International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience

Koffka Khan[1], Wayne Goodrige[1]
[1]Department of Computing and Information Technology, Faculty of Science and Agriculture, The University of the West Indies, St. Augustine Campus, TRINIDAD AND TOBAGO.
Email address: koffka.khan@gmail.com

Abstract—*This position paper explores the transformative potential of integrating biophysiological data into adaptive streaming systems to enhance the user experience. As streaming technologies evolve, there is an increasing recognition of the importance of personalization and real-time adaptation. We propose a paradigm shift towards "Emotion-Driven Adaptive Streaming" (EDAS), where biometric signals such as heart rate, facial expressions, and electrodermal activity are leveraged to dynamically adjust streaming parameters. Our paper discusses the theoretical foundations, potential applications, and ethical considerations associated with EDAS. By examining the intersection of technology and human emotion, we advocate for a holistic approach that prioritizes user well-being and engagement. This position paper aims to stimulate discussion and guide future research in the quest for a more emotionally aware and personalized streaming experience.*

Keywords— *biophysiological data: adaptive streaming systems: emotion-driven: personalized.*

I. Introduction

In the rapidly evolving landscape of streaming technologies, the pursuit of an optimal user experience has become paramount. Traditional adaptive streaming systems primarily rely on technical metrics such as network bandwidth and device capabilities to dynamically adjust streaming parameters. However, as the demand for personalized and immersive content experiences continues to surge, there is a compelling case for the integration of biophysiological data into the streaming ecosystem.

This position paper introduces the concept of "Emotion-Driven Adaptive Streaming" (EDAS), a novel approach that posits the utilization of biometric signals to dynamically tailor the streaming experience based on the viewer's emotional and physiological responses. The foundational idea behind EDAS is to move beyond the conventional technical metrics and delve into the realm of human emotion as a key factor in shaping content delivery. By incorporating biophysiological data such as heart rate variability, facial expressions, and electrodermal activity, EDAS aims to create a more nuanced and personalized streaming experience.

The emergence of EDAS is underpinned by the recognition that emotional engagement significantly influences the perception of content. As users increasingly seek not only high-quality visuals but also content that resonates emotionally, the integration of biophysiological data provides an avenue for streaming systems to respond dynamically to the viewer's emotional state. This paper explores the theoretical underpinnings of EDAS, discussing how biometric signals can be harnessed to understand user emotions in real-time. Furthermore, we delve into potential applications, ranging from adaptive content delivery based on emotional cues to the creation of interactive biofeedback features that respond to the viewer's physiological state. Amid these innovations, we also address critical ethical considerations surrounding user consent, privacy, and the responsible use of biometric data in streaming contexts. As EDAS stands at the intersection of technology and human emotion, this paper advocates for a paradigm shift that prioritizes both the technical optimization and the emotional well-being of streaming audiences. Through this exploration, we aim to ignite discussions, inspire further research, and shape the trajectory of future developments in the pursuit of a more emotionally aware and personalized streaming landscape.

The motivation for the Emotion-Driven Bitrate (EDB) System is as follows:

Personalized Streaming Experience [16]:

The motivation behind the EDB system stems from the recognition that each viewer's experience is unique. By incorporating emotional cues into the bitrate adaptation process, the system aims to provide a more personalized streaming experience. This personalization aligns the streaming content with the viewer's emotional engagement, enhancing satisfaction and connection.

Addressing Emotional Dynamics in Content:

Traditional adaptive streaming systems primarily focus on technical metrics, overlooking the emotional dynamics inherent in content. The motivation for EDB is to bridge this gap by dynamically adjusting the bitrate to match the emotional intensity of the narrative or live event. This ensures that the streaming quality resonates with the emotional nuances of the content being consumed.

Enhanced Immersion and Engagement:

The goal of the EDB system is to enhance viewer immersion and engagement by aligning streaming quality with emotional peaks in the content. By adapting the bitrate during emotionally charged scenes, the system seeks to heighten the impact of storytelling, creating a more captivating and memorable viewing experience.

Optimizing Resource Utilization [3]:

EDB is motivated by the need to optimize resource utilization, striking a balance between video quality and bandwidth consumption. By dynamically adjusting the bitrate, the system ensures efficient use of network resources, particularly during scenes with lower emotional intensity where a lower bitrate suffices.

User-Centric Approach [4]:

At its core, the motivation for the EDB system is to adopt a user-centric approach to adaptive streaming. By considering the viewer's emotional responses, the system aims to go beyond technical optimizations and cater to the subjective and emotional dimensions of the streaming experience. This approach acknowledges that user satisfaction extends beyond video quality metrics.

Competitive Edge and User Retention:

Streaming platforms are motivated to implement innovative features that provide a competitive edge. The EDB system, by offering a novel and emotion-aware streaming experience, can contribute to user retention and attract audiences looking for a more tailored and engaging content delivery.

Evolution of Adaptive Streaming:

The motivation for EDB arises from the ongoing evolution of adaptive streaming technologies. As streaming becomes a dominant form of content consumption, there is a growing emphasis on advancements that go beyond technical optimizations. EDB represents a pioneering step in the evolution of adaptive streaming systems toward a more emotionally aware and user-focused paradigm.

Research and Technological Innovation:

The motivation for EDB extends to the realm of research and technological innovation. By exploring the integration of biometric data into streaming algorithms, the system contributes to the broader conversation on the intersection of technology and human emotion, pushing the boundaries of what is achievable in the realm of adaptive content delivery.

In essence, the motivation for the Emotion-Driven Bitrate (EDB) system lies in its potential to revolutionize the streaming experience, placing a strong emphasis on user satisfaction, emotional resonance, and the dynamic adaptation of streaming parameters in response to the nuanced storytelling and emotional nuances present in diverse forms of content.

This paper consists of sections. In section II the basics of adaptive video streaming is introduced. Section III gives the proposed methodology while proposed experiments are discussed in section IV. EDAS rate adaption is given in section V. The benefits and limitations of emotion-driven bitrte (EDB) process is explored in section VI. EDB process parameters are given in section VII. A general discussion is presented in section VIII. Finally, the conclusion is given in section IX.

II. Adaptive Video Streaming

Adaptive video streaming [9] has revolutionized the way we consume digital content, providing viewers with a seamless and personalized experience irrespective of varying network conditions, device capabilities, or user preferences. This innovative technology has become a cornerstone in the ever-evolving landscape of online media delivery, enhancing the quality, accessibility, and user satisfaction in video streaming.

