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A Proposal of a Method for Video Advertisement Insertion on Smartphone

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Abstract –
In this research, we propose a method for video advertisement insertion on smartphone. The method has an algorithm which estimates a comfort timing to insert a video advertisement using the acceleration data at the time of watching a video. To create the algorithm, we formulated three hypotheses; (1) Viewers who watch video contents on smartphones sitting on chairs change their posture when they take a short breath, (2) The postural change can be detected by analyzing acceleration data from the accelerometer of the smartphone, (3) The timings of the postural changes correspondent with timings of a scene change on the video content and one of the timings is an appropriate timing to insert a video advertisement. We conducted a preliminary experiment and found these hypotheses were true. On the basis of the finding, we proposed an algorithm which estimates a comfort timing using the acceleration data to detect a viewer's postural change. The evaluation results showed accuracy rate of the proposed algorithm was 86% and useful in terms of practical usage.

Keywords: Video Advertisement, Insertion Algorithm, Smartphone, Accelerometer

1 INTRODUCTION

In recent years, video sharing services introduce a business model which inserts video advertisements in their video contents in the same manner as TV. The business model becomes popular with increase of smartphone users. Major video sharing services such as YouTube [1] and niconico [2] provide smartphone applications to users and the smartphone applications insert video advertisements to make a profit. Therefore, many smartphone users have to watch video advertisements on the video sharing services.

There are three types of video advertisements, which are pre-roll, post-roll and mid-roll. The pre-roll video advertisement inserts a video advertisement before video start. The post-roll inserts a video advertisement after video end. The mid-roll inserts a video advertisement viewing a video content like TV commercials and becomes popular in recent years. Adobe reports the mid-roll video advertisement is engaging commercials which have high completion rate [3]. The mid-roll video advertisements will be used even further in the next several years.

The mid-roll video advertisement, however, creates disadvantage for viewers. If video advertisements are inserted at the wrong time, the viewers feel discomfort about the advertisement and it will reduce effectiveness of the advertisement. Furthermore, the discomfort about the advertisement gives the viewers cause to use adblock software. There are over 600 million devices running adblock software and 11% of the global internet population is blocking ads on the web [4]. Moreover, Google Chrome starts to block web advertisements which do not conform to Better Ads Standards defined by the Coalition for Better Ads [5]. The advertisements ads which disrupt users' experience tend to be excluded from web services. Therefore, it is important to insert video advertisements at right timing so that the viewers can watch video contents comfortably and the advertisements do not disrupt their experiment. Otherwise, the video advertisements will be blocked and meaningless.

We have proposed a video advertisement insertion method which does not interfere with video viewing to make viewers accept the video advertisements [6]. In the previous work, it analyzes characteristics of viewers' comments for the video content. It enables viewers to watch videos more comfortably without feeling of interruption of their video viewing by the video advertisement insertion. However, there are two issues in the previous method. The first issue is that the previous method does not apply to various video sharing services. This is because it needs special kind of viewers' comments with playback time such as comments on the niconico. The second issue is that the previous method has room for improvement of viewers' experience. This is because it does not personalize the timing of video advertisement insertion in spite of difference of the right timings for each viewer.

In order to solve these issues, based on the fact that the number of users watching videos on smartphones has increased rapidly, it is worthwhile considering a method using smartphone sensor information. In this research, we use acceleration information from the accelerometer of the smartphone at the time of watching video contents. We try to find relationship between the acceleration information and appropriate timings for video advertisement insertion. Utilizing the relationship, we propose a method which estimates an appropriate timing to insert a video advertisement for each viewer.

The paper is organized as follows. In the next section, we describe related work and previous work to clarify the issues. In section 3, we formulate hypotheses in order to create a new method which utilizes the accelerometer of the smartphone. Then, we conduct a preliminary experiment in section 4. We propose a new video advertisement insertion method in section 5. In section 6, we evaluate the new method compared with the previous method. Section 7 gives some conclusions and our future work.

2 RELATED WORK

In this section, we describe an advertising model which becomes a reason why the viewers' discomfort should be removed. Then, we describe related work of video advertisement insertion and detail of our previous work.

