

Video Evidence Appraisal Using Changing Keypoints: A case study

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Abstract

The objective of this paper is to present the video authentication method that is accepted as evidence in court. In this regard, this paper aims to compare and analyze the changes in the keypoints at the door and peripheral parts of washing machine in the video required for authentication. To this end, two keypoints were set in this video. The first keypoint was set at the door hook of washing machine in this video. That is to say, the first keypoint is a “moving keypoint” because it is set at a moving object. The second keypoint was set at the latch hole of washing machine in this video. Unlike the first keypoint, this second keypoint is a “fixed keypoint”. This comparative analysis on the above-mentioned two keypoints provided the objective authentication result, thereby playing a big role in proving the innocence of defendant.

Keywords: video; evidence; appraisal; keypoint; authentication

INTRODUCTION

The purpose of this paper is to help analyze similar cases by introducing and analyzing the case of video analysis, which was served as critical evidence in the recent legal battle in 2015. Video materials, including CCTV, have been consistently accepted as evidence in court[1]. Video materials help judges make correct judgments with the assistance of experts[6]. However, the scope of video analysis varies depending on the demands of a requester. As a result, the analysis method varies greatly as well. In particular, each analyst has a different way of analysis. Thus, controversial results are often generated[7].

For example, in Korea, there was a controversy over a picture of a construction site regarding whether it was real or not. Many experts weighed in on the controversy and determined that the picture had been fabricated. However, a lab at a university later found that the picture in question was original by reconstructing the construction site's picture with 3D technology. Finally, the analyzed picture was chosen as a piece of evidence and helped solve a trial[2]. As a similar case, there was a conflict over judgement on whether the air rights of a construction sites was violated or not. The accuser insisted the tower crane installed at a new apartment construction site violated the air rights of his house. In order to confirm the violation of the air rights, CCTV in the area was reviewed by a civil engineering expert. The result clearly stated that the tower crane violated the air rights of the accuser's property. But another expert found the error of analysis report and claimed positioning CCTV camera, wind and optical characteristic of camera. At last, expert's analysis report was chosen as lawful evidence[4]. Also, one suspect was convicted

at the original trial because the national investigative agency accepted the wrong video appraisal report as proof of lawful evidence. However, there was a case of one victim who was found not guilty last time with the correct video appraisal report[5].

One of the ways to prevent such controversy is to study thoroughly the video materials that were accepted as evidence in court. That is to say, this paper analyzed the recent case in which video analysis was accepted as evidence in court. In this regard, this paper selected and compared the two keypoints of the washing machine in order to determine the damage done to the door of washing machine in the video submitted to the court.

PROBLEM STATEMENTS

In Korea, there was a recent court case in relation to the damaged door of washing machine at the Consumer Electronics Show (CES). The person who was charged of damaging the washing machine was acquitted in the first trial of the court because the court did not recognize that he had any intention to do so. This particular case is summarized as follows.



Figure 1. The scene that Bob is touching washing machine at the CES.

Alice (the staff of Consumer Electronics Company A) filed a lawsuit accusing Bob (the staff of Consumer Electronics Company B) of property damage and obstruction of business. “ Fig. 1,” That is, Alice accused Bob of intentionally damaging the washing machine by pressing the door. Later, Alice and Bob arrived at an agreement. Nonetheless, the prosecutor of this case continued to investigate this case because obstruction of business falls under a category of “no punishment against will”. The evidence at issue was the video taken by the staff after Bob left.

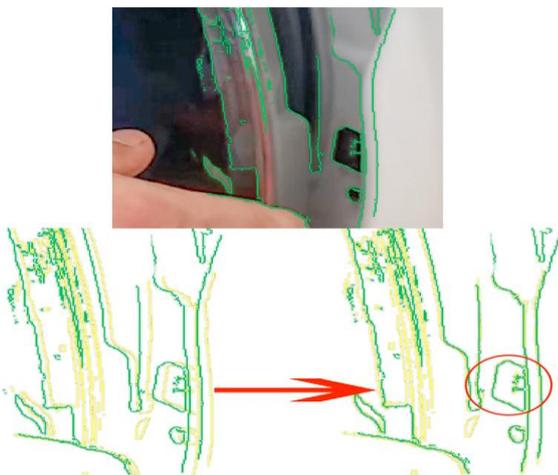
In this video, the staff tried to close the door but to no avail. This video could be accepted as evidence in court to prove that Bob broke the door of washing machine. However, the defendant argued that the shop staff seemed to have pressed the door in this video. Thus, a thorough analysis was required. Therefore, it was required to ascertain the truth of the scene that showed the door of washing machine and the hand of shop staff who was pressing the door downward. The purpose of this step was to determine whether the shop staff in the video broke the door by pressing the door of washing machine downward.



