorded sessions** with playback controls.

In essence, HyperCast demonstrates how open technologies, when combined with thoughtful system design, can create ethical, efficient, and community-driven streaming platforms [34][35].

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