2.1 Advertising Model

There is an advertising model, AIDMA [7] which is a psychological process model that leads consumers to purchase some products. The process goes along "Attention", "Interest", "Desire", "Memory" and "Action". At first, consumers watch advertisements and aware of a products (Attention). Then, they are interested in it (Interest) and desire to get it (Desire). They memorize the product (Memory) and purchase it at last (Action).

In viewpoint of video sharing services, wrong timing of video advertisement insertion has a negative impact on the process. If the viewers feel uncomfortable about the video advertisement which is inserted at the wrong time, the process will stop at "Attention" phase and not proceed to "Interest" phase. Therefore, it is important to insert video advertisements at right timing.

2.2 Video Advertisement Insertion

There are studies of interactive advertising to provide interactivity to the advertising [8]-[11]. The interactive advertising allows selecting appropriate ads according to the viewers and changing video length and display methods. Our research is regarded as one of technologies for interactive advertising. Tao Mei et al. [12] proposed a scheme of appropriate video ad insertion for online videos. In this research, the appropriate timing for video advertisement insertion is determined detecting an unattractive video shot boundary. The unattractive video shot boundary is detected by importance of the scene audio-visually. Since this research analyzes video image and audio in detail, the processing cost will be high when it applies to a large number of videos on the video sharing services. Our study aims to find other approaches which estimate the appropriate timing for video advertisement insertion without heavy audio-visual processing.

2.3 Our Previous Work

We have proposed a method for video advertisement insertion which was applicable to the action game videos using viewers' comments for the video contents on the niconico [6]. We found appropriate timings for video advertisement insertion corresponded with timings of scene changes on the video content. The timings of the scene changes could be estimated by analyzing viewers' comments. Details of the method is as follows.

1. Getting 10,000 viewers' comments of the video.
2. Detecting shot boundaries of the video.
3. Calculating sample variance of number of viewers' comments per second from first shot boundary to last shot boundary.
4. Omitting the first shot and the last shot from the following process.
5. Detecting a shot boundary which is first with lowest sample variance after the first boundary with maximum sample variance from start of the video.
6. Referring 7 shots centered at the detected shot boundary.
7. Calculating variance of number of viewers' comments per second for each shot.
8. Calculating difference of the variance between two adjacent shots.
9. Finding maximum difference of the variance.
10. Choosing the shot boundary for video advertisement insertion.

However, the previous method does not apply to various video sharing services because it needs special kind of viewers' comments with playback time such as comments on the niconico. Moreover, it does not personalize the timing of video advertisement insertion in spite of differences of right timing for each viewer. In this paper, we try to solve these two issues and propose a method which does not need viewers' comments with an appropriate timing of video advertisement insertion for each individual.

3 HYPOTHESES FORMULATION

In this section, we indicate possibility that there is a relationship between human motion and degree of interest. We also describe existing techniques of sensing for human motion to choose what sensor is appropriate for estimating human motion on smartphones. Then, we formulate hypotheses in order to create a new method.

3.1 Human Motion and Degree of Interest

There are several techniques for estimating human motion by sensor devices on the smartphone. There are also some studies which show a relationship between human motion and degree of interest.

The relationship between eye motion and degree of interest is well-known [14]-[17]. The data of eye motion can be acquired by eye-tracking techniques. However, high accurate eye-tracking techniques require special devices for eye tracking or strict restrictions of the measuring environment. It is difficult for smartphone users to prepare for the special devices and strict restrictions force inconvenience upon the users. For these reason, the eye motion is not suitable to estimate viewers' degree of interest on the smartphone.

The relationship between posture and degree of interest is mentioned [18]. People change their posture at intervals from 15 to 20 minutes at the time of sitting because of fatigue [19][20]. Meanwhile, their postural change hardly occurs when they are interested on something. We can apply this knowledge to a method which estimates an appropriate timing to insert a video advertisement for each viewer if we can detect viewers' postural change by smartphone sensors.