Figure 2. The staff tried to close the washing machine door.

SELECTION AND REALIGNMENT OF KEYPOINTS

To track down the trajectory at which the door of washing machine swings open and closed, this paper selected a certain part of the washing machine as a fixed keypoint that could serve as a point of reference. Moreover, this paper selected a part of the door of washing machine as another keypoint that could be compared with the point of reference. In other words, this experiment analyzed the moment in which the shop staff opened and closed the door of washing machine. The right and left movement of the keypoint at the door of washing machine can be regarded as the natural trajectory at which the door swings open and closed. However, if there is a section of rapidly changing up and down movement in the keypoint at the door of washing machine, this particular section implies that the shop staff applied force down to the door from top to bottom when swinging the door open and closed.



A. Section from 23.06 to 20.23 seconds

The total play time of this video is 58.29 seconds. The section between the point of 20.23 second and the point of 23.06 second was chosen as the subject of analysis. This section shows that the shop staff repeatedly hits the door hook to the bottom of latch hole because he cannot shut the door of washing machine.

To analyze this section, (1) 72 frames were first extracted from this section with duration of 2.42 seconds was first extracted. (2) The contour line of door was then extracted through canny edge[3]. (3) Two keypoints were chosen in the frame in which the contour line was extracted. (4) In these 72 frames, a moving keypoint (Keypoint A) was set at the top of door hook and a fixed keypoint (Keypoint B) was set at the top of latch hole. (5) The frame position of 72 footages was realigned in accordance with Keypoint B. (6) Lastly, the x- and y-coordinates of Keypoint A were derived. X-coordinate varied in the horizontal direction, whereas y-coordinate varies in the vertical direction. As a result, Keypoint B is fixed in the realigned frames. Therefore, the value of y of Keypoint A must be constant or similar unless physical force is applied to Keypoint A.

Figure 3. Realignment of edge.

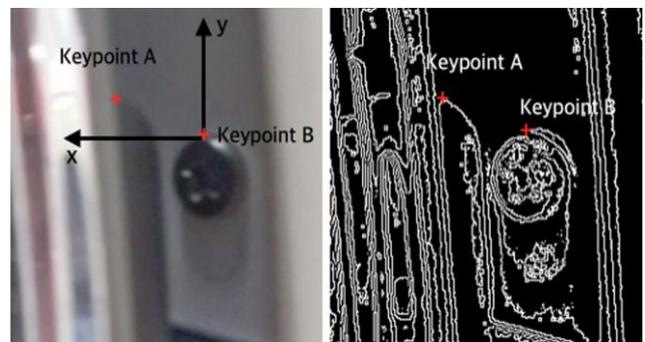


Figure 4. Selection of keypoints A and B.

B. Section from 55.06 to 52.16 seconds

The shop staff pretended that the washing machine is unable to be closed for duration of 2.9 seconds. He kept smashing the door hook toward the latch hole until he closed the door at the end of the fraction of the 2.9 seconds. However, it is able to be observed even with naked eye that door hook could get into the latch hole at this part. So the door is well operating.

To analyze this section, (1) 66 frames were first extracted from this section with duration of 2.9 seconds was first extracted. (2) The contour line of door was then extracted through canny edge. (3) Two keypoints were chosen in the frame in which the contour line was extracted. (4) In these 66 frames, a moving keypoint (Keypoint C) was set at the bottom of door hook and a fixed keypoint (Keypoint D) was set at the top of latch hole. (5) The frame position of 66 footages was realigned in accordance with Keypoint D. (6) Lastly, the change of the distance was measured between Keypoints C and D in 66 frames.

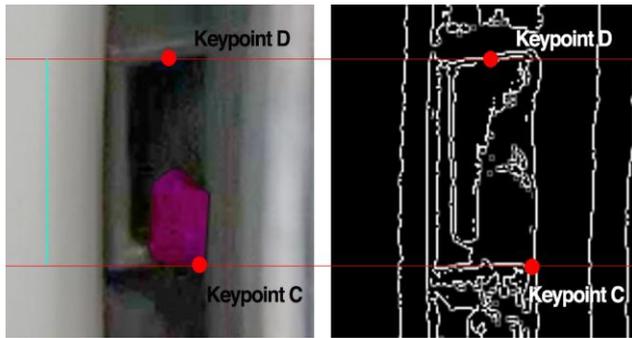


Figure 5. Selection of keypoints C and D.

