

# Report of Research Results

## A. Title

The Accuracy of Traffic Signal Phases Switching Time Anchoring

## B. Researchers

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## C. Summary

After crashes, especially for those involved fatality or disablement, parties involved usually struggle in great agony while fighting for compensation. As either judicial decision or mediation is related to comparative responsibility of each party, objective evidence, which refers to information based on facts that can be proved by means of search, is apparently crucial. This research is based on T. Hugh Woo's (2009) study on the application of traffic signal phases switching time anchoring in verifying signal violation. The anchoring method, developed for crash reconstruction, is often applied to deal with the issue—in the accident of no-traffic-signal-included videos recorded by traffic or surveillance cameras, involving red-light running. As whether the involved parties running the red light or not is decisive to right-of-way that causes strict impact on claim request and judicial decision about penalty, this issue often is the battle field for parties in action in an intersectional crash lawsuit. However, the accuracy of Woo's technique is lack of sufficient accounts with scientific data under different traffic characteristics, affecting its degree of proof for the reconstruction result. In this case, this research is to examine the influence of factors on the accuracy of the technique mentioned above. By analyzing pseudo-reconstruction data of more than 28-hour video clips from several intersections, stepwise logistic regression indicates that “number of stop lines or it's reference” gains the greatest positive impact, while “percentage of lanes recorded” has the most negative impact among all factors. Two classification tables are derived from the analysis, which are applicable to forensic cases.

## D. Aim of Research

By applying the anchoring method, investigation agencies can reasonably reconstruct the phase at the intersection when the crash was recorded in a no-traffic-signal-included or signal-unrecognizable video, and provide the evidence to the court for the judgment of the traffic accident responsibility based on the right-of-way. However, the accuracy of the method in different environments lacks sufficient data to support. For this reason, this

research focused on the comparison of the accuracy of the anchoring method at different intersection environments by performing traffic signal phases switching time anchoring for each collected intersection pseudo-surveillance video, and proposed an adaptive strategy so that the stakeholders and the court can understand the correct rate of the investigation result more precisely and reasonably, and refer to the result for damages, insurance claims, and judgments.

#### E. Method of Research & Progression

In order to understand the accuracy and related variables of the traffic signal phases switching time anchoring, this research selected the variables to be discussed from practical experience. Due to the difficulty of getting no-traffic-signal-included surveillance videos, cameras were installed to obtain materials that simulated the location, height, and angle of these surveillance cameras for anchoring. After the variables were selected, requirements and standard operating procedures of the recording process were also established accordingly, and the videos were recorded at intersections where the signal timing plan satisfied the requirements. Then, the traffic count per second of each direction was recorded for anchoring. Lastly, the result obtained using the anchoring method was compared to the actual traffic signal configuration, and the deviation in second was recorded.

This research focused on 2 critical odds ratios using stepwise logistic regression:

1. The odds ratio of “the deviation of the anchoring result is +1” versus “the deviation of the anchoring result is not +1”.
2. The odds ratio of “the anchoring result is unique” versus “the anchoring result is not unique”.

The reconstruction result would be compared to the actual signal configuration (the exact traffic signal of each direction for every second in the video) to examine whether the reconstruction result was correct, and regression analysis would be performed on all reconstruction results to understand the accuracy, the uniqueness of the result, and the impact of variables involved.

#### F. Results of Research

On the accuracy of the method, the anchoring results were divided into “the deviation is +1” and “the deviation is not +1”. According to the inference logic of the correct value can be obtained by confirming the result and the deviation of the result, “the deviation is +1” was “correct” since the correct value could be obtained by subtracting the deviation (1 second); “the deviation is not +1” was “incorrect since the calibration value was unknown.