There are a lot of techniques to estimate body motion using sensors. Visual analysis using video data taken by camera devices is one of the techniques. However, usage of camera devices causes large power consumption and it is a disadvantage especially on the smartphone. Visual analysis is not appropriate to estimate body motion. Estimation of the body motion using acceleration information is popular and lightweight techniques [21][22]. Most of smartphones have accelerometer and many researchers study estimating body motion of the smartphone users from the acceleration information. These researches show various states of smartphone users such as sitting, standing, walking, running, going up and down the stairs and so on can be discriminated. Usage of accelerometer to detect postural change of smartphone users is reasonable.

3.2 Hypotheses

Our previous work shows appropriate timings for video advertisement insertion corresponded with timings of scene changes on the video content. The viewers may change their posture in scene changes on the video content. We formulate three hypotheses as follows.

1. Viewers who watch video contents on smartphones sitting on chairs change their posture when they take a short breath.
2. The postural change can be detected by analyzing acceleration data from the accelerometer of the smartphone.
3. The timings of the postural changes correspondent with timings of a scene change on the video content and one of the timings is an appropriate timing to insert a video advertisement.

If these hypotheses are true, we can create a new method which estimates an appropriate timing for each individual to insert a video advertisement by analyzing acceleration data from the accelerometer of the smartphone.

4 PRELIMINARY EXPERIMENT

We conduct a preliminary experiment to reconfirm if there are difference of right timings to insert a video advertisement for each viewer and test the hypotheses.

4.1 Methodology

We select 5 videos at random from several videos which were used in the previous work. We ask 3 participants for cooperation, who are in their twenties and thirties and have used some video sharing services. At first, we explain about the experiment to the participants. They watch the 5 videos in random order on a smartphone sitting on a chair. We shoot a video to record their watching situation. In the smartphone, an application which records acceleration data from the accelerometer is running. After watching the videos, we carry out a questionnaire survey to ask the participants top 3 comfort timings if a video advertisement is inserted. We explain the participants the length of the video advertisement is about 15 seconds. Then, we interview the participants showing the recorded video. Table 1 shows the overview of the experiment.

Table 1: Overview of the experiment.

Participants	3 people in 20s and 30s who have used video sharing services
Smartphone	Nexus 5
Videos	Video 1: 3D action game [23] Video 2: 2D action game [24] Video 3: 3D action game [25] Video 4: 2D action game [26] Video 5: 3D action game [27]
Condition	Sitting on a rotary chair with backrest (seat height: 30 cm)
Procedure	1. Receive an explanation about the overview of the experiment 2. Watch the 5 videos in random order 3. Answer top 3 comfort timings if a video advertisement is inserted 4. Take an interview about the comfort timings.

Table 2: Comfort timings for each participant in video 1.

Video 1

	Participant A	Participant B	Participant C
1st comfort timing	01:47	07:00	01:08
2nd comfort timing	00:09	06:43	01:47
3rd comfort timing	06:30	01:47	06:43

Table 3: Comfort timings for each participant in video 2.

Video 2

	Participant A	Participant B	Participant C
1st comfort timing	01:00	09:49	01:23
2nd comfort timing	01:41	10:41	10:41
3rd comfort timing	09:41	05:45	09:41

4.2 Results

At first, we reconfirm whether there are differences of right timings to insert a video advertisement for each viewer or not. Tables 2-6 show the top 3 comfort timings in the 5 videos for each participant. These results show there are differences of the right timing for each participant. We found the participants had characteristic features to select the comfort timings. The participant A tended to select the 1st comfort timing in early scenes. The participant B tended to select the 1st comfort timing in late scenes. We reconfirmed that it was necessary to personalize the timing of video advertisement insertion because there were difference of the right timings for each viewer.

We also checked the recorded video. The participants changed their posture in the scene change and the timings of the postural change matched their comfort timing. The postural changes rapidly increased the resultant acceleration of 3-axis. These results show monitoring the rapid increase of the resultant acceleration can detect postural changes of the

Table 4: Comfort timings for each participant in video 3.

