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A Novel Construction Proposal of Error Protection Code for Video Transmission Over Wireless Broadband Networks

Bita Ghasemkhani[1], Reyat Yilmaz[2], Recep Alp Kut[3]

[1]Graduate School of Natural and Applied Sciences, Dokuz Eylul University, Izmir 35390, Turkey
Corresponding Author: *bita.ghasemkhani[at]ogr.deu.edu.tr*

[2]Department of Electrical and Electronics Engineering, Dokuz Eylul University, Izmir 35390, Turkey
reyad.yilmaz[at]deu.edu.tr

[3]Department of Computer Engineering, Dokuz Eylul University, Izmir 35390, Turkey;
alp.kut[at]deu.edu.tr

Abstract: ***To improve the reliability of video transmission in communication systems, error control coding is usually performed on the transmitted information. It is finding increasing use in applications requiring reliable and highly efficient information transfer over wireless communication links in the presence of corrupting noise. Therefore, this PhD proposal project is situated within the well-established research field that explores efficient error protection schemes for video transmission. This research aims to propose a novel construction scheme of error protection code for video transmission over wireless broadband networks to ensure reliable and efficient communications for high-speed delivery of video content. To achieve this goal, this research will be at the junction of three areas: wireless broadband networks, video coding, and error protection schemes.***

Keywords: wireless broadband networks, error protection code, video transmission, error control, reliable communication

1. Introduction

The wireless network has advanced rapidly in recent years. It is widely regarded as the method of choice for surfing the Internet, watching high-resolution video streams, transmitting digital multimedia content, and so on via different types of computers, mobile phones, handheld, fixed or shared devices. Such devices have cutting-edge technologies to allow intensive data processing and transmission tasks, e.g., video streaming, video conferencing, online interactive gaming, cloud computing, the Internet of Things, virtual or augmented reality applications, etc. They are intended to be online and in real-time, which requires ubiquitous availability of services and high-speed delivery of video content [2]. As a result, the increasing demand for transmission of high-definition video data, based on the limits of mobile and wireless networks, is becoming a challenge and also has the highest requirements for quality of service and a user's quality of experience.

Broadband technologies are essential in the high-speed transmission of voice, video, and ICT applications over networks. The introduction of broadband technologies, communications antennas, optical fibers, satellites, and fixed or mobile wireless systems has enabled traditional and new forms of telecommunications to become a reality throughout the world. The constant evolution of telecommunications technologies leads to the availability of broadband access technologies. It offers wireless broadband networks that improve previous networks' limitations, such as high-speed access for multimedia services.

The wireless broadband network provides high-speed wireless Internet access or computer network access technologies in wide areas. Moreover, it can be a mobile or fixed outdoor wireless network that creates wireless point-to-multipoint or point-to-point connections for broadband services with half-duplex or full-duplex communication capabilities. Although the proposed research is focused on wireless broadband networks such as WMANs, WLANs, 3G, 4G/ LTE, and the emerging 5G for telecommunications and the information exchange between wireless communication systems, the results can also refer to other types of wireless networks via multiple access methods, e.g., Multimedia Wireless Sensor Networks [1].

Recent technologies and infrastructure developments in communication networks are adding to the promise of multimedia support for remote collaborations. As of 2020, video has become the most popular type of media out there. Many factors, such as the coronavirus pandemic, have contributed to that fact, but one thing is undeniable; video content is dominating the world at an unprecedented pace. It can be more eligible than other multimedia because of the booming of powerful sharing or transmission tools of digital video content and its size, and the demand for video quality is getting higher and higher [17]. Thus, efficient video coding has become one of the hot research topics in IT. It has been widely investigated for decades because of its importance in many practical applications, such as the transmission of high-definition TV, internet video, video conferencing, video surveillance, etc.

