NAVISECTION: A NOVEL METHOD JOINING NATURALISTIC DRIVING DATA COLLECTION WITH EXPERT WITNESS EVENT LOGGING FOR ENHANCED ASSESSMENT OF DRIVER SAFETY

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ABSTRACT

Research on driving safety related to impairment on the national level focuses primarily on impaired driving from alcohol or drug abuse and older drivers due to increased mortality per miles driven. There is a lack of evidence to inform policies relating to issues of medically-impaired (M-I) driving with progressive conditions, self-restriction of driving, and effectiveness of adaptive driving strategies. Currently, the best available methods of screening the population for driving capability are policies for age-based license review/renewal and physician reporting of medically-impaired drivers. Driver rehabilitation programs are charged with the task of driving assessment and evaluation to provide recommendations for medical advisory boards within state Departments of Transportation.

This paper proposes a complimentary method for assessment of driver capability within driver rehabilitation programs called navisection. Navisection facilitates automatic data segmentation for driving evaluation through the combination of naturalistic driving data collection with event logging by a Certified Driver Rehabilitation Specialist (CDRS). Using CDRS-assisted driving

events as a surrogate measure for crash risk, it may be possible to track causal factors of driving errors, apply standard algorithms to naturalistic driving data for intelligent screening and referral systems, and produce longitudinal driver monitoring to support contextual driver education/advising systems.

The navisection methodology is also discussed with respect to two exemplary efforts sponsored in part by the National Highway Traffic Safety Administration. The first case discussed is driving safety assessment by review of the 100 car naturalistic study by the Virginia Tech Transportation Institute. The second case discussion analyzes driver referral pathways concerning the Maryland Model Driver Screening and Evaluation Program.

Keywords: driving assessment, driver safety, driver screening, driver rehabilitation, medically-impaired driving, driving capability

INTRODUCTION

The basis for driver safety protection is grounded in the Haddon matrix (1973). Incidents in driving can range from near misses or property damage all the way to injury and fatality. With the combined analysis of crash causality and severity, safety experts have been challenged to reduce the burden of injury in society so that independent transportation can thrive. These efforts have led to many improvements for drivers at the levels of post-crash response, in-crash protection, vehicle safety, and environmental (physical or social) reforms. A challenging aspect of safety is to address pre-crash prevention at the level of the driver. When viewing driver-level factors, the AAA Foundation for Traffic Safety (2010) surveyed safety culture regarding errors in the categories of distraction, impairment, and behavior/attitude. The errors made by drivers in the pre-crash scenario present a great challenge for safety experts when attention is placed on the area of active correction or behavioral change. Many passive correction approaches have the advantage of initiating change by enforcement of standards or penalties beyond the control of the driver.

The topic of driver impairment can introduce a wide variety of concerns. In the broadest view, distractions can be interpreted as external factors motivating impairment through cognitive errors, and unsafe behavior/attitude can be seen as internal impairments to decision making processes. However, the central issues studied under driver impairment by National Highway Traffic Safety Administration (NHTSA) Driving Safety (2011) site involve alcohol abuse, substance abuse, medication side-effects, and medical-impairment in older drivers. Drowsy driving could also be counted within the topic of impairment. Younger drivers are viewed as inexperienced with the enforcement of punitive measures for reckless/aggressive behavior. Many drivers risk periods of transient impairment from the consumption of alcohol/drugs or use of certain medications, but the older adults are targeted for onset of chronic impairment beyond the transient forms caused by lifestyle choices.

The results of the reality on US roadways summate to cause a great burden for older drivers. Janke’s literature review (1994) concluded that driver competency among elderly drivers particularly entail dementia, the combined effects of impairment with medications, and the frail elderly with reduced time driving on the road. The study titled Older Driver Involvement in Injury Crashes in Texas by Griffin (2004) reported that drivers over the age of 65 are 1.78 times as likely to die in car crashes as middle-aged drivers between the ages of 55 to 64. Results were attributed to the likelihood of illness, physical ailment or perceptual lapses. Furthermore, MacLennan et al (2009) showed that 69% of surveyed drivers, age 55 and above used one or more prescriptions known to affect driving at the time. While crash mortality per miles driven was upheld by Eberhard (2008) to be elevated for younger and older drivers, the capability concerns of older drivers were called into question with evidence that only the infrequent drivers have increased risk and older drivers were being more of a risk to themselves than other road user age groups. The RAND Corporation (2007) reported that drivers 65 and older are one-third as likely to cause auto accidents as drivers age 15 to 24. Conversely, the report stated that senior drivers are nearly seven times more likely to be killed in two-car collisions than younger drivers. At the same time, Cooper (1990) found that the average number of accidents was not higher for older driver groups, while the number of accidents per conviction was.