1. Evolution of Video Streaming:

The journey of video streaming has witnessed a remarkable evolution [12]. Initially, static streaming methods struggled to cope with the diverse array of devices and network conditions. However, the advent of adaptive video streaming marked a paradigm shift, introducing dynamic adjustments that tailor the streaming experience to each viewer's unique environment.

2. Adaptive Streaming Fundamentals:

Adaptive video streaming operates on a fundamental principle: the dynamic adjustment of video quality in response to changing network conditions and device capabilities [8]. This real-time optimization ensures that viewers receive the best possible quality without interruptions or buffering, creating a more immersive and satisfying viewing experience.

3. Key Components of Adaptive Streaming:

Bitrate Adaptation: Adaptive streaming adjusts the bitrate of the video stream based on the viewer's network bandwidth [10]. During high-speed connections, higher bitrates deliver superior quality, while lower bitrates ensure uninterrupted playback during network fluctuations.

Resolution Adjustment: The resolution of the video is dynamically altered to match the viewer's device capabilities and screen size. This ensures optimal visual quality while conserving bandwidth when necessary.

Segmented Content Delivery: Videos are divided into small segments, and the streaming server dynamically selects the appropriate segment based on current conditions. This approach enhances flexibility and responsiveness.

4. Manifest Files and Adaptive Bitrate Streaming Protocols:

Dynamic Manifest Files: Adaptive streaming utilizes dynamic manifest files that provide information about the available video segments at different quality levels. This enables the player to seamlessly switch between segments based on changing conditions.

Protocols (e.g., HLS, DASH): Popular adaptive bitrate streaming protocols, such as HTTP Live Streaming (HLS) and Dynamic Adaptive Streaming over HTTP (DASH), facilitate the delivery of segmented content. These protocols contribute to the widespread adoption of adaptive streaming across various platforms.

5. User-Centric Experience:

Adaptive video streaming places the viewer at the center of the experience. By continuously monitoring network conditions and adjusting streaming parameters in real-time

Koffka Khan and Wayne Goodrige, “Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

[11], adaptive streaming ensures that users enjoy consistent and high-quality content, regardless of external factors.

6. Device Compatibility:

Adaptive streaming caters to a diverse range of devices, from smartphones and tablets to smart TVs and desktop computers. This compatibility ensures a uniform viewing experience across devices, allowing users to seamlessly transition between platforms.

7. Challenges and Innovations:

While adaptive streaming has significantly improved the streaming experience, challenges persist, such as latency concerns and the need for efficient adaptation algorithms [13]. Ongoing innovations aim to address these challenges, pushing the boundaries of what adaptive streaming can achieve.

In conclusion, adaptive video streaming stands as a technological cornerstone, transforming the digital viewing landscape by prioritizing user experience and responsiveness. This dynamic approach ensures that viewers can enjoy their favorite content effortlessly, even in the face of unpredictable network conditions and diverse device ecosystems. As technology continues to advance, adaptive streaming remains a pivotal force in shaping the future of online video consumption.

III. Proposed Methodology

To explore the feasibility and potential of Emotion-Driven Adaptive Streaming (EDAS), a comprehensive methodology is devised to guide the investigation. The methodology encompasses both theoretical considerations and practical implementation strategies aimed at understanding the intricate interplay between biophysiological data and streaming parameters.

A. Theoretical Framework:

The initial phase involves an in-depth literature review to establish the theoretical foundation of EDAS. This includes an exploration of existing research in emotion-aware computing, human-computer interaction, and adaptive streaming technologies. By synthesizing insights from psychology, neuroscience, and computer science, we aim to define a conceptual framework for understanding how biophysiological signals can be indicative of user emotions during content consumption.

The theoretical framework of Emotion-Driven Adaptive Streaming (EDAS) is foundational to the development and implementation of this innovative approach to content delivery. This phase involves a comprehensive exploration of existing literature across diverse disciplines, including emotion-aware computing, human-computer interaction (HCI), and adaptive streaming technologies. The goal is to construct a theoretical foundation that draws insights from psychology, neuroscience, and computer science to conceptualize how biophysiological signals can serve as indicators of user emotions during content consumption.

1. Literature Review in Emotion-Aware Computing:

The exploration begins with a thorough examination of the literature in emotion-aware computing. This domain investigates how computational systems can recognize, interpret, and respond to human emotions. Existing research in affective computing, affective neuroscience, and affective computing applications provides valuable insights into the methodologies and technologies used to detect and analyze emotions. By reviewing studies on emotion recognition from facial expressions, voice, physiological signals, and other modalities, the theoretical framework starts to take shape.

2. Human-Computer Interaction (HCI) Research:

The HCI literature is a critical component of the theoretical framework, as it focuses on the interaction between humans and technology [17]. Understanding how users engage with digital interfaces, particularly in the context of media consumption, informs the design principles for EDAS. Research in HCI provides guidance on user experience design, usability, and the integration of interactive features that align with emotional responses. This interdisciplinary approach ensures that EDAS is not only technically sound but also user-centered.

3. Adaptive Streaming Technologies:

A thorough investigation into adaptive streaming technologies forms another pillar of the theoretical framework. Existing literature on adaptive bitrate streaming, content delivery networks (CDNs) [5], and Quality of Experience (QoE) metrics offers insights into the technical aspects of content delivery. Understanding the mechanisms behind traditional adaptive streaming provides a baseline for contrasting EDAS's innovative approach. This phase involves studying how bitrate, resolution, and other streaming parameters are conventionally adjusted based on network conditions, device capabilities, and user preferences.

4. Synthesizing Insights from Psychology and Neuroscience:

To bridge the gap between technical methodologies and human emotions, the theoretical framework incorporates insights from psychology and neuroscience. Understanding the physiological correlates of emotions, such as changes in heart rate, electrodermal activity, and facial expressions, enriches the theoretical foundation. Research on the neural mechanisms underlying emotional responses contributes to a holistic view of how emotions manifest and can be measured. This synthesis ensures that EDAS is grounded in a nuanced understanding of the human emotional experience.

5. Conceptual Framework Development:

Through the synthesis of insights from emotion-aware computing, HCI, adaptive streaming technologies, psychology, and neuroscience, a conceptual framework for EDAS emerges. This framework outlines the key components, relationships, and principles that govern the integration of biophysiological signals into the adaptive streaming process. It defines the parameters that EDAS will leverage to adapt streaming dynamically based on user emotions. The conceptual framework serves as a guide for the subsequent phases of development, providing a clear roadmap for the implementation of EDAS.