Video 3

	Participant A	Participant B	Participant C
1st comfort timing	01:23	10:50	07:09
2nd comfort timing	02:19	11:11	10:50
3rd comfort timing	07:09	06:14	11:11

Table 5: Comfort timings for each participant in video 4.

Video 4

	Participant A	Participant B	Participant C
1st comfort timing	01:39	07:10	01:39
2nd comfort timing	01:44	09:38	07:10
3rd comfort timing	07:10	10:16	03:45

Table 6: Comfort timings for each participant in video 5.

Video 5

	Participant A	Participant B	Participant C
1st comfort timing	03:41	10:51	05:44
2nd comfort timing	05:44	06:50	06:50
3rd comfort timing	06:50	11:15	11:15

viewers and estimate one of their comfort timings to insert a video advertisement in the video content.

5 PROPOSED METHOD

The preliminary experiment shows the possibility of estimating a comfort timing for each viewer to insert a video advertisement utilizing their postural change which can be detected by the rapid increase of the resultant acceleration of 3-axis. On the basis of the finding, we create an algorithm for video advertisement insertion.

5.1 Algorithm for Video Advertisement Insertion

Figure 1 shows a flowchart of the algorithm for video advertisement insertion using an accelerometer on the smartphone. In the algorithm, it calculates a test statistic based on acceleration values for outlier detection which means occurring the viewer's postural change. The test static T_i can be calculated using $Acceleration_t$, E_t, SD_t at time t. $Acceleration_t$ denotes the resultant acceleration of 3-axis at time t. E_t denotes the average of the resultant acceleration from the video start to time t. SD_t denotes the standard deviation of the resultant acceleration from the video start to time t. T_t is calculated by the following equation.

$$T_t = |\ (\ Acceleration_t - E_t\ )\ |\ /\ SD_t$$

The outlier can be detected when the following inequality is completed.

$$T_t > 2 * SD_t$$

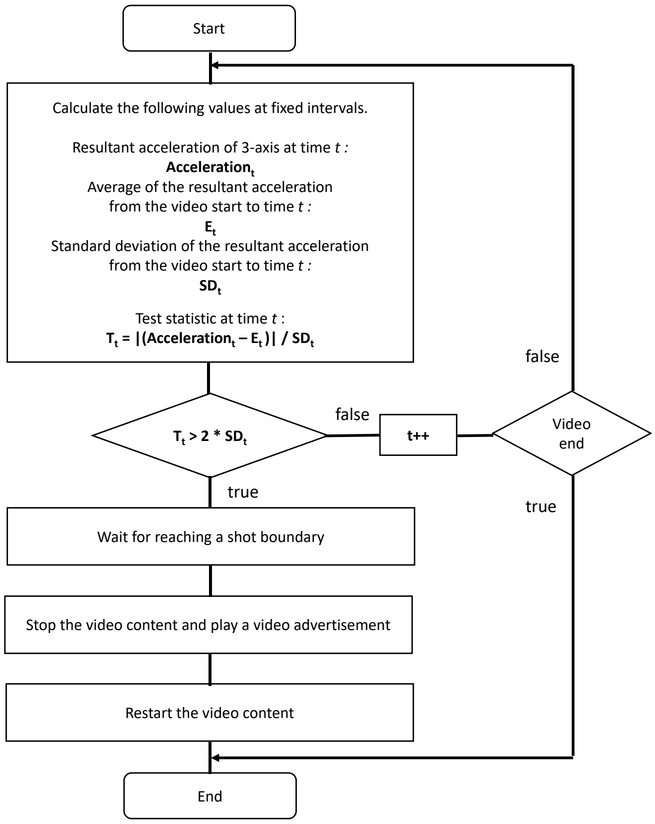

Figure 1: The flowchart of the algorithm for video advertisement insertion.

If the outlier is detected, the algorithm waits for reaching a next shot boundary. In the next shot boundary, the video content is stopped and a video advertisement starts. After completion of the video advertisement, the video content restarts and the algorithm terminates the process of the video advertisement insertion.

5.2 System Design

We assume the algorithm for video advertisement insertion is implemented on the smartphone as an application for video viewing. A video advertisement and acceleration data are input to the algorithm. The algorithm outputs less than one comfort timing for each viewer in the video content.