Considering the breadth of driver causal factors of crashes, the pressing question is then how to definitively assess the capability of a driver to be safe on the road. As a clarifier, this can be specified as capability to handle the crash risk levels typically encountered by drivers on the road. Brookhuis and de Waard (2003) described the need of a golden yardstick for driving performance with regards to driver impairment, but the discussion lacked any mention of medically-impaired older drivers. Eby and Molnar (2008) edited the recommendations report of the North American License Policies Workshop, where AAA Foundation President, J. Peter Kissinger, shared a 2025 projection that people aged 65 and older will account for 25 percent of drivers to reflect an increase of 15 percent from 2005. This trend is well noted by Stutts and Wilkins (2003) where survey and focus group results called for increased involvement of driving schools under the practice of certification as a Driver Rehabilitation Specialist (CDRS).

Screening the Community for Fitness to Drive

Fitness to drive is a context-based concept. Before the actual evaluation of on-road driving, driver fitness includes multiple associated issues including knowledge of driving rules and regulations, the means for owning/maintaining a vehicle, and the basic motivation (volition) to continue driving. Multiple sources provide extensive and/or contemporary views of holistic driving models (Lindstrom-Forneri et al, 2010; Heikkila and Kallanranta, 2005; Beatson and Gianutsos, 2000; and Pellerito, 2006), but there is less information available on how to systematically practice and standardize all aspects of driving into a comprehensive evaluation. The dissertation work of Justiss (2005) provides one example of a systematic approach to on-road evaluation to strengthen the repeatability of assessments and clarity of driver ratings. To complement the sophistication of structured on-road evaluation, Horberry and Inwood (2010) reported the benefits of standardizing evaluation using a static assessment rig (SAR) for its high face validity and potential to build consensus towards key driver characteristics for safe driving.

The authors of this paper view on-road driving assessment on two levels relating to driving capability and performance. For clarity, the intent is to focus on capability and not capacity. The concept of capacity is not addressed here as it would imply the evaluation performance up to a driving task in the most maximal complex scenario while maintaining a level of safety and control. Some measure of driving capacity could be incorporated, but that would not directly aid the duty of determining whether or not a person should be licensed to drive. While the concept of performance is a context-based review of the quality and safety of driving maneuvers, capability is only a review of independence in control of a vehicle. The contexts of driving location/geography or type of vehicle are negligible for the assessment of capability when viewed within a standard class of driver licensing (class C license). Only the ability to independently operate and execute driving maneuvers is called into question when considering capability. However, the impact of changes in environment and vehicle present definite changes in performance requirements that may alter the outcome when evaluating capability.

As a topic of wide debate, the responsibility of screening the population for driving is largely placed upon the family doctor or a mandatory age-based review of license renewal. Langford and Koppel (2006) summarized the case for and against mandatory age-based assessment of older drivers by reporting no demonstrable road safety benefits from the age-based approach in the face of over-representation in crashes involving mortality. The state Department of Motor Vehicles (DMV's) control licensing with more routine renewal requirements beyond a certain age in many states. The challenge here is how to assess licensure at time points of interest with respect to medical-impairment. The 2003 Stutts and Watkins study supported the role of medical advisory boards with DMV's in order to fulfill this role for the rising demand in society. Coughlan et al. (2004) surveyed a large number of older drivers who self-selected when to stop or restrict driving without formal screening processes either independently or through conversations with a family member or trusted friend.

For a supplementary approach, primary care physicians or specialists are expected to report their patients who exhibit clinically-measurable impairments to driving related skills in the NHTSA and American Medical Association (2009) guide. Strategies for healthcare providers were shared by Odenheimer (2006) on how to maintain a trusting, comfortable relationship with patients. Currently, this practice is only fully mandated in about one-fifth of the states in the US. The Association for Driver Rehabilitation Specialists (ADED) Best Practices Committee (2009) provides standards of practice and certification for driving evaluators to facilitate licensure decision by medical advisory boards at DMVs. The role of the CDRS is to provide a broad range of services that best assess a client's fitness to drive and maximizes their potential to remain as safe drivers on the road.

Technologies for Driver Safety

The Research and Innovative Technology Administration (RITA) of the US Department of Transportation released their Intelligent Transportation Systems (ITS) Strategic Research Plan for 2010-2014 to outline the five-year trajectory for anticipated research initiatives. RITA Administrator Peter Appel (2010) shared that RITA was created to coordinate multimodal research, advance technology deployment, supply comprehensive transportation statistics, and further education and training opportunities in transportation-related fields. In 1991, the ITS Society (2008) was formed as a federal advisory committee, and has since been a leading advocate for ITS development as well as a thought leader in transportation policy. The current growth of attention towards ITS applications presents great promise for cross-disciplinary exploration and the rapid deployment of effective technologies. Anderson et al (2011) have recently reported a list of potential crash reductions by technology modality, and monetized crash savings were greatest for forward-collisions avoidance, alcohol interlocks, and fatigue management systems.