In conclusion, the theoretical framework for Emotion-

Koffka Khan and Wayne Goodrige, “Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

Driven Adaptive Streaming is a multifaceted synthesis of knowledge from diverse disciplines. It not only lays the groundwork for the development of EDAS but also ensures that the integration of biophysiological signals is informed by a rich understanding of human emotions, user interaction, and existing technologies in the field of adaptive streaming. This comprehensive approach sets the stage for the practical implementation and testing of EDAS in subsequent phases of research and development.

B. Data Collection:

The data collection phase of the EDAS methodology is a critical component that revolves around gathering biophysiological data directly from viewers. This process involves the deployment of advanced wearable devices capable of capturing nuanced signals, including heart rate, facial expressions, and electrodermal activity. Collaborating closely with experts in human-computer interaction (HCI), controlled experiments and real-world user studies are meticulously designed to elicit and record a diverse spectrum of emotional responses to streaming content. Throughout this process, ethical considerations take center stage, guiding the implementation of robust protocols for informed consent and data anonymization to uphold the highest standards of user privacy.

1. Wearable Biometric Devices:

Advanced wearable devices [2] equipped with sensors capable of measuring key biophysiological signals are carefully selected and deployed. These may include:

Heart Rate Monitors: Non-invasive devices that measure the viewer's heart rate in real-time.

Facial Expression Analysis Tools [1]: Cameras or sensors that capture and analyze facial expressions to discern emotional states.

Electrodermal Activity Sensors [15]: Devices that measure changes in skin conductance, providing insights into emotional arousal.

The choice of wearable devices is crucial, ensuring they are unobtrusive, accurate, and capable of capturing the subtle nuances of emotional responses during streaming.

2. Controlled Experiments and User Studies:

In collaboration with HCI experts, controlled experiments and user studies are meticulously designed to create scenarios that elicit a diverse range of emotional responses. These experiments may include:

Emotionally Charged Content: Curated streaming content designed to evoke specific emotional responses, spanning a spectrum from joy and excitement to tension and sadness.

Interactive Features: Incorporating interactive elements to gauge emotional responses during user engagement with the streaming platform.

The controlled environment ensures a systematic approach to eliciting and capturing emotional data, enabling a deeper understanding of how viewers respond to various content and interactive features.

3. Real-World User Studies:

To complement controlled experiments, real-world user studies are conducted to capture a broader range of authentic emotional responses in everyday streaming scenarios. Participants engage with the streaming platform in their natural environments, offering insights into how EDAS performs in diverse contexts.

4. Ethical Considerations and Informed Consent:

Ethical considerations are paramount throughout the data collection process. To ensure the well-being and privacy of participants:

Informed Consent: Participants are provided with comprehensive information about the study's objectives, the nature of data collected, and their rights. Informed consent is obtained before any data collection occurs.

Voluntary Participation: Participation in the study is entirely voluntary, and participants can withdraw at any point without consequences.

Transparent Communication: Transparent communication is maintained, ensuring participants are aware of the purpose and potential impact of the study on their streaming experience.

5. Data Anonymization and Privacy Safeguards:

Rigorous protocols for data anonymization are implemented to protect the privacy of participants. This includes:

De-identification: Personally identifiable information is carefully removed or anonymized to prevent the identification of individual participants.

Secure Data Storage: Biophysiological data is stored securely, with access restricted to authorized personnel only.

Limited Retention: Data is retained for the necessary duration for analysis and then promptly and securely discarded.

In summary, the data collection phase of the EDAS methodology is a meticulous and ethical endeavor. It employs advanced wearable devices, controlled experiments, and real-world user studies to capture a comprehensive range of emotional responses during streaming. Ethical considerations, informed consent, and robust data anonymization protocols ensure that the research is conducted with the utmost respect for participant privacy and well-being. The resulting biophysiological data serves as a rich foundation for the subsequent stages of EDAS development and validation.

C. Integration with Adaptive Streaming Systems:

The integration of Emotion-Driven Adaptive Streaming (EDAS) with adaptive streaming systems is a pivotal phase that builds upon the theoretical foundation and the biophysiological data collected. This process involves collaborating closely with streaming platform developers to implement prototypes that seamlessly incorporate EDAS concepts. The goal is to create adaptive streaming algorithms that dynamically adjust streaming parameters in real-time based on the ongoing analysis of users' biometric signals, thereby enhancing the overall streaming experience. The adaptation mechanisms include alterations in bitrate, resolution, content recommendations, and interactive features, all finely tuned to the viewers' real-time emotional cues.

1. Collaboration with Streaming Platform Developers:

Collaborative efforts with experts in streaming platform

Koffka Khan and Wayne Goodrige, “Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

development are essential. This interdisciplinary collaboration ensures a holistic approach that aligns technical considerations with the principles derived from the theoretical framework and the nuances of user emotional responses.

2. Prototype Development:

The development of prototypes involves implementing the EDAS concepts into adaptive streaming algorithms. Key components of the prototypes include:

Real-Time Emotion Analysis [7]: Integration of real-time emotion analysis algorithms that continuously process biophysiological signals to infer users' emotional states.

Parameter Adjustment Mechanisms: Algorithms that dynamically adjust streaming parameters, such as bitrate, resolution, and content recommendations, based on the inferred emotional cues.

Interactive Feature Integration: Incorporation of interactive features within the streaming platform that respond to the users' emotional states, enhancing engagement and immersion.

3. Dynamic Parameter Adjustments:

The adaptive streaming algorithms dynamically adjust various parameters based on real-time emotional cues. These adjustments may include:

Bitrate Adaptation: Higher emotional engagement may trigger an increase in bitrate for a more immersive and high-quality streaming experience.

Resolution Changes: Alterations in resolution based on emotional intensity, optimizing the visual experience in response to the users' emotional state.

Content Recommendations: Dynamic content recommendations that align with the users' current emotional preferences, ensuring a personalized and resonant content selection.

Interactive Features: Activation of interactive elements, such as polls or adaptive storylines, based on the users' emotional responses.

4. Biometric Signal Analysis in Real-Time:

The integration involves the continuous analysis of biometric signals in real-time. Algorithms process the incoming data streams from wearable devices to discern changes in heart rate, facial expressions, electrodermal activity, and other relevant signals.

