GA-based feature selection for QoE estimation using EEG during video viewing

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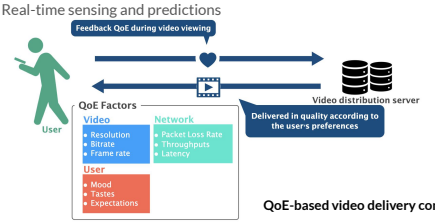
Background

- Dramatic increase in popularity of video delivery services
  - Globally, IP video traffic will grow 4-fold from 2017 to 2022[1]
  - Importance of improving QoE (Quality of Experience) is increasing
  - QoE-based video delivery control attracts researchers' interests
- Challenges to using QoE in video delivery control
  - Considering Internal Factors of Users
  - Real-time sensing and predictions



QoE-based video delivery control

[1] Cisco, "Cisco Visual Networking Index: Forecast and Trends, 2017–2022,"

Existing Research on QoE Estimation of Video Viewing Users

- Most existing research focus on network/video quality
  - Not considering the internal factors of the users
- QoE estimation using biometric information[2-4]
  - To reflect the user's internal factors in the QoE estimation results
    - Heart rate, Eye movement[2], EEG[3,4]
  - EEG data is majorly used

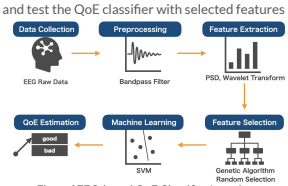
[2] D. Egan, S. Brennan, J. Barrett, Y. Qiao, C. Timmerer and N. Murray, "An evaluation of Heart Rate and ElectroDermal Activity as an objective QoE evaluation method for immersive virtual reality environments," 2016 Eighth International Conference on Quality of Multimedia Experience (QoMEX), Lisbon, 2016, pp. 1-6, doi: 10.1109/QoMEX.2016.7498964.
[3]S. Scholler, S. Bosse, M.S. Treder, B. Blankertz, G. Curio, K. Muller,and T. Wiegand, "Toward a direct measure of video quality perceptionusing eeg," IEEE Transactions on Image Processing, vol.21, no.5,pp.2619–2629, May 2012.
[4]A. Moldovan, I. Ghergulescu, S. Weibelzahl, and C.H. Muntean,"User-centered eeg-based multimedia quality assessment," 2013 IEEEInternational Symposium on Broadband Multimedia Systems andBroadcasting (BMSB), pp.1–8, June 2013.

EEG-based QoE estimation

- EEG (Electroencephalogram)
  - Potential changes in the brain observed by electrodes on the scalp surface
  - Widely used in the field of psychology and cognitive science
  - Available as real time data of millisecond order
- EEG-based QoE estimation for video delivery control
  - Estimate QoE by machine learning methods based on user EEG data
  - Need to select only few features for the reduction of the computational time
  - In our previous study, GA-based feature selection improved accuracy of emotion estimation
    - GA : Genetic Algorithm

Purpose and Approach

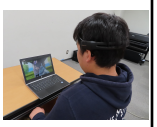
- Purpose
  - Implement a feature selection method that achieves better accuracy even with a limited number of features
- Approach
  - Collection of EEG and QoE data during video viewing by experiments
  - Evaluate EEG-based QoE estimation accuracy with different feature selection methods
    - Select features with GA-based method and random
    - Train and test the QoE classifier with selected features by SVM



Flow of EEG-based QoE Classifier Learning

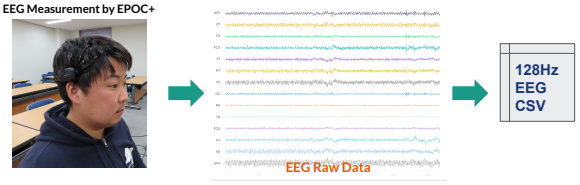
Experiment for Data Collection

- Collect EEG and QoE data during video viewing
  - To train and evaluate QoE-classifier
- Measurement
  - Record participant's EEG data during video viewing using EPOC+
    - Watch 10 different videos in random order
    - Video quality changed randomly in 5 levels
  - Ask how they felt about the video viewing
    - Options : Good, Normal, Bad
    - Responses are used as a QoE-label for learning later
    - Use only Good or Bad data (To focus especially QoE decline)



EEG Measurement Equipment

- Emotiv EPOC+
  - 14 channels
  - Sampling rate : 128Hz
  - Wireless measurement is possible through a Bluetooth connection



[4] EMOTIV, "EPOC+ user manual, 2018." https://emotiv.gitbook.io/epoc-user-manual/,2019/02/14

Feature Extraction

- Extract features from EEG data split every 2s window
- Extracted Features
  - Bandpower
    - The signal's power of θ (4-8Hz), α (8-12.5Hz), β (12.5-30Hz), wholebands (4-30Hz)
    - Use each powers and the ratio of θ, α, and β to total power
  - PSD (Power Spectral Density)
    - Measure of the signal's power distribution per unit frequency (1 Hz)
    - Calculate on θ, α, β , wholebands
    - Use median, max, min, variance value of each
  - DWT (Discrete Wavelet Transform)
    - A time-frequency analysis method using wavelet functions for basis functions
    - Use median, max, min, variance value of level 2 to 4 components of DWT

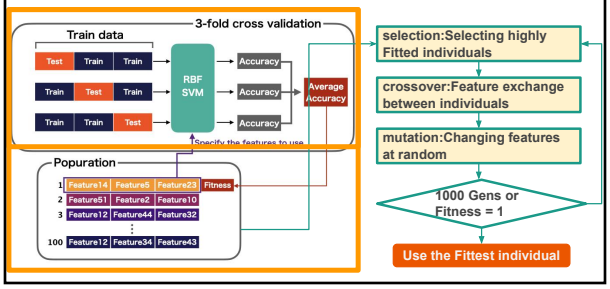
The Number of Features

14 channel × (4 subbands × 4 values + 7 subbands + 3 levels × 4 values) =

490 features

Feature Selection

- Choosing the suitable features for QoE estimation
  - Comparing methods in random and GA
  - The number of features to be selected was evaluated at 3, 5, 10
- Feature Selection with GA

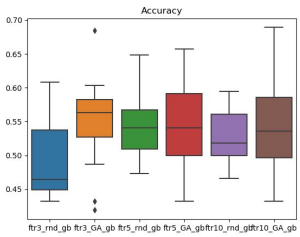


Evaluation

- Evaluating feature selection methods
  - By QoE classification accuracy
  - Comparing random selection and GA
  - Also evaluate performance with the different number of features
- Classification Method
  - SVM with a RBF (Radial Based Function) kernel
  - Train the SVM for each participant
  - Divide the data from the trials into test data and train data
- Dataset
  - EEG and QoE data
  - Only good or bad QoE data were used

Compare with feature selection methods

- GA-based selection outperformed the random selection in more than half cases at every number of features
- At some subjects GA-based selection has lower accuracies than random
  - Some individuals have characteristics that make them prone to overlearning
    - ex) The tendency for reactions to vary greatly depending on the content of the video



Summary and Future Work

- Summary
  - Make GA-based feature selection method for EEG-based QoE estimation
  - Collect EEG and QoE data during video viewing for evaluation
  - Evaluate the accuracy of learning a classifier in GA and random selection
  - Show that the accuracy was 6% better than that of the random selection
  - On the one hand, some subjects showed no improvement in accuracy with GA
- Future Work
  - Improve the QoE estimation accuracy
    - Use content information for estimation
    - Use ERP (Event Related Potentials) for estimation
    - Use Continuous QoE measurement method like SSCQE
  - Construct a rate control method considering user's QoE