The more mature market for ITS solutions is commercial transportation with fleets of delivery trucks. For example, the Federal Motor Carrier Safety Administration has sponsored efforts to demonstrate the viability of Lane Departure Warning Systems (LDWS). This is shown in the work of Houser et al. (2005) for concepts of operations and voluntary requirements for implementation, and Houser et al. (2009) for a benefits and cost analysis. When viewing the personal vehicle market, some ITS features have been growing from the perspectives of entertainment (for passengers), comfort/customized settings, and vehicle maintenance support. Furthermore, there are a handful of technologies that have just surfaced with the 2010-2011 line of vehicles to provide features relating to driver assistance. However, the ITS technologies on the horizon may completely revolutionize the boundaries of driver assistance with direct short range communications (DSRC). Andreone and Provera (2005) highlighted ways that vehicle to vehicle (V2V) and vehicle to infrastructure (V2I) communication may help alert drivers to developing hazards beyond the driver’s line of sight.

In order for the technologies to reliably predict or identify road hazards, there has been much effort on the part of engineers, human factors experts, and psychologists to define critical performance measures for rating the safety of a scenario. A special issue in Applied Ergonomics presented the latest research on simulation or modeling of driver behaviors and the complexity of driver-vehicle-environment monitoring to support drivers on the road (Casucci et al., 2010; Cacciabue and Carsten, 2010; and Amditis et al., 2010). In consideration of decision criteria among expert driving evaluators, Jamson et al. (2008) previously demonstrated the difficulty and barriers to developing a Safety Index for driving through a Delphi study. Concluding statements pointed towards the work of studies using naturalistic driving data for the comparison of crash and non-crash driving scenarios.

A future that promises the embrace of ITS advancements does not come without hurdles. Challenges and doubts are visibly present within the Pellerito text (2006) regarding the extent to which ITS solutions are being proven before deployment and the true value to driver safety as opposed to overall road safety. One way to view this concern is by considering the difficulty of biomedical technology development in general. In addition to the complexities of designing and testing sound engineering systems, there is also the burden of demonstrating real effects of change that correct or stabilize impairments to humans. The haunting question for the future is then to ask how new ITS safety features in vehicles will affect the decision making processes for assessing fitness to drive. While the safety features may certainly protect against crashes, it remains to be seen whether the features prompt drivers towards safer behaviors or if the safety features ensure safer roads without regard to stability or improvement of driver behaviors in the vehicle. This concern would be best addressed if the ITS and CDRS communities joined in an effort to bilaterally strengthen advances within their respective fields.

NOVEL METHODOLOGY

Safe Driving is one of the research thrusts funded by the National Science Foundation under the Quality of Life Technologies Engineering Research Center (QoLT ERC). Under the Safe Driving umbrella of projects DriveCap is an effort to extend the reach and service of driver rehabilitation programs. Developed at Carnegie Mellon University, DriveCap is a low-cost, portable package of vehicle sensor technologies that can be installed onto most automobiles within an hour. In concert with the primary aim of enhancing driver rehabilitation, the research themes aim to promote a safety philosophy for self-selection of safe driving behaviors. Figure 1 illustrates this perspective as a frequency plot of driving activities over the continuum of risk levels. As opposed to targeting risky driving behavior beyond an acceptable safety threshold, the Safe Driving philosophy is to apply assistive technology to facilitate an overall shift towards less risky driving behavior exhibited on the road. This figure was adapted from driver safety philosophies already published by Knipling et al. (2004) in safety programs for commercial transportation.