ANALYSIS OF KEYPOINTS

A. Keypoints A and B

The section between the point of 20.23 second and the point of 23.06 second shows the shop staff trying to shut the door of washing machine. In this specific section, the shop staff hits the door hook to the bottom of latch hole twice and then he opens the door again and hits the door hook to the latch hole for the last time. The analysis result of this section indicated that the value of x of Keypoint remained unchanged when the shop staff shut the door. However, there was a section that had a different value of y.

“ Fig. 6,” is the schematic view showing the value of y, which is the vertical displacement, in chronological order. Among the 72 frames, Frame No. 16, Frame No. 24 and Frame No. 63 were the sections in which the shop staff hit the door hook to the bottom of latch hole once. However, the value of y in Frame No. 63, in which the shop staff hit the door hook to the bottom of latch hole for the last time, was lower than the values of y in Frame No. 16 and Frame No. 24.

Hence, the values of x and y in the 72 frame were reanalyzed for the purpose of determining the reason for which the value of y in Frame No. 63 was lower than the values of y in Frame No. 16 and Frame No. 24. The values of x and y of Keypoint A, which represent the vertical position of this video are the moment, in which the door of washing machine swung open and closed. Thus, they must be the same or similar value in all the frames.

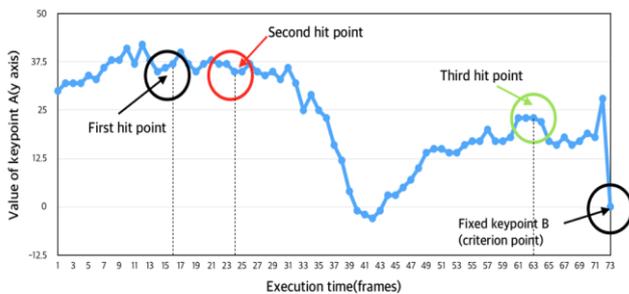
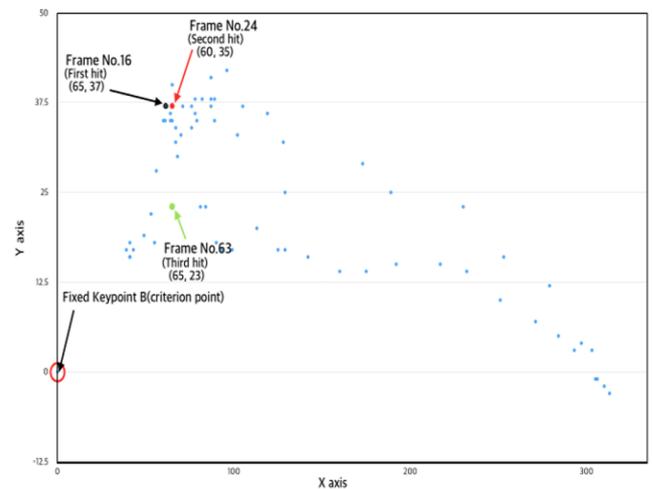


Figure 6. Unusual points according to time passage.

In the first two sections in which the shop staff hits the door, the values of x and y of Frame No. 16 (65, 37) and Frame No. 24 (60, 35) were similar to each other. However, the values of x and y of Frame No. 63, in which the shop staff hits the door for the last time, were 65 and 23, respectively. That is, the value of y of Frame No. 63 was substantially lower than the values of y of Frame No. 16 and Frame No. 24. In other words, the analysis reveals that the door could not be closed properly because the door of washing machine was moved down due to the force of shop staff, which could be seen in Frame No. 63 in which he shut the door for the last time.

“ Fig. 7,” shows the values of x and y of Keypoint A of the door in the 72 frames. It was confirmed that there was a movement in the vertical direction even when the angle at which the door swung open remained similar (that is, the x-direction displacement was identical). On this account, this finding indicates that the shop staff repeatedly pressed and released the door downward while swinging the door of



washing machine open and closed.

Figure 7. Analysis of Keypoint A.

B. Keypoints C and D

In the 66 arrayed frames, the values of the change of the distance between the keypoints C and D were measured. At this time, the length of the cross-section area of the washing machine was 86 pixels, and that of the door hook was 35 pixels.

Therefore, if the distance between the keypoints C and D is shorter than 86 pixels, the door hook enters the latch hole and the door closes. However, if the distance between C and D is longer than 86 pixels, the door hook cannot enter the latch hole and the door does not close. Furthermore, if the distance between keypoints C and D is shorter than 35 pixels, door hook gets out the top part of latch hole. Thus, washing machine door will be able to be closed, only when the distance is between 36 and 86 pixels.