5. Feedback Mechanisms:

Prototypes include mechanisms for collecting user feedback. This feedback loop is essential for refining and improving the EDAS integration. Users may provide insights into the perceived impact of adaptive streaming adjustments on their experience and satisfaction.

6. Usability Testing:

Rigorous usability testing [20] is conducted to evaluate the effectiveness and user-friendliness of the integrated EDAS prototypes. This phase involves soliciting user feedback, observing user interactions, and identifying any potential challenges or areas for improvement.

7. Iterative Development:

Based on user feedback and usability testing results, iterative development cycles are undertaken. This ensures that the integrated EDAS algorithms evolve and mature, addressing any identified issues and incorporating refinements to enhance overall performance.

8. System Optimization:

System optimization is a continuous process aimed at refining the integrated EDAS algorithms for efficiency, responsiveness, and scalability. This phase may involve performance tuning, addressing latency concerns, and optimizing the overall responsiveness of the adaptive streaming system.

In summary, the integration with adaptive streaming systems is a sophisticated process that involves collaborative efforts, prototype development, dynamic parameter adjustments, real-time biometric signal analysis, user feedback mechanisms, usability testing, and iterative development cycles. This integration positions EDAS as a responsive and user-centric enhancement to conventional adaptive streaming, promising a more emotionally aware, personalized, and engaging streaming experience.

D. User Feedback and Iterative Refinement:

User feedback and iterative refinement constitute a crucial phase in the development of Emotion-Driven Adaptive Streaming (EDAS). This phase is designed to systematically gather insights from users, both qualitatively and quantitatively, to assess the impact of EDAS on the perceived streaming experience. The iterative process involves refining the adaptive algorithms, making adjustments based on feedback, and continuously enhancing the system to align with user expectations. This user-centric approach ensures that EDAS not only meets technical benchmarks but also delivers meaningful improvements in the streaming experience.

1. Usability Studies and Surveys:

Rigorous usability studies and surveys are conducted to solicit user feedback on the EDAS-enhanced streaming experience. This involves:

Usability Testing: Observing users interacting with the streaming platform, noting challenges, and identifying areas of improvement.

Surveys: Administering structured surveys to collect quantitative data on user satisfaction, perceived streaming quality, and overall experience.

2. Quantitative Metrics:

Quantitative metrics are employed to objectively measure the performance of the EDAS system. These metrics may include:

Streaming Quality: Assessing the visual and audio quality of the streaming content delivered by EDAS.

Buffering Rates: Monitoring the occurrence of buffering events to ensure a seamless streaming experience.

Adaptation Responsiveness: Evaluating how quickly EDAS adapts streaming parameters in response to changes in emotional cues.

3. Qualitative Insights:

Qualitative insights are equally important and are gathered through open-ended survey questions, interviews, and user

Koffka Khan and Wayne Goodrige, “Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

comments. Key qualitative aspects include:

Perceived Impact: Understanding how users perceive the impact of emotional adaptation on their engagement and immersion.

User Preferences: Identifying user preferences regarding specific adaptive streaming features and adjustments triggered by EDAS.

Challenges and Concerns: Recognizing any challenges or concerns users may have encountered during their streaming experiences.

4. Continuous Refinement:

Based on the collected feedback, the adaptive algorithms of EDAS undergo continuous refinement. This involves:

Algorithm Adjustments: Fine-tuning the algorithms responsible for adapting streaming parameters to improve responsiveness and accuracy.

User Interface Optimization: Enhancing the user interface elements related to EDAS, ensuring transparency and providing users with control over adaptive features.

Content Recommendations: Improving the accuracy and relevance of content recommendations based on emotional cues.

5. User-Centric Design Iterations:

The iterative refinement process is inherently user-centric, focusing on creating an adaptive streaming system that aligns with user expectations and preferences. Design iterations are driven by the goal of enhancing user satisfaction and the overall streaming experience.

6. Collaboration with User Experience (UX) Designers:

Collaboration with UX designers is pivotal during the refinement phase. Their expertise ensures that the adjustments made to the EDAS system not only address technical considerations but also adhere to best practices in user interface design and user experience.

7. A/B Testing:

A/B testing [18] may be employed to compare the performance of different iterations of the EDAS system. This allows for data-driven decisions regarding which refinements contribute most significantly to an improved user experience.

8. Iterative Development Cycles:

The refinement process operates in iterative development cycles. After each cycle, the system is re-evaluated, and refinements are made based on the latest user feedback. This cyclical approach ensures continuous improvement.

9. Transparency and Communication:

Transparent communication with users is maintained throughout the iterative refinement process. Users are informed about changes, and their feedback is acknowledged and valued. This transparency fosters trust and user engagement.

10. Performance Monitoring:

Performance monitoring is ongoing to assess the impact of refinements on the overall performance of the EDAS system. This includes tracking key performance indicators and addressing any emerging issues promptly.

In summary, the user feedback and iterative refinement phase is a dynamic and collaborative process that integrates quantitative metrics, qualitative insights, continuous refinement, user-centric design, and transparent communication. This meticulous approach ensures that the EDAS system evolves in tandem with user expectations, delivering a streaming experience that is not only technically advanced but also resonant with the diverse emotional responses of its users.

E. Ethical Considerations:

The integration of ethical considerations is a fundamental and ongoing commitment throughout the Emotion-Driven Adaptive Streaming (EDAS) methodology. Ethical principles guide every stage of the research process, ensuring the protection of participant privacy, well-being, and rights. The following details the comprehensive approach to ethical considerations in EDAS:

1. Ethical Review Board Oversight:

An ethical review board, comprised of experts in relevant fields such as computer science, human-computer interaction, and bioethics, oversees the entire research process. This board ensures that the methodology aligns with established ethical guidelines and regulations.

2. Privacy Guidelines and Regulations [6]:

Compliance with privacy guidelines and regulations is a top priority. This includes adherence to laws such as the General Data Protection Regulation (GDPR) and other relevant data protection laws. Protocols are in place to protect participant privacy throughout the research journey.

3. Informed Consent Procedures:

Transparent and comprehensive communication is maintained with participants. Informed consent procedures are a cornerstone of the methodology, encompassing:

Detailed Information: Providing participants with detailed information about the research objectives, procedures, potential risks, and benefits.

Voluntary Participation: Clearly communicating that participation is voluntary, and participants have the right to withdraw at any point without consequences.

Q&A Sessions: Facilitating question-and-answer sessions to address participant queries and concerns before obtaining consent.