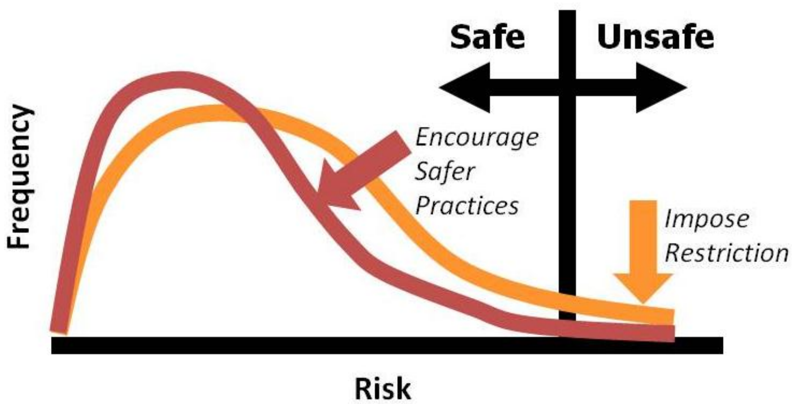

Figure 1: Safe Driving philosophy adapted from commercial driving risk models

With the prevailing view of impairment/distraction as a transient scenario that is avoidable, it is critical to consider also the case of people with disabilities and the rise of chronic disease as a new paradigm for driving with irreversible impairments. In Table 1, crash risk factors are spread out under the three categories of crash causality, while the pre-crash risks are further broken into internal and external risk factors.

Table 1: Pre-crash scenario of Haddon Matrix broken into internal and external factors

Medical fixed impairment Medical transient impairment Substance-related impairment (drugs, alcohol, medications) Fatigue Behavior/Attitude/Experience	Turning stability Braking distance Traction over slick/compliant roads	Driver Cabin: noise, alarms, glare/light, smell, vibrations Passengers Cargo	***Internal Risk***
Capability Deficit	Vehicle Operational Limits	Vehicle Environment	***Crash Risk***
Driver Error Sources →	***Vehicle Error Sources →***	***Environmental Context***	
Distraction/Interference	Vehicle Malfunction	Driving Environment	
Distraction: Cell, Radio/CD, Food, Make-up Interference: Poor Position, Poor Access	Flat/low tire Steering wheel loss of power assist Gas/brake pedal malfunction Mirror/windshield setup or cracks	Weather condition Road/Traffic condition Road/intersection design Street signs and signals Local traffic laws Fellow motorists	***External Risk***

Presentation of the Navisection Method

A novel method is proposed here to have ITS complement driver rehabilitation programs in order to establish a validation pump. While driver rehabilitation programs establish and verify clinical standards of driving assessment based on ITS-generated measurements, the technology in turn gains valuable ground truth baselines for systematic evaluation of driving safety and performance. This union of technology and clinical expertise has been titled navisection as exhibited in Figure 2. The definition of navisection is the enhancement of supervised driving evaluation by collection of naturalistic driving data for supporting evidence and context-based driver education. Within the driver rehabilitation field, this technique would translate the expertise of a driver rehabilitation specialist into sensor data patterns, which create a standard of evidence-based practice for assessing driver capability. Towards the goal of enhancing driver rehabilitation, the intent is to accommodate measures on all road types, in any weather conditions, and during the entire on-road driving session (as long as 2-3 hours). Combining the findings across driver rehabilitation programs will facilitate the discussion on which kinds of errors determine driver capability and the proper thresholds for measuring safety.