Figure 2 shows the system design of the proposed method. The proposed system have two servers, which are for video sharing and video advertisement. Video uploaders submit their video contents to the video sharing server. Advertising sponsors provide video advertisements to the video advertisement server. Video viewers have smartphones with a smartphone application for video viewing which has the algorithm for video advertisement insertion. The smartphone application plays a video content from the video sharing server. Shot boundaries of the video content are detected by existing techniques for shot boundaries detection and it lies outside the scope of our research. While the video viewer is watching the video content, the algorithm for video advertisement insertion

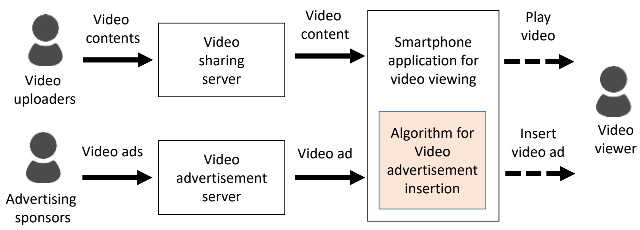

Figure 2: System design of the proposed method.

monitors acceleration data of the smartphone. The smartphone application stops the video content temporarily and starts a video advertisement from the video advertisement server when the algorithm estimates the timing is comfort for the viewer. After that, the video content restarts without any more video advertisement in the viewing. Note that we suppose the algorithm works only when the video viewer is sitting on a chair and the viewer watches the video holding the smartphone without video skip. In case of other conditions, new routines should be added to the algorithm.

6 EVALUATION

We evaluate the performance of the proposed algorithm for video advertisement insertion using an accelerometer on the smartphone. Comparing the previous algorithm, we verify the proposed algorithm estimates a better comfort timing for each viewer.

6.1 Methodology

The evaluation is conducted in the same manner as the preliminary experiment. We use 5 videos which are same videos in the preliminary experiment. We ask 10 participants for cooperation, who are in their twenties and thirties and have used some video sharing services. At first, we explain about the experiment to the participants. They watch the 5 videos in random order on a smartphone sitting on a chair. We shoot a video to record their watching situation. In the smartphone, an application which records acceleration data from the accelerometer is running. After watching the videos, we carry out a questionnaire survey to ask the participants top 3 comfort timings if a video advertisement is inserted. We explain the participants the length of the video advertisement is about 15 seconds.

After getting data of acceleration and comfort timings, we estimated a comfort timing for each viewer by using the proposed algorithm. We also estimated a comfort timing by using the previous algorithm which used viewers' comments on the niconico. Then, we compared the result of the proposed algorithm with one of the previous algorithm.

6.2 Results

Figure 3 shows graphs of the resultant acceleration of 3-axis on the smartphone when each participant was viewing the Videos 1-5. The horizontal axis and vertical axis of these graphs show elapsed time since the video started and the resultant acceleration of 3-axis. The proposed algorithm for video advertisement insertion estimated a comfort timing for each viewer based on the acceleration data. From these graphs, we can see the rapid increase of the resultant acceleration caused by the participant's postural change.

Table 7 shows the result of comparing an estimated timing of the proposed algorithm with top 3 comfort timings for each viewer. Table 8 shows the result of comparing an estimated timing of the previous algorithm with top 3 comfort timings for each viewer. In these tables, "1st" means the estimated timing coincides with the 1st comfort timing for the viewer. The same applies to "2nd" and "3rd". "n/a" means the estimated timing does not coincide with any top 3 comfort timings. We regard the estimated timing is an appropriate timing if it coincides with one of the top 3 comfort timings.

From Table 7, the proposed algorithm could estimate 43 appropriate timings of the 50 chances. The accuracy rate of the proposed algorithm was 86%. On the other hand, the previous algorithm could estimate only 22 appropriate timings of the 50 chances as shown in Table 8. The accuracy rate of the previous algorithm was 44%. Comparing these results, the proposed algorithm improved the accuracy rate more than 40%. Personalization of a timing to insert a video advertisement contributed the improvement of accuracy rate.

