Analys av data från händelsestyrd insamling av krockar med video

Public report

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Content

1. Summary

Video and time series data collected through Video Event Recorder (VER) equipment installed in vehicles have been identified as a valuable source for insights into the causation of crashes. Previous collaborations with a commercial company providing behaviour-based-safety services allowed the participants to have access to VER video and time series data. In this context, the vision of this project was to enable access to VER data and produce a deeper understanding of the factors leading to crashes as a basis for the development of safety measures and driver models.

The project started with the objective to set up an agreement between the Swedish and external partners (including the US based VTTI and University of Iowa) about how to organize a long-term relationship with the provider of VER video and time series data. Such an agreement would have ensured the provision of crash and near-crash data continuously for the partners for many years. Unfortunately, the agreement was not reached and the data provider withdrew from the project in December 2016.

Given the unexpected situation, we looked for alternative analysis solutions and shifted the project focus to method development and analysis of existing data. The new direction in the project produced the following results:

- Definition of process and methodology for annotating VER videos: the main output of this activity was the issue of a codebook with the list, and a corresponding description, of the variables which can be extracted from (VER) video and time series.

- Inter-rater reliability analysis of annotations obtained from naturalistic driving data (NDD): the main output of this activity was the assessment of the inter-rater reliability of NDD video coding performed by different annotators. A study was conducted with 12 students who annotated from 40 videos a set of variables extracted by the codebook developed in the previous activity.

- Glance behaviors and crash causation analysis for intersection crashes: the main output of this activity was the quantitative analysis of drivers' glance behaviors as well as the qualitative causation analysis of crashes occurred in the left turn across path / opposite direction (LTAP/OD) conflict scenario.

2. Sammanfattning på svenska

Video och annan tidsseriedata insamlat genom Händelsestyrda Videoinspelningar (HV) av kommersiella företag har identifierats som en datakälla för forskning och utveckling av trafiksäkerhetssystem med mycket stor potential. Tidigare användning av sådan data har bland annat skett i det VINNOVA-finansierade projektet ANNEXT samt i ett projekt där svensk fordonsindusti och academi samarbetade med Kinesiska partners (ChinaBBS och

ChinaBBS2 projekten inom CTS). Förutom analys av data för krockanalys var en vision inom detta projekt att etablera processer och samarbeten för att säkra långsiktig tillgång till HV för forskning.

Projektet startade med två parallella spår. Det ena var en initial diskussion mellan projektparterna om hur de skulle föredra att organisera ett långsiktigt samarbete med den tilltänka dataleverantören av Händelsestyrd Videoinspelningar (HV). Det andra var en fortsatt utveckling av en kodbok för annoteringar av HV data, som planerades användas på data från projektet, samt i andra kommande projekt. Vi hade veckovisa möten inom båda spåren. Tyvärr drog den tilltänkta dataleveransören sig ur förhandlingen/samarbetet i december 2016 (troligen pga en intern policyändring kring forskningsprojekt). En hel del resurser hade då lagts ner på förhandlingar med dem och att sätta processen för dataleverans. Vi övervägde då våra alternativ och efter ett tag ändrade vi fokus på delar av projektet mot att analysera redan befintliga data. Arbetet med att utveckla kodboken fortsatte. Vi genomförde en studie för att utvärdera hur konsekvent nya annoterare kunde använda den kodboken för att annotera VH – ett kvalitetssäkringsarbete. Kodboken användes sedan i annoteringar av befintliga data innan analys (men också i andra projekt, t.ex. EU-projektet UDrive, samt i ISO arbete, där denna kodbok tydligt bidragit till det ISO dokument som snart släpps). Vi genomförde också en studie av vilka faktorer som orsakar olyckor genom att jämföra tre olika tillgängliga dataset. Studien fokuserade på blickbeteende, men också på att identifiera andra orsaker till att olyckor korsningssituationer.

Ett mål inom projektet var att skapa djupare förståelse för vilka faktorer orsaker trafikolyckor, samt hur detta görs – detta som grund för att utveckla trafiksäkerhetssystem. Ett annat mål var att säkra tillgång till kontinuerliga krockdata från en leverantör av Händelsestyrda Videoinspelningar (HV) av krockar och nästankrockar, att användas för forskning inom trafiksäkerhet. Tyvärr fick vi bordlägga våra försök att nå det andra målet då dataleverantören drog sig ur, efter att varit positiv till ett samarbete under lång tid. När det gäller analys av data ändrades fokus till att analysera redan befintliga data, samt att vidareutveckla verktyg för kvalitetssäkring och annotering av HV. Följande genererades i projektet:

1. En genomgående förbättring och fokusering av kodningschema för annotering av HV genom ett samarbete mellan de svenska parterna och två organisationer i USA: Virginia Tech Transportation Institute and University of Iowa. Särskilt viktigt var modifiering och harmonisering av variabeldefinitioner för att annotera HV, snarare än kontinuerliga naturalistiska data.