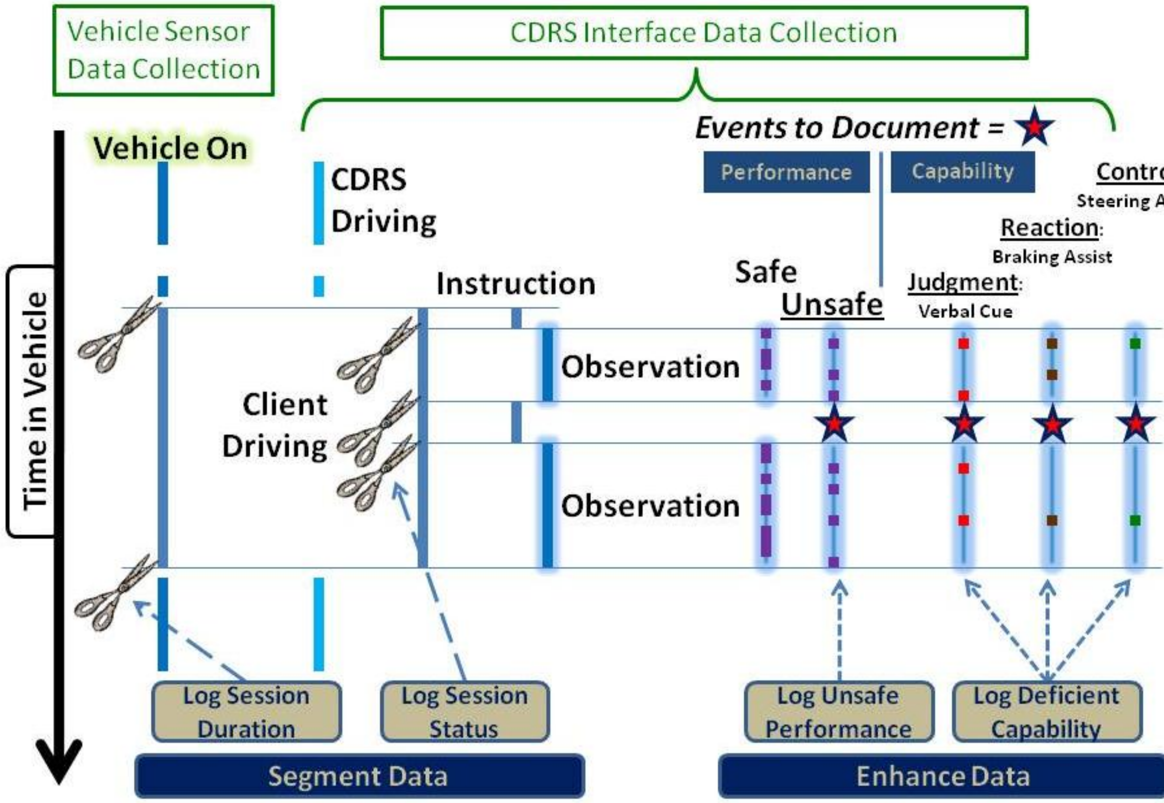

Figure 2: Navisection scheme for data segmentation and enhancement

ITS in vehicles will be on or available at all times, but clinical visits will require more sophistication to identify the data corresponding to specific clients. The first step is to segment data according to times when the client is driving the vehicle. Driving evaluation is not always a testing scenario. Thus, there may also be a need to segment data according to when the client is actually being evaluated and when instructions are being given or training is taking place. The significance of this step in segmentation is to consider the impact to measures of driver safety or performance such that algorithms do not skew estimates of an individual's driving capability.

Following the segmentation features, there is the possibility to enhance the data for contextual interpretation and categorization of error types due to the presence of a CDRS. The enhancement features rely on two modes of event detection. The passive event detection allows for CDRS-witnessed errors to be flagged in time with an unsafe event log. For instance, this may physically be a button that would be pressed when a client runs a stop sign at an empty intersection. Although there is no risk of harm or collision, the driving maneuver is clearly unsafe and illegal. Conversely, there are certain events that coincide with or lead towards the risk of an accident or collision. In this scenario, the CDRS must first ensure the safety of the client, their own life, and the program vehicle. Active event detection is necessary under this scenario to log the occurrence of an unsafe event. CDRS-assisted driving events become the target of active event detection, where the vehicle is the witness of anytime the CDRS assists their client in control/operation of the vehicle by steering assistance, braking assistance, or verbal cues for decision making assistance. Thus, CDRS-witnessed driving events are classified as driving performance measures of safety and CDRS-assisted (vehicle-witnessed) driving events are classified as driving capability measures of independence.

Finally, the complement of segmentation and enhancement markers with ITS-based naturalistic driving data provides the means to document evidence supporting clinical findings and recommendations within mandatory program reports (See Figure 3). Typically, paper based checklists and narratives are the standard documentation technique for report generation of comprehensive evaluations. Among the authors, Beyene and Lane (2011) found few driver rehabilitation specialists that utilize technology to measure driving performance on the road. Given an added CDRS logging interface, the navisection technique unlocks the potential of ITS data collection for clinical use. Figure 3 uses an image from the DriveCap system to represent the integration of any ITS solution for data collection. With a robust synching routine for time, the navisection-based markers can direct the display of acquired naturalistic driving data to key points of interest within the navigated path of the driving evaluation session. The CDRS may annotate data plots or tables that support the program findings and recommendations, and the interpretations of naturalistic driving data promote evidence-based practice for driver rehabilitation. While variations among CDRS-witnessed driving events may make comparisons between programs more difficult, the logging of CDRS-assisted driving events will more clearly reflect a scenario where CDRS engagement was necessary to avoid a collision.