Table 7: Result of comparing an estimated timing of the proposed algorithm with top 3 comfort timings for each. viewer

	Video 1	Video 2	Video 3	Video 4	Video 5
Participant A	1st	2nd	1st	2nd	n/a
Participant B	1st	1st	2nd	n/a	n/a
Participant C	1st	3rd	1st	1st	1st
Participant D	3rd	1st	3rd	n/a	1st
Participant E	1st	1st	2nd	1st	3rd
Participant F	1st	1st	1st	2nd	2nd
Participant G	2nd	3rd	1st	1st	n/a
Participant H	1st	2nd	1st	n/a	1st
Participant I	1st	n/a	3rd	2nd	3rd
Participant J	2nd	1st	1st	1st	1st

Table 8: Result of comparing an estimated timing of the previous algorithm with top 3 comfort timings for each. viewer

	Video 1	Video 2	Video 3	Video 4	Video 5
Participant A	n/a	n/a	n/a	1st	n/a
Participant B	n/a	n/a	1st	n/a	3rd
Participant C	n/a	n/a	2nd	1st	n/a
Participant D	n/a	n/a	3rd	3rd	n/a
Participant E	n/a	3rd	1st	3rd	n/a
Participant F	n/a	2nd	3rd	n/a	2nd
Participant G	3rd	n/a	1st	2nd	n/a
Participant H	n/a	n/a	1st	n/a	2nd
Participant I	n/a	n/a	n/a	3rd	n/a
Participant J	3rd	3rd	1st	n/a	n/a