2. Forskningresultat (publikationsarbete pågår) gällande utvärdering av hur konsekvent olika individer annoterar video (mellan och inom individ) baserat på den utvecklade kodboken. En delmängd av variablerna i kodboken valdes och 12 annoterare genomförde annoteringar på ett set av HV, vilka sedananalyserades. Resultaten kan användas (används) för att optimera var mest kvalitetssäkring behöver göras i studier som använder

naturalistisk kördata, identifiering av vilka variabler som är mer koncist definierade (och lättkodade), samt för att förbättra operationalisering av annotering i framtiden

3. Forskningsresultat från analys av blickbeteende samt studie av andra faktorer som påverkar uppkomsten av trafikolyckor i korsningar. Tre olika naturalistiska dataset jämförds avseende blickbeteende för scenariot vänstersväng över annans färdväg. Resultaten visar till exempel på att förväntningar spelar en möjligen ännu större roll i korsningsolyckor än i bakifrånkollisioner. I 60% av olyckor som studerades saknades undanmanövrar i princip helt.

3. Background

Video and time series data collected through Video Event Recorder (VER) equipment installed in vehicles have been identified as a source for insights into the causation of crashes with huge potential. Previous collaborations with a commercial company providing behaviour-based-safety services allowed the members of the consortium to have access to VER video and time series. In a previous VINNOVA sponsored project, called ANNEXT, first steps were taken towards analyzing this type of data. Another project, sponsored by VINNOVA through the China Sweden Research Centre for Traffic Safety (CTS) program, also analysed this type of data.

4. Purpose, research questions and method

The purpose of this project was to produce a much deeper understanding of the factors leading to crashes as a basis for the development of safety measures and driver models. To reach this objective, the enhancement of methods for video annotations was a consequent aim of the project. Also, together with two additional US (affiliated) partners we aimed to establish a consortium for long term research collaboration on analysis of VER video and time series. In order to achieve this objective, we planned to set up an agreement with a commercial company providing behaviour-based-safety services, which we had already collaborated with in the past.

5. Objective

The detailed objectives of the project were the following:

Task 1: Preparations and definition of contractual aspects for setting up an agreement with a commercial company providing behaviour-based-safety services

Task 2: Generic analysis plan and process development

Task 3: Development/enhancement of codebook for annotations of VER videos

Task 4: Training of annotators and inter/intra-rater reliability analysis of annotations of VER videos

Task 5: Analysis of the annotated VER videos with respect to one or a couple of scenarios, and comparison with SHRP2 data

Task 6: Writing of scientific publications

6. Results and deliverables

The project started with two parallel tracks. One, the initial discussions among the partners on how we would prefer to organize a long-term relationship with the provider of VER data. The other, a continuation of the development of the codebook for annotations of VER data that we aimed to use during the project.

Due to the withdrawal of the data provider from the project in December 2016, Task 1 could not be completed. After reviewing our options, we shifted the project focus to analyze existing data and method development. This new focus produced a change in Task 5 which was redefined as it follows: "Task 5: Analysis of the crash causation mechanisms of intersection crashes, based on previously available datasets."

The final results of the projects dealt with three main research areas which are described with more detail in the next sections:

- Definition of process and methodology for annotating VER videos

- Inter-rater reliability analysis of annotations obtained from naturalistic driving data (NDD)

- Glance behaviors and crash causation analysis for intersection crashes

6.1 Definition of process and methodology for annotating VER videos

Before the withdrawal of the data provider from the project, weekly meetings were held between Chalmers, AB Volvo, Volvo Cars, Virginia Tech Transportation Institute and University of Iowa to define the Video Event Reduction Protocol and methodology (VERP). The VERP is an ad-hoc protocol detailing the process to obtain Annotated Data from the Video Event Recorder (VER) video and time series. The need for such a protocol depends on the fact that (VER) video and time series differ from traditional continuous naturalistic data, due to the shorter length of the video and fewer availability of sensors' information.

The main output of the VERP was to provide a codebook with the list, and a corresponding description, of the variables which can be extracted from (VER) video and time series: the variables were defined in four categories, as reported below:

- Event details: Annotations or provided data describe the value or category that is valid for the overall event (e.g. weather, light conditions, number of conflicts)
- Continuous time series annotations: Those annotations describe a value for each frame during the whole event (e.g. speed, acceleration, width of the lead vehicle)
- Transition time series annotations: Those annotations describe the value of a variable frame by frame during a limited time period of the event (e.g. visual obstruction, road surface conditions)
- Time details: Those annotations describe the value of a time, indicating the start/end of an important occurrence for the analysis (e.g. start and end of secondary task, start of precipitating event)

6.2 Inter-rater reliability analysis of annotations obtained from naturalistic driving data (NDD)

During the project, one of the aim was to evaluate the inter-rater reliability of VER videos coding performed by different annotators. As reported earlier, one of the initial task of the project was the development of a codebook to be used for annotating VER videos. In order to conduct reliable analysis with minimum annotator bias, it is of extreme importance that the annotations made with the codebook are accurate and precise. Previous studies about inter-rater reliability – that is agreement between raters/annotators – of annotations of Naturalistic Driving Data are lacking and, therefore, a study was planned and conducted: 12 students were hired to annotate a set of variables from 40 video events. The annotations focused on the four categories of variables, described in detail in the previous section.