4. Sensitive Biophysiological Data Handling [19]:

Handling sensitive biophysiological data with the utmost care is integral to ethical practice. This includes:

Data Anonymization: Removing or anonymizing personally identifiable information to prevent the identification of individual participants.

Secure Data Storage: Implementing secure storage measures to protect biophysiological data from unauthorized access.

Limited Access: Restricting access to biometric data to authorized personnel only.

5. Participant Well-being:

The well-being of participants is prioritized throughout the research process. Measures are in place to:

Koffka Khan and Wayne Goodrige, “Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

Minimize Discomfort: Minimizing any potential discomfort or inconvenience for participants during data collection.

Debriefing Sessions: Conducting debriefing sessions after experiments or studies to address any emotional impact or concerns.

Referral to Support Services: Providing information and support services for participants who may require additional assistance.

6. Continuous Monitoring and Auditing:

Continuous monitoring of ethical considerations is incorporated into the research framework. This involves:

Internal Audits: Regular internal audits to assess compliance with ethical standards and identify areas for improvement.

External Oversight: Engaging external ethics experts for periodic reviews to ensure an unbiased evaluation of ethical practices.

7. Transparency in Communication:

Transparent communication with participants is maintained throughout the research process. This includes:

Regular Updates: Providing participants with regular updates on the progress of the research.

Communication Channels: Offering accessible channels for participants to express concerns or ask questions.

8. Community Engagement:

Engaging with the broader community is a proactive step to ensure awareness and understanding of the research. This includes:

Community Outreach: Sharing information about the research with the local community and stakeholders.

Feedback Mechanisms: Establishing mechanisms for community members to provide feedback or express concerns.

9. Responsible Publication Practices:

Responsible publication practices are upheld, ensuring that research findings are shared in a manner that respects participant privacy and confidentiality.

In summary, ethical considerations in the EDAS methodology are not merely a procedural requirement but a comprehensive commitment to protecting participant rights, privacy, and well-being. The integration of these ethical principles strengthens the integrity of the research and contributes to the responsible advancement of knowledge in the field of adaptive streaming technologies.

Through this comprehensive methodology, the research endeavors to not only validate the viability of EDAS but also to contribute insights that inform the responsible and ethical integration of biophysiological data into adaptive streaming systems.

IV. PROPOSED EXPERIMENTS

Here is some advice on a general EDAS experiment:

Objective:

The primary objective of the proposed experiments is to empirically evaluate the effectiveness of Emotion-Driven Adaptive Streaming (EDAS) in enhancing the user experience. The experiments aim to investigate how real-time integration of biophysiological data into adaptive streaming algorithms influences streaming quality, user engagement, and overall satisfaction.

Participants:

A diverse group of participants, reflecting various demographics and streaming preferences, will be recruited for the experiments. Participants will provide informed consent, and efforts will be made to ensure a comfortable and non-intrusive environment during data collection.

Biophysiological Data Collection:

Participants will wear non-invasive biometric monitoring devices capable of capturing key physiological signals, including heart rate, facial expressions, and electrodermal activity. The experiment will involve controlled exposure to a variety of streaming content, selected to elicit a range of emotional responses. Biophysiological data will be synchronized with streaming events to establish a correlation between emotional states and streaming parameters.

Experimental Design:

The experiments will employ a within-subjects design, allowing participants to experience both traditional adaptive streaming and EDAS in a counterbalanced order. Participants will engage in streaming sessions where adaptive algorithms, informed by biometric signals in the EDAS condition, dynamically adjust streaming parameters in real-time.

Dependent Variables:

Streaming Quality Metrics: Quantitative measures, including video bitrate, resolution, and buffering rates, will be assessed to evaluate the technical performance of both traditional adaptive streaming and EDAS.

User Engagement [21]: Surveys and qualitative interviews will be conducted to gather participants' subjective experiences, exploring aspects of emotional engagement, immersion, and perceived content relevance.

Biophysiological Correlations: Statistical analyses will be performed to identify correlations between specific biophysiological markers and user-reported emotional states during streaming. This aims to validate the efficacy of EDAS in capturing and responding to user emotions.

Data Analysis [14]:

Both quantitative and qualitative data will be analyzed to compare the performance of traditional adaptive streaming and EDAS. Statistical tests, such as t-tests and ANOVA, will be employed for quantitative measures, while thematic analysis will be used for qualitative insights gathered from participant interviews and surveys.

Ethical Considerations:

The experiment will be conducted in accordance with ethical guidelines, ensuring participant privacy, informed consent, and the secure handling of biometric data. An ethics review board will oversee the experiment's design and execution to ensure compliance with ethical standards.

Through these experiments, we aim to provide empirical evidence regarding the potential benefits and challenges associated with integrating biophysiological data into adaptive

Koffka Khan and Wayne Goodrige, "Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience," *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

streaming systems, contributing valuable insights to the evolving field of personalized and emotion-aware content delivery.

Here are some specific examples for EDAS experiments:

et's choose three Emotion-Driven Adaptive Streaming (EDAS) parameters and design experiments to improve different types of streaming: 360-degree video, Ultra High Definition (UHD) streaming, and Augmented Reality (AR) streaming.

Parameter: Dynamic Field of View Adjustment (DFOVA):

Experiment for 360-degree Video Streaming:

Objective: Evaluate the impact of dynamically adjusting the field of view based on user emotion in 360-degree video streaming.

Methodology:

Participants wear VR headsets for an immersive 360-degree video streaming experience.

DFOVA adapts the field of view based on facial expressions and emotional cues.

Experiment involves exposure to emotionally charged 360-degree content (e.g., virtual experiences like concerts or scenic views).

Quantitative measures include user feedback on immersion, emotional engagement, and perceived content relevance.

Biometric data, particularly facial expressions, are correlated with user-reported emotional states to validate the effectiveness of DFOVA.

Parameter: Emotion-Driven Bitrate (EDB):

Experiment for UHD Streaming:

Objective: Investigate how dynamically adjusting bitrate based on user emotion influences the UHD streaming experience.

Methodology:

Participants engage in UHD streaming sessions, where the EDB algorithm dynamically adjusts bitrate based on real-time emotional cues.

Controlled exposure to UHD content with varying emotional intensity (e.g., movie scenes with different emotional tones).

Quantitative metrics include video quality assessments, buffering rates, and user satisfaction surveys.

Biometric data, particularly heart rate and electrodermal activity, are analyzed to understand the correlation between emotional states and adaptive bitrate adjustments.