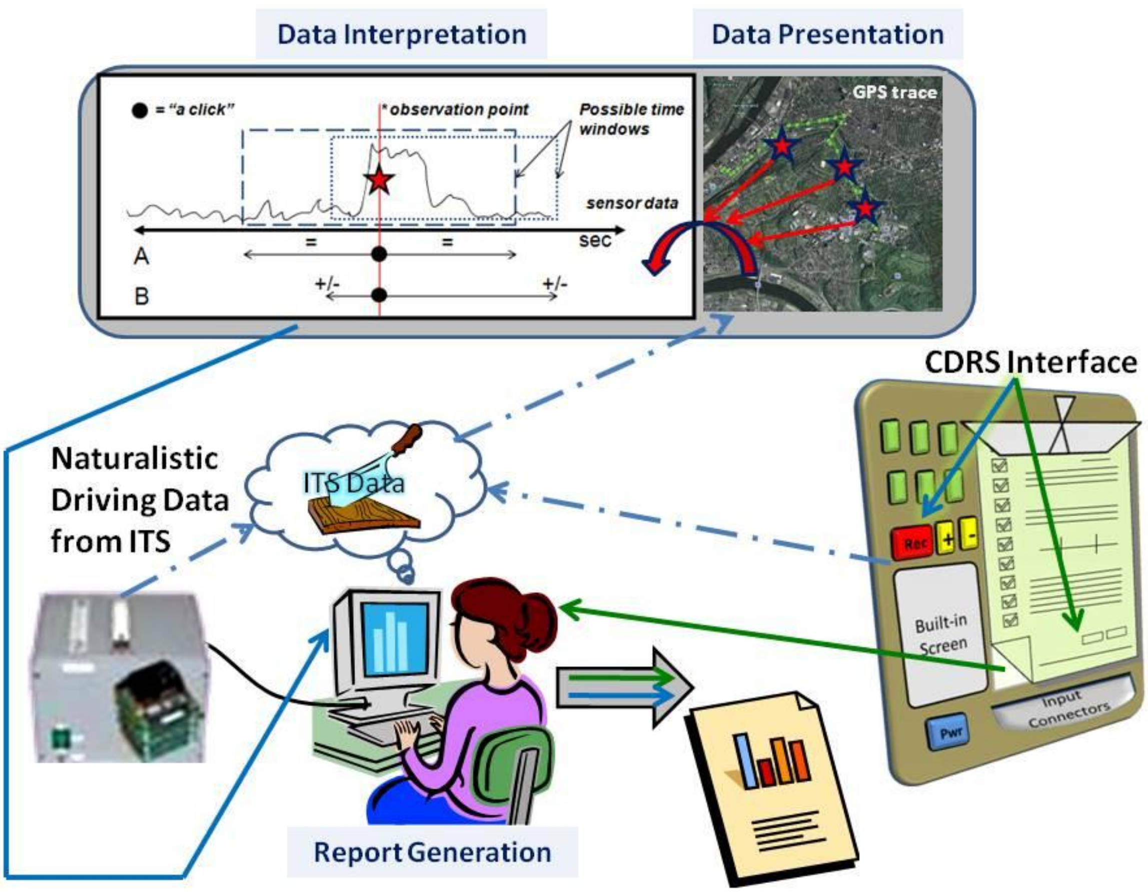

Figure 3: Navisection model for data processing, presentation, interpretation and reporting

General algorithms can make use of various data sources in order to generate automatic report data that is consistently required for internal and client records of a driver rehabilitation program. Recommendations for clients should discuss driving evaluation exposures, capability, performance, and driver fitness recommendations as a minimum. The exposure measures could specify the driving maneuvers performed, road types traveled during assessment, and total time spent on the road. Capability and performance reporting can include rates of independent vehicle control and counts of assisted driving events along with quality measures regarding speed control, distance management, and general smoothness of driving maneuvers. Recommendations on driver fitness should relate back to clinical measures indicating functional performance capabilities/impairments and highlight the areas of weakness in driving maneuvers based on exposures plus capability or performance measures. This approach would facilitate the recommendation for a client to resume driving, continue with training/remediation, or transition to alternative transportation modes with driver cessation.

Forecast of Expected Benefits and Limitations

The navisection methodology could impact driver rehabilitation programs in additional areas of service delivery. While the intended development of the approach was targeted at on-road driving evaluation, there are a number of ways (See Table 2) to assist administrative and program evaluation aspects of driver rehabilitation programs.

Table 2: Scope of applications for navisection within driver rehabilitation program

Administrative	**Program evaluation**	**Enhanced reporting**
Billing – driving time log	Training – client error types	Safety – performance measures
Maintenance – mileage log	Equipment – services requested & client needs	Quality – accuracy/reaction measures
Scheduling – travel time log	Advertising – client volume by region	Capability – independence measures
		Exposures – driving time on different road types

Benefits from navisection can extend beyond the driver rehabilitation programs to facilitate research as well. Studies can be conducted to identify pure driver capability measures without confounders of in-vehicle distractions (ex. Eating, putting on makeup, kids in the back seat, passengers, etc.) or vehicle performance shifts (ex. Multiple vehicle types, Low tires, poor windshield wipers). At the same time, there would be a large volume of naturalistic driving data available through driver rehabilitation programs nationwide. The navisection methodology will be demonstrated within the Adaptive Driving Program in Pittsburgh during the Fall of 2011.