From the analysis of deviation, it was found that when the length of phase map (or the number of signal cycles analyzed using the anchoring method) increased by 1 unit (or 1 cycle), the odds of “the deviation is +1” would increase 1.068 times, and most importantly, this factor was the only controllable factor in practice. Therefore, the authority shall try to provide a video with enough length to the forensic investigator to improve the accuracy of the anchoring result. Assuming a traffic signal cycle of 200 seconds, submitting a video with a length of 1000 seconds (approximately 16.5 minutes) could increase the probability of “the deviation is +1” by 17.62 times, without considering other positive impacts contributed by other factors. In addition, the investigator could also evaluate the probability of “the deviation is +1” from two main factors, “number of stop lines or its reference” in the image and “whether the view is blocked or the cars are hard to be identify”, and answer some commonly asked questions, such as “ How confident are you?” Moreover, the investigator could also include other factors that were statistically significant to the calculation and provide a more accurate probability.

Discovered from the estimation of the odds ratio, the “number of stop lines or its reference” was the most influential factor of all significant variables. When the other variables were controlled, increasing the “number of stop lines or its reference” by 1 unit, the probability of “deviation is +1” was 10.867 times larger than the probability of “deviation is not 1”. The finding was sound as whenever there was a stop line or its reference in the image, the recording personnel would be able to accurately and uniformly document the passing count, which drastically promote the forensic data quality. On the other hand, when a stop line or its reference was not recorded in a direction, it indicated that the footage may be recorded distant from the stop line. Since the distance between the stop line and the recorded location would affect the start-up delay, the passing judgment would be shift forward or backward due to the time lag between “the traffic signal turns green” and “the car pass through the stop line”. As a result, the accuracy of the anchoring method decreased. Thus, when performing traffic signal phases switching time anchoring, if the “number of stop line or its reference” was not zero, the investigator could consider excluding the direction that lacked stop line or its reference to increase the accuracy. It was known that the distance between the recorded location and the stop line would affect the accuracy, while further details on its impact is worth studying.

Facing the thorny problem that the method may generate multiple results, “length of phase map”, the only controllable factor, still had a solid impact on raising the probability of “the deviation result is unique”. When the length of phase map increased by 1 unit, the probability of obtaining a unique anchoring result increased by 1.074 times. For those intersections with a shorter traffic signal cycle, such as 60 or 120 seconds, it was not difficult to export a video with 10 to 15 cycles but the probability of getting a unique anchoring result could raise by 10.74 to 16.11 times, and a forensic investigation opinion

for some cases could be established. Moreover, other main factors, such as the percentage of recorded lanes, average passing count per lane, etc., could be used to predict the possibility of having a unique value and determine whether the anchoring method was suitable for the case.

In future practice, if one would like to predict the accuracy of Woo's traffic signal phases switching time anchoring utilized the two logistic regression covered in this research, the classification tables in Attachment 1 and Attachment 2 of the thesis could be referenced to set an appropriate cut-off point. When choosing the cut-off point, one should not consider the correct rate only, but also include sensitivity and specificity simultaneously. For example, if the party would be found guilty when "the deviation is +1" and the case was predisposed as better wrong than missed, sensitivity could be prioritized when selecting the cut-off point while the correct rate lied within an acceptable range; but using this standard to select the cut-off point had the negative impact that the probability of false-positive would increase, and that the innocent party may be charged as guilty. On the contrary, if the case with the same scenario but was better missed than wrong, specificity could be prioritized when selecting the cut-off point.

#### G. Future Areas to Take Note of, and Going Forward

Since factors affecting the accuracy of the anchoring method are complicated and multifold, some of the factors are thought to be consequential but could not be covered in this research, such as the distance between image shown and the stop line, weather and vehicle type. Meanwhile, most of the footages analyzed in the research are recorded in downtown area, in which the demographic characteristics would be nonidentical to suburb. Hence, future studies could try to reach factors which have not been discussed; further, analysis of footages of suburb might lead to different conclusion.

#### H. Means of Official Announcement of Research Results

1. Proposed as a dissertation of master degree of Transportation and Logistics Management from National Chiao Tung University, while mentioning that this research was supported through Mitsui Sumitomo Insurance Welfare Foundation, and would be barely possible to gain such rich quantity of footages for the analysis without the grant.
2. Presented at an academic conference held by Central Police University (Conference for Road Traffic Safety and Enforcement, Sept. 2019), while mentioning that this research was supported through Mitsui Sumitomo Insurance Welfare Foundation, and would be barely possible to gain such rich quantity of footages for the analysis without the grant.