Parameter: Augmented Reality Content Overlay (ARCO):

Experiment for Augmented Reality (AR) Streaming:

Objective: Assess the impact of dynamically overlaying AR content based on user emotion during streaming experiences.

Methodology:

Participants use AR glasses for streaming content enriched with dynamically generated AR overlays.

ARCO adjusts the type and intensity of AR overlays based on user emotional responses.

Experiment involves scenarios where AR content enhances emotional elements in real-world settings (e.g., emotional cues in educational content or emotional storytelling).

Quantitative measures include user feedback on AR content relevance, perceived impact on emotional engagement, and overall satisfaction.

Biometric data, including facial expressions and heart rate, are analyzed to validate the correlation between ARCO adjustments and user emotions.

These experiments aim to explore the effectiveness of specific EDAS parameters in enhancing the streaming experience across different types of content delivery, catering to the unique characteristics and challenges of 360-degree video, UHD streaming, and Augmented Reality. The outcomes of these experiments can contribute valuable insights to the ongoing development of emotion-aware adaptive streaming technologies.

V. EDAS Rate Adaptation

The Emotion-Driven Bitrate (EDB) parameter aims to dynamically adjust the bitrate of streaming content based on the user's emotional state. The rate adaptation process involves real-time monitoring of biophysiological signals, such as heart rate and electrodermal activity, to infer the viewer's emotional engagement. Here's a detailed description of how the EDB rate adaptation would take place:

Biophysiological Signal Monitoring:

The streaming system continuously monitors the viewer's biophysiological signals, including heart rate and electrodermal activity, using wearable devices or sensors integrated into the streaming platform.

Emotion Inference:

A machine learning model or algorithm analyzes the biophysiological data to infer the viewer's emotional state. For example, an increase in heart rate and electrodermal activity might be associated with heightened excitement or tension.

Emotion-Driven Bitrate Adjustment:

Based on the inferred emotional state, the EDB algorithm dynamically adjusts the streaming bitrate. Different emotional states may trigger varying bitrate adjustments to optimize the streaming experience.

Example:

If the algorithm detects a high level of excitement or intense emotional engagement, it may increase the bitrate to deliver a higher quality, more immersive video experience. This could be especially relevant for scenes in a movie with high emotional impact or critical moments in a live event.

Conversely, during periods of lower emotional engagement or calmer scenes, the algorithm might reduce the bitrate to conserve bandwidth without sacrificing the overall viewing experience.

Real-Time Bitrate Switching:

The adaptation is not a one-time adjustment but occurs dynamically throughout the streaming session. Real-time bitrate switching ensures that the streaming quality aligns with the user's emotional responses to different content segments.

User Feedback Loop:

The system incorporates a user feedback loop to validate the effectiveness of the EDB adjustments. Users may be prompted to provide feedback on perceived video quality during and after streaming sessions.

Example:

If users consistently report high satisfaction during emotionally charged scenes but provide lower ratings during calmer moments, it indicates that the EDB algorithm is effectively adapting to emotional cues.

A possible EDB Rate Adaptation Illustration may show the x-axis representing the timeline of the streaming content, and the y-axis representing the bitrate. The adaptive EDB algorithm dynamically adjusts the bitrate (represented by the curves) based on the inferred emotional states at different points in time. Peaks in emotional engagement trigger increases in bitrate, providing a high-quality streaming experience during emotionally impactful moments.

This Emotion-Driven Bitrate (EDB) adaptation process ensures that the streaming system responds in real-time to the user's emotional journey, optimizing the balance between video quality and bandwidth consumption for a more personalized and engaging streaming experience.

VI. Benefits And Limitations of Emotion-Driven Bitrate (EDB) Process

The following lists benefits of the EDB process:

Enhanced User Experience:

Benefit: EDB has the potential to significantly enhance the overall user experience by dynamically adjusting the streaming bitrate to align with the viewer's emotional state. This can result in a more immersive and emotionally resonant streaming experience.

Optimized Quality and Bandwidth Usage:

Benefit: By adapting the bitrate in real-time, EDB optimizes the quality of the streaming content during emotionally charged moments, while conserving bandwidth during less intense scenes. This ensures an optimal balance between video quality and efficient bandwidth utilization.

Personalization:

Benefit: EDB contributes to a more personalized streaming experience, as it tailors the bitrate to individual emotional responses. Users with diverse preferences and sensitivities can have a streaming experience that aligns with their emotional engagement levels.

Increased Viewer Satisfaction:

Benefit: With EDB, users are more likely to receive content at a quality level that aligns with their emotional expectations, leading to higher satisfaction rates. This adaptability contributes to positive feedback and a more engaged user base.

Dynamic Content Delivery:

Benefit: EDB enables streaming platforms to deliver content dynamically, adjusting to the emotional dynamics of the narrative or live event. This can be particularly impactful in areas such as live sports, concerts, and interactive storytelling.

Limitations of Emotion-Driven Bitrate (EDB) Process:

Biometric Accuracy and Variability:

Limitation: The accuracy of emotion inference from biometric signals may vary among individuals, and physiological responses can be influenced by factors other than emotional states (e.g., health conditions, environmental factors). Inaccuracies in emotion detection could lead to suboptimal bitrate adjustments.

Ethical Considerations and Privacy Concerns:

Limitation: The collection and utilization of biometric data for emotion-driven adaptation raise significant privacy concerns. Ensuring user consent, data anonymization, and adherence to privacy regulations are critical to mitigate ethical issues associated with biometric data usage.

Complexity of Emotional States:

Limitation: Human emotions are complex and multifaceted. The EDB process may face challenges in accurately capturing the nuanced spectrum of emotions, and an oversimplified model may not fully represent the viewer's emotional experience.

User Perception and Preferences:

Limitation: Users may have varying preferences for streaming quality, and some may prefer consistency over dynamic adjustments. Perceived interruptions or artifacts during bitrate changes, even if subtle, could impact user satisfaction.

Technical Challenges:

Limitation: Implementing real-time bitrate adjustments based on emotion requires sophisticated algorithms and a responsive streaming infrastructure. Technical challenges, such as latency issues and system responsiveness, need to be addressed to ensure a seamless user experience.

In summary, while Emotion-Driven Bitrate (EDB) offers several potential benefits in enhancing user experience and personalization, there are important considerations regarding accuracy, privacy, and user preferences that must be carefully addressed to mitigate limitations and ethical concerns. The success of EDB implementation relies on a balance between technical sophistication and a user-centric approach.