As reliable and highly efficient video transfer over noisy wireless channels is problematic, video transmission mechanisms such as retransmission and Forward Error Correction (FEC) are essential to ensure that the video arrives at its destination while retaining its quality. While

some of these mechanisms can obtain good performance, this does not mean they provide an optimal situation. Several factors negatively impact the Quality of Experience (QoE) in video transmission [18]. Adaptive Forward Error Correction schemes aim at protecting against packet loss errors by analyzing several relevant characteristics of the video or the network traffic load and using them to apply unequal error protection (UEP) to different parts of the video. Taking this into account, it is clear that an adaptive FEC mechanism is a viable option to achieve optimal error control, thus increasing the video transmission's resilience.

2. Research Aims

In this project, a novel construction scheme for error protection code over wireless broadband networks will be presented, considering high-speed video transmission with an optimal level of accuracy. One interesting notion is investigating machine learning-based video coding and low-complexity heuristic algorithms to reach a novel method and solve this optimization problem. With this idea in mind, it is precious to consider intelligent error protection schemes that encode the video based on its advanced cognitive information, which can reduce the complexity of video transmission over wireless communication links. In particular, it is focused on factors that promote the efficiency of the novel method by addressing measurements required to evaluate the wireless network and making comparisons with other related works. It is believed that such a study can give insights into developing a reliable network that enables secure and efficient video transmission, which is in high demand for wireless multimedia services.

3. Research Questions

- How can the efficiency of error protection codes be assessed in wireless broadband networks?
- Which measures are adopted to provide low-latency and high-reliable wireless communications?
- How can machine-learning-based video coding optimize error protection over wireless links?
- What are the constraints on the transmission of coded video streams in wireless networks?
- Is it possible to apply metaheuristic algorithms to optimize the construction scheme of error protection code for robust transmission of video content over wireless networks?

4. Problem Definition

Mobile and wireless technologies such as Wi-Fi, WiMAX, 3G, 4G/LTE, and the emerging 5G require the communication of high-quality videos with limited available bandwidth. High-Efficiency Video Coding (HEVC)/H.265 and Advanced Video Coding (AVC)/ H.264 multimedia standards are implemented in these technologies to fulfil mentioned requirements. Moreover, these standards achieve high error performance over wireless channels and large compression efficiency, thereby optimizing channel bandwidth [1]. Although numerous kinds of systems have been adopted in mobile and wireless networks to improve efficiency without sacrificing the channel bandwidth, the problem of establishing reliable wireless communication links for recent and future networks is still a big challenge for researchers.

Besides the bandwidth resource limitations in wireless communications, other major network issues are channel fading, scattering, interference, and uncertainty, which lead to the loss of data packets and the occurrence of burst errors in data transmission. Thus, for applications such as video streaming, the perceived quality of the received content is significant [2]. On the other hand, the demands for such multimedia applications and services in limited spectrum capacity have significantly increased among wireless users. Also, video coding development by compressing videos into a much smaller size has become saturated to some extent while the compression ratio continuously grows in the last three decades. Therefore, an important aspect of video communication is to have effective video coding algorithms to optimize the available bandwidth. For example, machine learning algorithms, especially those employing deep learning, which is capable of discovering knowledge from massive unstructured data and providing data-driven predictions, provide new opportunities for further upgrading video coding technologies [16].

Indeed, data protection strategies are used to solve mentioned problems and increase the reliability of transmission in wireless communication channels. Therefore, error control methods for data protection enable the reliable delivery of data and improve the quality of received content via error detection and correction codes. Accordingly, the literature contains many proposals for mitigating the effects of packet losses in wireless networks. For example, Automatic Retransmission reQuest (ARQ) [3,7,8], Forward Error Correction (FEC) [4,9,11,12] and Unequal Error Protection (UEP) [1,5,6,10] based research works. Also, video encoding standards such as HEVC and AVC have been highly adopted over wireless networks considered in the different state-of-the-art research works [13,14,15]. Depending on the application requirements, these standards can trade off computational complexity, compression rate, robustness to errors, and encoding/decoding delay time. Thus, the increasing importance of error control has led to the introduction of various mechanisms to improve the efficiency of video data transmission based on the characteristics of wireless communication channels.