For advances in comparative research, data from many clients with cognitive impairments could present gradients for comparison groups based on diagnosis for distracted drivers. In general, navisection would provide much cheaper instrumentation costs and faster collection of data with a single program vehicle or fleet of evaluation vehicles covering all classes of motor vehicles. Also, the presence of an expert witness (CDRS) in the passenger seat allows for real-time documentation of contextual details during actual driving events of interest that can enhance the interpretation of data. Further, the clinical setting provides the safest strategy of testing people on the road for naturalistic driving data while driving with impairment. The navisection methodology should produce a higher “hit rate” for collection of impaired-driving events/near-miss events/incidents among clients of adaptive driving programs.

With all the benefits of navisection for research efforts, there are certain limitations to the scope of driver safety issues that may be addressed due to the setting of data collection. Within a driver rehabilitation program, there would likely be no night-time driving data. While the pure assessment of driver capability is a potential benefit, there would be no cell phone use or texting while driving and limited distracted driving data due to events within the vehicle. The only plausible connection that could be drawn would involve intentional distractions by the evaluator (such as holding a conversation) when testing for divided attention during the sessions.

Overall, the efforts to understand crash causality are equally of interest to driver rehabilitation specialists. Their job is to identify crash causality due to the driver by assessment and evaluation of capability. The on-road portion of a comprehensive evaluation definitively uses naturalistic driving as a strategy. In some cases, driving evaluators are also used prior to heading onto the road. With the proposed methodology, measurement technologies and surrogate measures can be applied in order to generate safety management strategies for M-I drivers. The advancement of ITS technologies should be introduced here in order to properly achieve validation within the cycles between safety management and understanding crash causality.

DISCUSSION

The paths of development for ITS solutions and driver safety screening appear to be seeking the same target with disjointed mapping systems behind their strategic plans. If the navigated course of these two endeavors were to intersect, navisection would be the clear answer towards building a consensus on driving safety measures. From the initial consideration to licensure, navisection may lead to a common platform through which to address the more complex consideration of performance. While the driver rehabilitation community would seek perspective on performance for the advocacy of driving restrictions and gradual progression towards driver cessation, the ITS community would seek an understanding of performance in order to modulate their solutions in a manner that is fitting to the varying demands of our roadways or diverse levels of ability among our motorists.

The following two case studies will apply the stated benefits and limitations of navisection to prominent research efforts in naturalistic driving data interpretation and driver screening process improvements. Without attempting to exhaust all comparisons of navisection with the example case methodologies, these case studies are intended to spark wider discussion and consideration of how driver rehabilitation programs could combine with ITS design and development to mutually enhance the causes of each critical endeavor for promoting driver safety.

Case Study 1: 100 Car Naturalistic Study

Neale et al. (2005) reported an overview of 100 car naturalistic study stating 10 specific goals. From the listed goals, the navisection methodology could potentially address all except severe fatigue and with reduced exposure to secondary task performance or traffic violations. With the expectation that a massive repository of data could support research into the future, the navisection methodology poses that data could continually be collected with refinements to instrumentation or supporting documentation completed on the fly as the knowledge base and opinion of the research community change.

For the 100 car naturalistic study, there were no instructions for driving and no experimenter present during the data collection. While video data capture allows a fair amount of contextual evidence for events that transpired during the study, the navisection methodology ensures a much greater level of descriptive detail for the context of driving errors within a driving session.

The study also was able to have 78% of participants driving their own vehicle. In this area, the navisection methodology would result in very few people driving their own car, although there is a possibility that instrumentation could one day be installed in personal vehicles for clients of driver rehabilitation programs.

Considering the subjects recruited and vehicles instrumented the 100 car naturalistic study yielded data on the targeted drivers, an equally large number of family members, and recruited based on 6 different models of car ownership. The navisection methodology would generate a similar number of subjects without the inclusion of family members or the depth of data that continuous monitoring would provide. However, the navisection methodology could potentially incorporate many more models of vehicles as well as the best possible sample for use of adaptive controls with vehicle modifications.

Case Study 2: Maryland Model Driver Screening and Evaluation Program

The final technical report by Staplin et al. (2003) provided numerous findings based on the use of functional tests as predictors of driving impairment. However, there was no inclusion of technology for on-road evaluation incorporated with the pilot study. This may be another reflection of the lack of technology use found in the survey study by Beyene and Lane (2011) among driver rehabilitation specialists. The navisection methodology in this case is still too nascent for comparison, particularly concerning the secondary aim to assess the administrative feasibility of delivering the targeted functional tests reviewed for validity. If outcomes of studies based on the navisection methodology were to result in an on-road driving screening tool, then it is feasible to pose that ITS solutions enhanced by navisection-based research could serve as intelligent referral systems. This futuristic perspective would address the timeliness of screening; whereas the Maryland Model Driver Screening and Evaluation Program does little to explore how drivers can be empowered to screen themselves or how the timing of a screening can be more tightly centered around the onset of impairment or a transient decline in performance.