VII. EDB Process Parameters

The Emotion-Driven Bitrate (EDB) process relies on capturing and interpreting biophysiological data to dynamically adjust streaming parameters. Here are several possible parameters that the EDB process can use:

Heart Rate:

Description: The number of heartbeats per minute, which can be indicative of arousal or emotional intensity.

Koffka Khan and Wayne Goodrige, “Emotion-Driven Adaptive Streaming: A Position Paper on Integrating Biophysiological Data for Enhanced User Experience,” *International Journal of Multidisciplinary Research and Publications (IJMRAP)*, Volume 6, Issue 6, pp. 131-142, 2023.

Use Case: Higher heart rates might suggest heightened emotional engagement, triggering an increase in bitrate for a more immersive experience.

Electrodermal Activity (EDA):

Description: Measures skin conductance, which can be influenced by emotional arousal, stress, or excitement.

Use Case: Peaks in EDA might signal emotionally charged moments, prompting bitrate adjustments for optimal streaming quality.

Facial Expressions:

Description: Analysis of facial expressions using computer vision technology to detect emotions such as happiness, surprise, or sadness.

Use Case: Dynamic bitrate adjustments based on detected facial expressions to align with the emotional tone of the content.

Voice Analysis:

Description: Analyzing tone, pitch, and intensity of the viewer's voice, which can convey emotional states.

Use Case: Higher voice intensity or changes in tone might trigger bitrate adjustments during emotionally intense dialogues or interactions.

Galvanic Skin Response (GSR):

Description: Measures changes in skin conductance, providing insights into emotional arousal.

Use Case: EDB could adapt the streaming bitrate based on variations in GSR, optimizing video quality during emotionally charged scenes.

Eye Tracking:

Description: Monitoring the viewer's gaze and eye movements to infer areas of interest and emotional focus.

Use Case: Dynamic bitrate adjustments based on the viewer's focus on specific elements of the content, ensuring optimal quality for areas of emotional significance.

Brainwave Patterns (EEG):

Description: Analyzing electroencephalogram (EEG) data to understand cognitive and emotional states.

Use Case: Peaks in specific brainwave frequencies associated with emotional responses could trigger adaptive bitrate changes.

Skin Temperature:

Description: Monitoring changes in skin temperature, which can be influenced by emotional arousal.

Use Case: EDB could use skin temperature variations to dynamically adjust streaming parameters during emotionally charged moments.

Respiration Rate:

Description: Measures the number of breaths per minute, potentially indicating emotional arousal or relaxation.

Use Case: Changes in respiration rate could inform EDB adjustments to optimize streaming quality based on emotional states.

Accelerometer Data:

Description: Analyzing motion and movement patterns using accelerometer data.

Use Case: Sudden or intense movements might indicate heightened emotional responses, triggering EDB to adapt streaming parameters accordingly.

These parameters collectively contribute to the comprehensive understanding of the viewer's emotional state during content consumption, allowing the EDB process to dynamically tailor the streaming experience in real-time. The combination of these parameters offers a nuanced approach to emotion-aware adaptive streaming, enhancing the overall user engagement and satisfaction.

VIII. Discussion

Here is a discussion on the Emotion-Driven Bitrate (EDB) Process:

1. Personalization and User Engagement:

Benefit: The EDB process introduces a new dimension of personalization to the streaming experience. By dynamically adjusting bitrate based on the viewer's emotional state, the system aims to create a more engaging and tailored experience. This can enhance user satisfaction and foster a deeper connection with the content.

2. Optimization of Streaming Quality:

Benefit: EDB addresses the challenge of optimizing streaming quality by adapting to the emotional dynamics of the content. During emotionally intense scenes, the process ensures that viewers receive a high-quality, immersive experience, while conserving bandwidth during less intense moments. This optimization contributes to a more efficient use of network resources.

3. Dynamic Content Delivery:

Benefit: The EDB process facilitates dynamic content delivery by adjusting streaming parameters in real-time. This adaptability is particularly valuable in scenarios such as live events, where emotional peaks can vary widely. The ability to dynamically respond to the emotional tone of the content contributes to a more responsive and engaging streaming platform.

4. Challenges in Emotional Inference:

Limitation: Accurately inferring emotions from biophysiological data poses significant challenges. Human emotions are complex and multifaceted, and individual variations can make it challenging to develop a one-size-fits-all model. The accuracy of emotion inference algorithms is crucial for the success of the EDB process.

5. Ethical Considerations and Privacy:

Limitation: The collection and utilization of biometric data for emotion-driven adaptation raise ethical and privacy concerns. Ensuring transparent communication, obtaining informed consent, and adhering to privacy regulations are essential to mitigate potential risks and uphold user trust.

6. User Perception and Preferences:

Consideration: User preferences for streaming quality can vary. Some users may prefer a consistent streaming experience, while others may appreciate dynamic adjustments. Striking a balance and allowing users to customize or opt-out of emotion-driven adaptations is crucial to accommodate diverse preferences.

7. Technical Implementation Challenges:

Limitation: Implementing the EDB process requires sophisticated algorithms and a responsive streaming infrastructure. Technical challenges, such as minimizing latency during real-time bitrate adjustments, optimizing algorithm efficiency, and ensuring seamless transitions, must be addressed to provide a smooth user experience.

8. Collaboration with Content Creators:

Opportunity: Successful implementation of the EDB process could benefit from collaboration with content creators. Understanding the emotional nuances intended by creators and incorporating this insight into the adaptation process can lead to more meaningful and impactful adjustments.

9. Future Research and Innovation:

Opportunity: The EDB process opens avenues for future research and innovation. Exploring additional biophysiological parameters, refining emotion inference algorithms, and incorporating user feedback into the adaptation process can contribute to the ongoing evolution of emotion-aware adaptive streaming technologies.

10. User Feedback Loop:

Benefit: Integrating a user feedback loop is crucial for assessing the effectiveness of the EDB process. User feedback provides valuable insights into the perceived impact of emotional adaptation on the streaming experience, helping to refine algorithms and enhance user satisfaction.

In conclusion, the Emotion-Driven Bitrate (EDB) process represents a pioneering approach to adaptive streaming, introducing emotional awareness into the optimization of streaming parameters. While there are challenges and considerations, the potential benefits in terms of personalization, engagement, and optimized streaming quality make EDB a compelling area for continued research and development in the field of streaming technologies. The success of EDB lies in finding a delicate balance between technical sophistication, ethical considerations, and user-centric design.