The results of the study showed that annotators had a moderate or substantial level of agreement for most of the variables. The information provided by the study is useful to further improve the description of the variable to increase the inter-rater reliability in future annotations.

6.3 Glance behaviors and crash causation analysis for intersection crashes

Following the shift of project focus, existing data was used to conduct quantitative and qualitative analysis of crashes occurring at intersection. The analyses were centered on the left turn across path / opposite direction (LTAP/OD) scenario, which is one of the most and fatal crash scenarios. Three different data sources – already available to the researchers – were used to perform the following analysis:

- Quantitative annotations of intersection gaze release time (IGRT): the IGRT is defined as the duration between the time of the last glance towards oncoming traffic

before entering the encroachment zone and the last time before entering the encroachment zone.

- Qualitative analysis of NDD data with the CANDE method, partially developed as part of this project. The CANDE will not be described in detail, but it is based on qualitative but structured coding of crashes and near-crashes to identify the factors underlying crashes. In CANDE, all available information is reviewed by the analyst and the factors identified as having had an impact on the outcome (that the event became a crash/near-crash or not) are included.

The overall results of the analyses show that in 60% of the events analyzed, there was no evasive maneuver (braking/steering) by the driver of the turning vehicle. The reason for the lack of evasive maneuvers cannot be found in driver visual distraction (e.g. texting on mobile phone) but rather, more likely, in wrong expectations (or predictions) about how the traffic situation would evolve.

7. Dissemination and publications

7.1 Dissemination

How are the project results planned to be used and disseminated?	Mark with X	Comment
Increase knowledge in the field	X	The project has provided insight on the understanding of factors leading to crashes at intersections and on the enhancement of methods for video annotations. The results from the analyses of crashes at intersection have been used for the development of driver models and for the prospective benefit estimation of safety systems. The results provided by the inter-rater reliability study have produced improvements to the codebook for annotations of VER videos
Be passed on to other advanced technological development projects	X	The results from the analyses of visual behaviour during left-turn at intersection are currently used for the development of driver models and simulations of prospective benefit estimation of safety systems, within the VINNOVA funded project QUADRAE
Be passed on to product development projects		
Introduced on the market		
Used in investigations / regulatory / licensing / political decisions	X	The development of a codebook for annotations of VER videos and the inter-reliability analyses have provided information which favored the international discussion during the Naturalistic Data Studies Task Force held by the International Standard Organization (ISO)

7.2 Publications

There are no publications published or in-press but the following journal articles are in preparation:

- **The development and application of a novel metric for analysis of visual attention-selection in left turn across path/opposite direction (LTAP/ID) scenarios**: this paper describe the analysis of driver's glance behaviour during left turn maneuvers preliminary described in the section "Glance behaviors and crash causation for teens in LTAP/OD crashes". Aimed for journal publication.
- **Inter-rater reliability of annotations from a sample of event-triggered naturalistic data**: this paper illustrates the results of the inter-rater reliability study preliminary described in the section "Inter-rater reliability study". Aimed for journal publication.

8. Conclusions and future research

The CRASHED project has provided insight for parallel activities running at the Division of Vehicle Safety at Chalmers, together with Volvo Cars and AB Volvo. The results from the analyses of visual behaviour during left-turn at intersection are currently used in the development of driver models within the VINNOVA funded project QUADRAE. Those driver models are essential for the understanding of driver behaviour and can be used to support the design of active safety system and automated driving. In the future, further analyses of crashes in the same – intersection – or different conflict scenarios will provide additional relevant information to: 1) design of more accurate driver models 2) run simulations of prospective benefit estimation of safety systems, which requires driver models, mathematical models of the system and crash scenarios.

On the other hand, the results provided by the inter-rater reliability analyses have produced improvements to the current codebook for annotation of Naturalistic Driving Data. The information gathered from the study has also favored the international discussion during the Naturalistic Data Studies Task Force held by the International Standard Organization (ISO). Both authors of this document are representing Sweden in the ISO/TC 22/SC 39/WG 8 which aims to develop an international standard on how to annotate videos obtained from Naturalistic Driving Data collection. The future work will focus on the analyses of inter-rater reliability for the variables which have not been considered yet. Based on the final results, further discussion will be held with national and international partners to improve the current codebook.

Beside the research tasks, during the last period of the project, the authors got in contact with another company offering behaviour-based-safety services with the aim to get access to additional VER videos and time series of crashes.

9. Participating parties and contact persons

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