LiveLight: Crowd Generated Highlights

Muhammad Umair[1]
KAIST
Daejeon, South Korea
umair@kaist.ac.kr

Yungi Jang[1]
KAIST
Daejeon, Korea
crystani@kaist.ac.kr

Jiwoo Park[1]
KAIST
Daejeon, Korea
shapley_aldebaran@kaist.ac.kr

[1] These authors contributed equally to this work.

ABSTRACT

Live videos are often long and contain a lot boring and uninteresting moments. Generating highlights for live videos such as sports match, presidential debates etc. needs experts, and also viewers might have to wait for some time in order to watch those highlights. In this paper, we present LiveLight, a system that uses crowdsourcing to generate highlights for live videos. The unique feature of our system is that it processes crowd's input during the live stream and generates highlights before the live stream ends. To evaluate our proposed system, we ran three user studies. Tasks included participants to watch live video and generate candidate highlights and also view generated highlights. Participants rated generated highlights to be useful, interesting and increased their concentration during the video. Results indicate that LiveLight generated highlights cover key moments in the video and overlaps experts generated highlights for the most part but it misses out the context of generated highlights. The system walkthrough video is available at: https://www.youtube.com/watch?v=0i5bZOxbYMA

AUTHOR KEYWORDS

Highlights generation; Live streamed events; Crowdsourcing; Viewer-sourcing; Video summary

ACM CLASSIFICATION KEYWORDS

H.5.2 User Interfaces: Graphical User Interfaces

INTRODUCTION

Many people enjoy live videos in a wide range of areas like sports, video games, political events, and news. However, there are some impediments with enjoying live videos. First, they are usually too long to fully watch it. Also, live videos inevitably contain lots of unnecessary moments in their content. Second, an interesting moment in a live video passes too fast. So it is easy to miss an interesting moment. But the summary of a long live video requires expertise and takes a lot of time. Delayed highlight makes the user experience worse. To deal with those troubles, we have established two design goals. First, we tried to summarize the whole video into small chunks. Second, we aimed to give immediate, interactive highlights to viewers.

Previous approaches deal with these design goals with machines, but these systems are highly trained for specific types of videos so that they are not generalizable. Also, there are crowdsourcing approaches like Epic play that is analyzing the tweets [5], but these are not suitable for so-called long-tailed videos.

In our work, we used crowdsourcing approach. The viewers' acts as the crowd and their responses are used to generate. With our system, users press the "Add This Moment" button when they think the moment of the live event is interesting. When the candidate highlights gathered enough, our system runs DBSCAN algorithm in order to cluster those candidates, and when a new cluster is made it is sent back to clients to show it as a new highlight.

Our evaluation of the system showed that our crowdsourcing approach can generate highlights that can be comparable to expert highlight when proper parameters for DBSCAN algorithm are given. With the evaluation of the system with 7-point Likert scale questions, the participants perceived the highlights made by LiveLight as useful, enjoyable while making them more concentrated. Users also responded that LiveLight is useful in an open-ended question.

RELATED WORK

There are a lot of previous efforts to generate highlights without hiring expensive experts. Many of them use techniques like machine learning, image processing, and deep neural network in order to generate highlights from specific types of video, i.e. on-demand feature extraction along with a fuzzy inference system for football games [1], video-game specific events and highlight detection for live streamed video games [2], highlight detection with pairwise deep ranking for GoPro-like videos [3], and play scene extraction for baseball games [4]. However, those systems are not generalizable for various types of video as they are highly trained for the specific type of videos with specific signs like 'kill logs' [2], 'baseball field detection' [4], 'FIFA logos' [1].

There are also approaches for highlight generation using crowdsourcing. Epic play does this by monitoring the activities on Twitter. [5] But this approach has limitations that only videos for nation-wide popular events are expected to have a multiple number of tweets. So-called long-tailed videos like Livestream by a famous YouTube streamer are not likely to have a multiple number of tweets even if there are many fans of them and obvious necessity for highlights for that kind of videos. Afreeca TV, a Korean company providing live streams for various types of contents, has an interesting-moment-vote system named Kkuljaemgak (*꿀잼각*, it's going to be fun) [6]. Users press the button when they think it is fun. This works as voting for the highlights later. However, this system does not have a proper automated aggregation system. Therefore, there are human moderators who manually cut and post videos based on the votes.