IX. CONCLUSION

The Emotion-Driven Bitrate (EDB) process represents a significant stride in the evolution of adaptive streaming technologies, offering a novel approach to content delivery that transcends traditional technical metrics. By dynamically adjusting streaming parameters based on the viewer's emotional state, EDB introduces a new layer of personalization, engagement, and efficiency to the streaming experience.

In our exploration of EDB, we've identified several key considerations, benefits, and challenges. The process holds the promise of providing users with a more personalized and immersive streaming experience. The dynamic adaptation of streaming bitrate in response to emotional cues aligns the delivery of content with the viewer's subjective and emotional engagement, fostering a deeper connection and satisfaction.

However, the success of the EDB process hinges on overcoming challenges such as accurate emotion inference, ethical considerations surrounding biometric data usage, and technical implementation hurdles. Striking the right balance between user preferences, transparency, and privacy is imperative for the ethical deployment of emotion-aware technologies.

As the streaming landscape continues to evolve, the EDB process opens doors to future research, collaboration with content creators, and innovative solutions. Refining emotion inference algorithms, addressing technical challenges, and incorporating user feedback will be crucial for the continued advancement of emotion-aware adaptive streaming.

In conclusion, the Emotion-Driven Bitrate process stands at the intersection of technology and human emotion, pushing the boundaries of what is achievable in the realm of adaptive content delivery. While challenges exist, the potential benefits in terms of personalization, engagement, and optimized streaming quality make EDB a compelling avenue for further exploration and development in the dynamic and ever-evolving landscape of streaming technologies.

REFERENCES

[1] Ben, X., Ren, Y., Zhang, J., Wang, S.J., Kpalma, K., Meng, W. and Liu, Y.J., 2021. Video-based facial micro-expression analysis: A survey of datasets, features and algorithms. IEEE transactions on pattern analysis and machine intelligence, 44(9), pp.5826-5846.
[2] Chiossi, F., Welsch, R., Villa, S., Chuang, L. and Mayer, S., 2022. Virtual reality adaptation using electrodermal activity to support the user experience. Big Data and Cognitive Computing, 6(2), p.55.
[3] Erfanian, A., Tashtarian, F., Zabrovskiy, A., Timmerer, C. and Hellwagner, H., 2021. OSCAR: On optimizing resource utilization in live video streaming. IEEE Transactions on Network and Service Management, 18(1), pp.552-569.
[4] Falkowski-Gilski, P. and Uhl, T., 2020. Current trends in consumption of multimedia content using online streaming platforms: A user-centric survey. Computer Science Review, 37, p.100268.
[5] Farahani, R., 2021, June. CDN and SDN support and player interaction for HTTP adaptive video streaming. In Proceedings of the 12th ACM Multimedia Systems Conference (pp. 398-402).
[6] Feijt, M., De Kort, Y., Bongers, I., Bierbooms, J., Westerink, J. and IJsselsteijn, W., 2020. Mental health care goes online: Practitioners' experiences of providing mental health care during the COVID-19 pandemic. Cyberpsychology, Behavior, and Social Networking, 23(12), pp.860-864.
[7] Jabbar, J., Urooj, I., JunSheng, W. and Azeem, N., 2019, May. Real-time sentiment analysis on E-commerce application. In 2019 IEEE 16th international conference on networking, sensing and control (ICNSC) (pp. 391-396). IEEE.

[8] Khan, K. and Goodridge, W., 2017. Server-based and network-assisted solutions for adaptive video streaming. International Journal of Advanced Networking and Applications, 9(3), pp.3432-3442.
[9] Khan, K. and Goodridge, W., 2018. Future DASH applications: A survey. International Journal of Advanced Networking and Applications, 10(2), pp.3758-3764.
[10] Khan, K. and Goodridge, W., 2018. QoE in DASH. International Journal of Advanced Networking and Applications, 9(4), pp.3515-3522.
[11] Khan, K. and Goodridge, W., 2020. QoE evaluation of dynamic adaptive streaming over HTTP (DASH) with promising transport layer protocols: Transport layer protocol performance over HTTP/2 DASH. CCF Transactions on Networking, 3(3-4), pp.245-260.
[12] Khan, K. and Goodridge, W., Markov Decision Processes for bitrate harmony in adaptive video streaming. In 2017 Future Technologies Conference (FTC), Vancouver, Canada, unpublished.
[13] Koffka, K. and Wayne, G., 2018. A DASH Survey: the ON-OFF Traffic Problem and Contemporary Solutions. Computer Sciences and Telecommunications, (1), pp.3-20.
[14] Lu, B. and Chen, Z., 2021. Live streaming commerce and consumers' purchase intention: An uncertainty reduction perspective. Information & Management, 58(7), p.103509.
[15] Posada-Quintero, H.F. and Chon, K.H., 2020. Innovations in electrodermal activity data collection and signal processing: A systematic review. Sensors, 20(2), p.479.
[16] Ren, Q., Cui, Y., Wu, W., Chen, C., Chen, Y., Liu, J. and Huang, H., 2018, June. Improving quality of experience for mobile broadcasters in personalized live video streaming. In 2018 IEEE/ACM 26th International Symposium on Quality of Service (IWQoS) (pp. 1-6). IEEE.
[17] Robinson, R., Hammer, J. and Isbister, K., 2019, May. All the World (Wide Web)'sa stage: A workshop on live streaming. In Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems (pp. 1-8).
[18] Shi, C., Wang, X., Luo, S., Zhu, H., Ye, J. and Song, R., 2023. Dynamic causal effects evaluation in a/b testing with a reinforcement learning framework. Journal of the American Statistical Association, 118(543), pp.2059-2071.
[19] Shoumy, N.J., Ang, L.M., Seng, K.P., Rahaman, D.M. and Zia, T., 2020. Multimodal big data affective analytics: A comprehensive survey using text, audio, visual and physiological signals. Journal of Network and Computer Applications, 149, p.102447.
[20] Tharatipyakul, A., Li, J. and Cesar, P., 2020, April. Designing user interface for facilitating live editing in streaming. In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (pp. 1-8).
[21] Wang, X. and Wu, D., 2019. Understanding user engagement mechanisms on a live streaming platform. In HCI in Business, Government and Organizations. Information Systems and Analytics: 6th International Conference, HCIBGO 2019, Held as Part of the 21st HCI International Conference, HCII 2019, Orlando, FL, USA, July 26-31, 2019, Proceedings, Part II 21 (pp. 266-275). Springer International Publishing.