Implications to the Enhancement of Driver Rehabilitation and Licensure Policies

As presented earlier, the dissertation work of Justiss (2005) demonstrated the advantages of a structured driving assessment route. However, multiple sources speak towards the necessity of allowing for exploratory or familiar routes during assessment for more accurate assessment of drivers with dementia or heightened anxiety during evaluation (Beatson and Gianutsos, 2000;

Leung et al., 2009). The navisection methodology could result in a more flexible framework for standardized measures of driving safety that support fixed and exploratory assessment routes.

Going further, navisection could provide a framework for allowing more incremental paths to driver cessation and evidence to advocate for restricted driver's licensing practices that demonstrate reduced crash risk or mortality. A number of sources document interests in finding the difference between driving ability and driving skills in response to changes in the road settings or local environment (Galski et al., 1997; Freund and Petrakos, 2008; Eby and Molnar, 2008). Although this paper did not address legal action, Galski et al. (2000) covered multiple reasons why excessive trust in non-standardized tests can result in errors in decisions about fitness to drive as well as risks of litigation that may arise due to inappropriate recommendations.

Implications to the Advancement and Adoption of ITS Solutions

The involvement of driver rehabilitation specialists in the discussion of ITS application will minimize the rejection of these emerging technologies. As the advancements benefit the standards of practice, a whole field of experts in driving assessment will then be able to advance the design and regulation of ITS products. The introduction of this field into the evaluation of ITS will be more harmonious based on the shared goal of extending how long people can drive safely in society.

Hypothetically, there is a major advantage for automotive companies and technology leaders in ITS development if partnerships were made with driver rehabilitation programs. To overcome the lack of incident (near-miss event) detection, some proprietary technologies could possibly be loaned through donated program vehicles with a cooperative agreement that the data used in evaluation would also be shared with the donor companies. In this way, the fullest form of mutual benefit would be realized. Driver rehabilitation programs would not need exorbitant amounts of grant funding to acquire the technology and ITS producers would have a steady source of data collection to fuel the evaluation or further research and development of their systems.

Model Experiments and Initiatives to Guide Future Work

Following RITA's charge to generate transportation statistics, the TrafficSTATS project presented by Fischbeck et al. (2007) demonstrates an earnest effort to educate drivers as to the multi-factorial complexity of managing risk on the road. The web-based, interactive tool provides promise that the sophistication of emerging ITS solutions could be harnessed to inform drivers about the risk scenarios they embark upon as drivers on the road. Lotan and Toledo (2005) presented a system to provide young drivers with a monthly driving report card using an in-vehicle data recorder to generate risk statistics reflecting the driver's own performance. These examples demonstrate how inherent or experienced risk of driver-vehicle-environment scenarios might be able to modify an individual's driving behavior if the information is properly communicated and provided at appropriate times for consideration and adoption. The navisection methodology might be able to further increase the validity of the above mentioned tools by offering a higher order of ground truth as the basis for driver safety rating and trip planning decisions before traveling into the community.

From the promise of studies such as these, it is possible to envision a future where ITS solutions extend the reach of driver rehabilitation specialists to meet the demands for driver screening in our society. With the spirit of universal design, the decision making criteria that helps professionals to negotiate license restrictions based on driving performance could in turn help individuals to better monitor themselves when any cause for impairment threatens the safety of themselves or fellow motorists on the road.

CONCLUSIONS

Navisection is a method of driving assessment that has broad application and myriad benefits when viewed as a tool to improve relationships during the decision of whether or not to drive. As a witness-dependent methodology, the scope reaches to any setting where a witness is evaluating driving capability or performance. The targets for expanding the methodology would be physician-patient relationships, CDRS-client relationships, DMV-driver relationships, parent-child relationships (new drivers), and child-parent relationships (experienced/older drivers).

The products of this methodological advancement may lead towards a CDRS standard for driving assessment if the evidence yields a consensus for vehicle sensor data patterns correlating to capability and performance ratings. Given such a standard in the future, we could potentially pursue automated driver screening that is blind to age, gender, or social status. Standards would imply context-based, longitudinal evaluation of driving capability. Ultimately, the wealth of context-aware naturalistic driving data should also provide a common platform for interdisciplinary researchers and policy/safety experts to generate greater advocacy and policy recommendations.

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