“ Fig. 8,” After measuring 66 frames, the distance between keypoints C and D showed remarkable changes. The distance of No. 1 to No. 28 frame was longer than 86 pixels, the ones

between No. 29 to No. 37 and No. 42 to No. 66 were between 35 and 86 pixels, and the one between No. 38 to No. 41 was measured shorter than 35 pixels.

Accordingly, the frame between key points C and D was measured as between 35 and 86 pixels. These frames are the section where the washing machine door can be closed well enough. However the frames over 86 pixels and under 35 pixels might not be able to close the door well. In other words, because the shop staff closed the door while pushing it from the top, it was measured as a section out of the normal range.

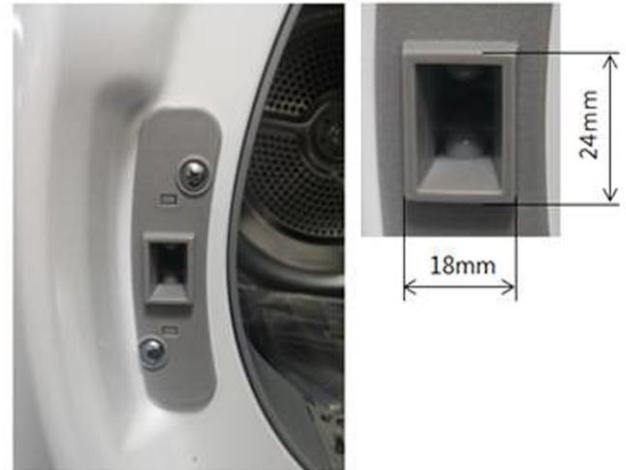


Figure 9. Real size of latch hole



Figure 8. Analysis of distance between keypoints C and D

RESULTS AND DISCUSSION

The results of this paper that is extracting the keypoints of images and comparing are as following. (1) The analysis of Keypoints A and B, set to keypoint B (latch hole) the point of reference and analyzed the moving patterns of the Keypoint A (door hook). As a result, an unusual point was found in the frames that the shop staff opens and closes the washing machine door three times. In the third frame when he opens and closes, it has lower the Y value of Keypoint A.

(2) In the analysis of C and D, the distance change of Keypoint C (door hook) and D (latch hole) was measured. As a result, the fact that the door can close enough was found in the frame which the shop staff insists that he can't close the door by pressing down.

According to the two research results, the shop staff insists that washing machine door doesn't close. But It was revealed to be fake. The door didn't close adequately because he pushed the door downward when he closed the door.

“ Fig. 9,” The real length of the latch hole was 24mm, and it was about 20 pixels in the analyzed video. As an analysis result of (1), the y value of No. 63 frame is between 12 and 14 pixels smaller than No. 16 frame, No. 24 frame. That is, the difference of No.63 frame's y value is big enough to form half of the latch hole. So if the shop staff didn't put power on the washing machine door, the door could have been closed.

The analysis result of (2) like the preceding, found the section between 35 pixels and 86 pixels which is the standard of closing door. Even though the shop staff insisted that he could not close the door, because he pressed down on the door too hard.

TABLE I. RESULTS WITH DIFFERENT FEATURES ON KEYPOINTS

Primary 3 Hit Point (72 frames)	KeypointA		Distance of Keypoints C and D(66 frames)	
	x	y		
1 hit (No.16 frame)	65	37	Under 35 pixels	3 frames
2 hit (No.24 frame)	60	35	Between 35 and 86 pixels	35 frames
3 hit (No.63 frame)	65	23	Over 86 pixels	28 frames
The y value of No. 63 frame is between 12 and 14 pixels smaller than No. 16 frame, No. 24 frame.			35 frames which account for over a half out of 66 are the section where the laundry machine door needs to be closed.	

CONCLUSIONS

The purpose of this research is to make a basis of even progress for method of appraisal through case study of appraisal. Therefore, this paper is a case study that compares and analyzes the changing keypoints. This research played a big role in the legal dispute that took place in Korea. As a result, the defendant was found innocent and acquitted. Video analysis requires a different analysis method depending on each case. To be accepted as evidence the result of appraisal in picture, method of that analyzation should be progressed by scientific and rational process. Furthermore, each analyst has a different way of analyzing video materials, thereby causing many controversies. Hence, the most appropriate way to prevent such controversy is to create a standard model for video analysis by categorizing diverse analysis techniques in a systematic manner. As a preliminary step, this paper examined the video analysis method that was accepted as evidence in court.

In future research, I will classify the examples of video appraisal which is chosen for legal proof by types. Although the current research just takes the legal proofs and analyzes those in Korea, I will analyze and classify the examples of

video appraisal in the world so that I can reduce the controversy over the video appraisals.

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