5. Research Methodology

This project aims to construct an efficient error protection code for video transmission over wireless broadband networks, which plays an important role in reliable video delivery over uncertain wireless communication channels. It includes an analysis of the existing studies that have been confirmed already to form the basis for this research. Furthermore, critical evaluation of the materials is carried out as an analytical methodology and correspondingly takes related works into account as survey research. Also, the use of illustration tools such as graphs and tables allows for the exploration and presentation ofimportant information, and therefore it facilitates the research process as a quantitative methodology. Moreover, since this research aims to improve

existing techniques and introduce a novel scheme, it is categorized as applied research.

Besides formulating the optimization problem, exploring relationships among variables, and assessing the derived data, this research will be based on simulations relying on MATLAB and Wolfram Mathematica. The reason for using these software systems is because of their universality and convenience in academia and industry. Also, both have already constructed many functions and simulators that can be easily used in wireless communications for performance analysis and system optimization [19]. MATLAB and Wolfram Mathematica will be mainly used for numerical simulations and analytical derivations in this research to fully exploit the advantages of both computing platforms. Besides involving simulation tasks, the different laboratory experiments can be conducted according to available equipment and facilities at the university for the proposed research.

6. Research Progress

- Practice and improve research skills through reading and guidance from supervisors.
- Prepare for initial writing and focus on in-depth reading around the research area.
- Develop the research according to previous findings and draft the literature review.
- Prepare the methodology part of the project and design the research plan in detail.
- Conduct the primary research and iron out any potential problems and challenges.
- Collect and analyze data to plan writing an article based on initial research findings.
- Continue revising the research and proofread all sections.
- Final review, write up, submit, and disseminate the research.

7. Conclusion and Future Scope

A mixed-method approach, including analytical, survey, quantitative, applied, as well as experimental research, will be employed in this project. First and foremost, a preparation phase will involve a study through the literature of error protection schemes, video coding, and the evolution of wireless network technologies. This initial phase will build an essential basis for the rest of the work, as it will provide an overview of the different techniques for improving the security and reliability of wireless broadband networks by developing efficient video coding and error control. A study of the solutions raised by previous research endeavours will also be conducted to complete and answer the research questions. Then, different types of resources will be explored and integrated with cutting-edge tools to guarantee the significance of this project. Finally, all the results, relevant outcomes, and new ideas will be synthesized and published. Therefore, a security protocol is expected to be developed at the end of this PhD proposal thesis for wireless broadband networks that may be commercialized or utilized in further research projects on related domains. Ideally, it will be great if the proposed research provides the development of secure access to broadband multimedia services and contributes to the potential to impact the world positively.

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Author Profile

Bita Ghasemkhani is currently a Ph.D. student at Dokuz Eylul University. As a graduate of Master of Science degree in Computer Engineering, Computer Architecture from the Azad University of Tabriz, Bachelor of Science degree in Software Engineering from UCNA University of Tabriz, and an academic senior lecturer in information technology with the experience in researching, planning, consulting, and controlling different types of academic and industrial projects.Her research interests are in information technology, machine learning, predictive maintenance, IoT systems, data mining, error control, wireless networks, and industrial monitoring.

Reyat Yilmaz was born in Antakya, Turkey. He received the B.Sc. and MSc. Degrees in Electrical andElectronics Engineering from Dokuz Eylul University, Izmir, Turkey in 1986 and 1988 respectively. Hereceived the PhD. Degree from Sussex University, Brighton, UK in 1993. He has been working as an Assistant Professor at Dokuz Eylul University since 1995. His research interest are in the area of information and communication technology, mobile radio communications: modulation, coding anddata-image compression techniques, machine learning, and data mining.

Recep Alp Kut is Full Professor at Dokuz Eylül University, Department of Computer Engineering, Founder Semafor Teknoloji Ltd. İzmir, Visiting Professor, South East European University, Tetovo, North Macedonia, Assistant Professor, Ege University, Department of Computer Engineering. His area of interestsare machine learning, big data, IoT systems, information technologies, health informatics.