Chapter 11
Machine Learning-Based Subjective Quality Estimation for Video Streaming Over Wireless Networks

Monalisa Ghosh
Indian Institute of Technology Kharagpur, India

Chetna Singhal
Indian Institute of Technology Kharagpur, India

ABSTRACT

Video streaming services top the internet traffic surging forward a competitive environment to impart best quality of experience (QoE) to the users. The standard codecs utilized in video transmission systems eliminate the spatiotemporal redundancies in order to decrease the bandwidth requirement. This may adversely affect the perceptual quality of videos. To rate a video quality both subjective and objective parameters can be used. So, it is essential to construct frameworks which will measure integrity of video just like humans. This chapter focuses on application of machine learning to evaluate the QoE without requiring human efforts with higher accuracy of 86% and 91% employing the linear and support vector regression respectively. Machine learning model is developed to forecast the subjective quality of H.264 videos obtained after streaming through wireless networks from the subjective scores.

INTRODUCTION

This chapter provides insight into the emerging applications of machine learning for catering the needs of the next generation wireless networks. It is expected that the next generation wireless networks must reinforce ultra-reliable, low-latency communication in addition to bestowing high video quality to users playing real time streaming or ongoing download applications. Several deployment of LTE femto cells, WiFi hotspots not only makes accessing faster, but also increases the number of users enormously.

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In next generation wireless networks, substantial volumes of data has to be gathered periodically and in real time across several sensing devices. The wireless uplink will confront growth of traffic due to large number of short-packet transmissions, opposed to general view of uplink being less congested compared to downlink. Tomorrow's wireless network must support cloud-based gaming, real-time HD streaming and several multimedia services. Infact, this will lead to varying networking environment whose applications and their heterogeneous quality-of-service (QoS) along with need for efficient network resource utilization, while maintaining reasonable cost endorse a fundamental change in the way in which next generation wireless networks are modeled, designed and optimized. Upcoming trends also aim at solutions that optimize the Quality of Experience (QoE) of the end users. This necessity for meeting the QoE can be realized by implementing the fundamental notions of machine learning across network infrastructure and the end-user equipments. This chapter presents basic architecture, training procedure, as well as the associated challenges and opportunities for communication problems that can be addressed using machine learning.

Recent studies are coming up that address the current state-of the-art applications of machine learning for QoE evaluation. The work by Grazia et al., (2018) devised a machine learning approach to carry out QoE-deployed video admission control and resource management algorithms. They developed a multi-stage learning system that combines the unsupervised learning of video features from the size of H.264-encoded video frames with a supervised classifier trained to automatically extract the quality-rate characteristics of unknown video sequences. They have developed a multi-stage machine learning system that blends the unsupervised learning of features obtained from video from the size of H.264-encoded video frames with a supervised classifier trained to spontaneously withdraw the quality-rate characteristics of unknown video sequences. This characterization of QoE is then used to govern parallel video transmissions via a shared channel in order to assure a minimum quality level conveyed to the destined users. The discussions by Casa & Wassermann (2017) presented a new proposal to multi-dimensional Quality of Experience (QoE) prediction incase of mobile video by use of machine learning models. A high dimensional input space is used by them inorder to model influence of buffering and beginning delay on QoE. The proposed models are trained and tested on publicly available mobile video dataset. The work by Bampis, Li, Katsavounidis, & Bovik (2018), deploy diverse recurrent dynamic neural networks that carry out continuous time subjective QoE prediction. They trained a variety of recurrent neural networks and non-linear autoregressive models to estimate the QoE using different available subjective QoE database. Another work by Gao, Kwong, & Jia (2017) devise a joint framework consisting of machine learning and game theory (MLGT) for inter frame coding tree unit (CTU) level bit allocation and rate control (RC) optimization in high efficiency video coding (HEVC). At first, the authors have devised a support vector machine-based multi classification scheme inorder to improve the prediction accuracy of CTU-level rate-distortion (R-D) model. Second, they have proposed a mixed R-D model-based cooperative bargaining game theory for bit allocation optimization. The minimum utility is adjusted by the reference coding distortion and frame-level quantization parameter (QP) change.

With extensive utilization of internet in today's world, it can be foreseen that several multimedia applications like video teleconferencing, video on demand, video streaming over the wireless, online streaming sites like YouTube, Hotstar etc. will occupy a huge proportion in the next generation wireless networks. Videos undergo ample distortions during any of these processes i.e. processing, compression or transmission which results in degradation of visual quality before reaching the destined users. Fluctuating bandwidth is a distinctive feature of the wireless channels that corrupts the transmitting bitstream. The recent advances in video coding and compression techniques make it feasible to deliver high quality