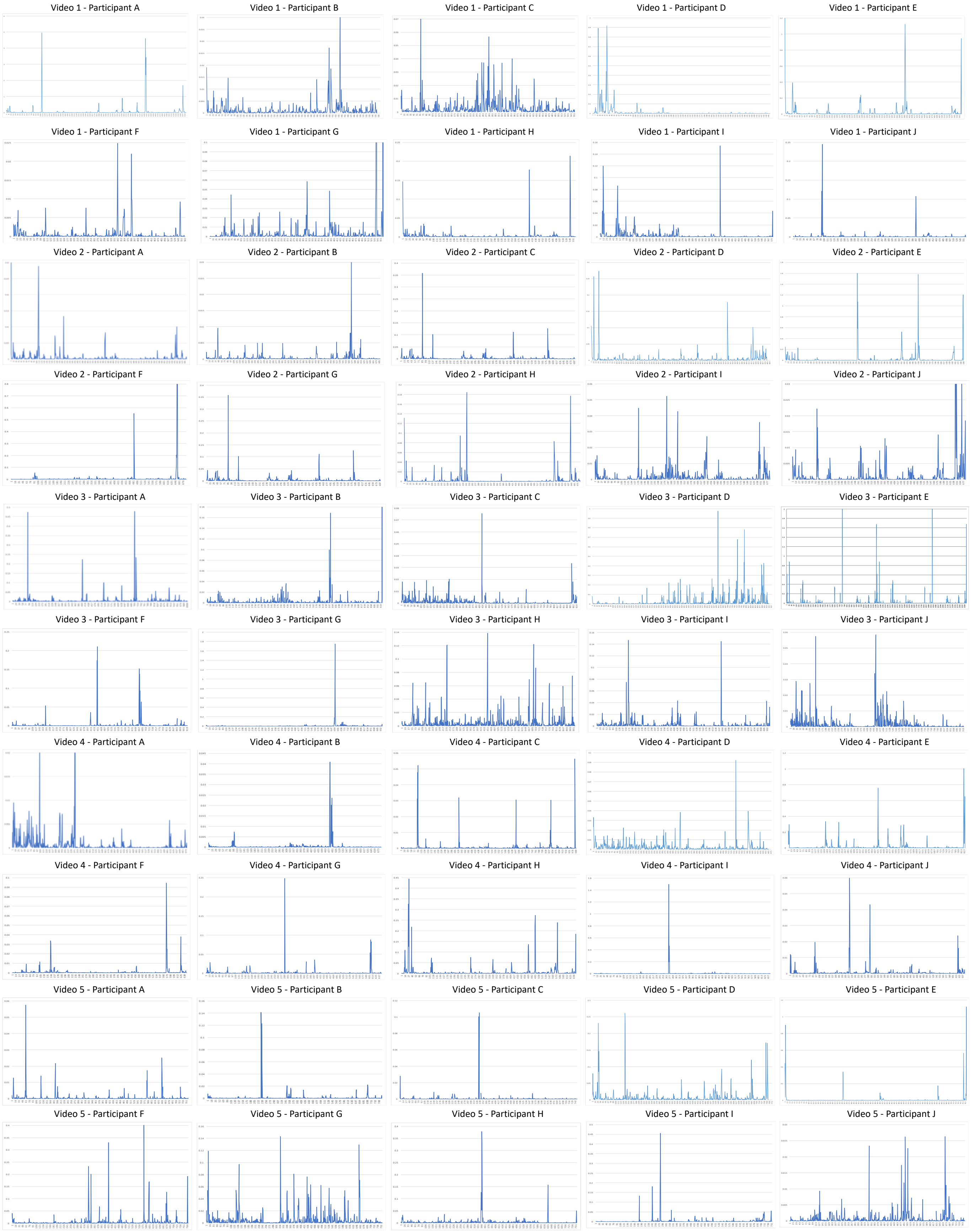

Figure 3: The resultant acceleration of 3-axis in Videos 1-5.

Table 9: Result of top 3 videos which the participants answered to hesitate to be watch a video advertisement.

	1st negative opinion of ad insertion	2nd negative opinion of ad insertion	3rd negative opinion of ad insertion
Participant A	Video 5	Video 4	Video 2
Participant B	Video 5	Video 4	Video 3
Participant D	Video 4	Video 1	Video 3
Participant E	Video 5	Video 3	Video 4
Participant G	Video 2	Video 5	Video 4
Participant H	Video 4	Video 2	Video 5
Participant I	Video 4	Video 5	Video 3

We interviewed the participants about the results. *Participant I* answered the estimated timing of the proposed algorithm in Video 2 was 7th comfort timing. This is not so comfort but an acceptable timing. From this fact, all participants will accept all estimated timings of the proposed algorithm in Videos 1-3. However, there are many unacceptable estimated timings of the proposed algorithm in Videos 4-5. To study a reason why the proposed algorithm did not estimate comfort timings, we also interviewed the participants if there were videos which they would like not to watch a video advertisement. 7 participants answered “Yes”. Then, we ask top 3 videos in which they hesitate to be watch a video advertisement. Table 9 shows the result of top 3 videos which the participants answered to hesitate to be watch a video advertisement. From the result, most of the participants answered Videos 4-5 are not suitable for video advertisement insertion. The reason why they does not like to be inserted a video advertisement in Video 4-5 is “There is not clear scene changes in these videos”. When there were not clear scene changes in a video content, it was better not to use the mid-roll video advertisement in the first place and the low accuracy rate of the proposed algorithm was unavoidable result.

7 CONCLUSION

In this paper, we proposed a method for video advertisement insertion using acceleration data on smartphone. From the preliminary experiment, we got 3 findings; (1) viewers who watch video contents on smartphones sitting on chairs change their posture when they take a short breath, (2) the postural change can be detected by analyzing acceleration data from the accelerometer of the smartphone, (3) the timings of the postural changes correspondent with timings of a scene change on the video content and one of the timings is an appropriate timing to insert a video advertisement. Then, we created an algorithm for video advertisement insertion and designed its system.

From the evaluation results, we found the proposed algorithm improved the accuracy rate more than 40% comparing with the previous algorithm. This result showed the effectiveness of the proposed algorithm. However, we also found the proposed algorithm could not estimate an appropriate comfort timing in the videos which did not have clear scene changes because it was inappropriate to use the mid-roll video advertisement.

For the future work, we will try to study other algorithms even if the viewer does not sit on a chair. We also study a method which switch mid-roll to pre-roll or post-roll video advertisement when there are not clear scene changes in the video content.

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