SYTEM

System overview

User interface

In order to serve the task from the needs for getting highlights even for long-tailed Livestream events, we developed a system called LiveLight. LiveLight is a website showing a live streamed event. Currently, we are showing repeating 12-mins video from *UFC 205: Conor Mcgregor vs Eddie Alvarez* [7]. The video plays every hour in order to mimic the behavior of live streaming. The users of LiveLight first see the interface as shown in **figure 1**.

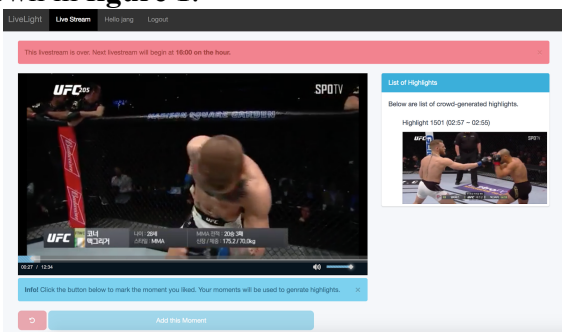

Figure 1. LiveLight main page.

While seeing the live video, the participants can press "Add This Moment" button. When the button is clicked, the moment that the user feels interesting gets marked. The blue markers on the timeline show the moments that are submitted by the user, and the red markers represent the moments that are submitted by the other users. Users may hover the mouse cursor on the markers to see who marked the moment.

Based on the markers, which should be regarded as candidate highlights, we run our algorithm to generate highlights. The algorithm runs whenever a user submits markers to the system. When there is a new highlight, then it is sent back to each client. The generated highlights by the crowd are listed on the right side of the webpage. Users can view those highlights by clicking one of thumbnails on the list even before the live-streamed event is over.

Result page for analysis

After the preliminary user evaluation test with a smaller group of people, we realized that the parameters for DBSCAN algorithm should be assigned properly according to the number of participants and their activities.

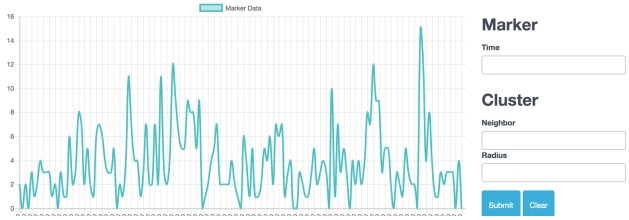

Figure 2. LiveLight result page for analyzing data.

Therefore, we implemented an additional result page as shown in **figure 2**. The graph is given to visualize the marker distribution of all participants in our study. Also, it is possible to choose a specific segment of test data by giving the value to Time input box. For example, when the Time input box is given as 22, then only the data from 10 pm is used. With this page, we could analyze the result of our algorithmic highlight generation based on user contribution.

The major factors that affect the highlight result are the parameters for DBSCAN algorithm. These values are also configurable on this page by filling out Neighbor and Radius values.

Implementation

LiveLight is implemented using node.js v6.6.0 as a server-side framework and Bootstrap v3.3.7 as a front-end web page framework.

The interaction between the server and client is done with Ajax and WebSocket. Other technologies include JQuery, socket.io, video.js. For mongoDB ODM, we used mongoose v4.4. Also, we generate thumbnail images with html2canvas v0.5.0-beta3. Finally, the authentication of users is done with passport v0.1.18.

The server is running on Heroku [8], which is a platform-as-a-service (PaaS). mongoDB is running on mLab (https://mlab.com/), which is a mongoDB platform that hosts mongoDB.

EVALUATION

Participants

We recruited 36 participants (28 male, mean age 24.5, stdev=4.57, max=35, min=14) in three user studies via personal contacts and social media.

Procedure

A 12-minute study session was conducted for all three user studies. All participants were provided instructions which included why we are conducting the experiment, what they are expected to do and also general guidelines to use our system. Next, participants performed two tasks: submitting candidate highlights during the video and viewing highlights generated by our system. After completing both the tasks, participants completed a questionnaire on the usability of the system and their experience and opinions about generated highlights.

Results

All participants submitted 566 candidate highlights for 12 min video. Peaks in **figure 3** show candidate highlights distribution of all participants across the video length. Results indicate that highlights generated by our algorithm capture the key moments in the video. When compared with expert generated highlights, our algorithm captures most of the expert-generated highlights but it misses out starting of the game, calling off a round and starting a new round because participants in our user study didn't think them as interesting. Also, highlights generated by experts captures proper context of a key moment in the video as compared to LiveLight generated highlight.

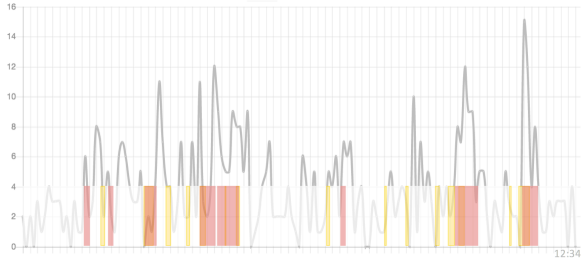

Figure 3. Highlights distribution and comparison with the gold-standard highlight by experts.

Perception of generated highlight

In response to 7-point Likert scale questions about the generated highlights, participants indicated that they found highlights to be "useful" (μ=4.92), "enjoyable" (5.25), "represent their perception of highlights" (4.67) and "increased their concentration" (5.07). In an open-ended question, we asked participants how they feel about adding their favorite moments. Common responses were "*Cool to see that other people also see my moment*", "*It feels amazing. This allows me to capture my favorite moments and allows me to watch them later so I can later on show them to my friends and have a discussion on their favorite moments"*. When asked how do they feel about watching highlights generated by other people, participants responded that "*Gives me a perspective on the individual likes of different persons. Though some of their highlights were exactly the same as mine."* and "*It was kind of interesting, because our opinions affect to official highlights*".

Perceived usability of LiveLight

In an open-ended question regarding the usability of LiveLight system, participants critiqued that "*Video was disturbed by buffering, so pre-loaded videos with smooth run will keep up the interest*", "*Waiting 5 seconds is too long. I want to repeatedly push button fast*", "*Maybe the option to select entire span of time instead of just a moment*" and "*Strong visual effect for adding marker is needed*". Others said "*I enjoyed it. it was interactive*" and "*Good that I can watch it simultaneously with watching the live video*".

DISCUSSION AND FUTURE WORK

After deployment of our system with the concept of viewer-sourcing, which is trying to make participants motivated themselves by providing interesting contents for them, we were surprised by the diversity of users' prior experiences. Responses from our user evaluation indicated that 70% of our participants didn't watch UFC videos before. Also, analysis of 566 candidate highlights (mean candidate highlights 16.5, stdev=16, max=74, min=1) generated by participants revealed that some participants submitted up to 74 candidate highlights followed by 51, 44, while 5 participants submitted less than 2 candidate highlights. We believe that this variation in candidate highlights is because of participants' perception of highlights. Analysis of the participants' highlights data revealed that some of them were submitting highlights for every other punch in the UFC video, while others generated highlights only at key moments in the video. Participants who had experience of watching UFC videos before submitted from 5 up to 15 highlights. We think that since a lot of our participants were new to UFC videos, adding several videos for participants to choose from would be a good addition and will help generate more quality data. When asked about what videos should be added in future, common responses were "sports", "debates", "dramas" and "movie clips" etc.

Also, with our evaluation result, we realized that there should be more robust methods to deal with miss behaviors of the users. The intrinsic motivation to meet the audiences own needs could make them to participate in the process of highlight generation earnestly, but the huge variance of the candidate highlights could have been prevented by providing a proper user behavior pattern recognition.

We kept on improving our system based on participant's feedback such as video buffering and broken thumbnails issues, but there is still need for strong visual aids for our system. Also, we plan to automatically adjust algorithm parameters based on live viewers and highlights submitted. Choosing optimal parameters would fix problems for video context and would improve generated highlights also. Other improvements include adding 2D timeline for our video, testing our system with live videos and implementing quantitative methods for evaluation.

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