The Challenges of Designing Effective Persuasive Technology on the Road: Towards Adaptive Mobile Mashups

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ABSTRACT

Today's vehicles and on-road infrastructures are equipped with a large number of sophisticated sensory devices. These sensory devices are capable of monitoring and providing data pertaining to vehicle status, real-time traffic conditions, traffic incidents, and road crashes. Urban commuters are also carriers of sensors embedded in their mobile devices. We are deluged with a massive pool of data that has the potential to increase our understanding of our social behaviours in the transportation network. This will assist in the design of effective persuasive technology on the road to monitor and target voluntary travel behaviour change in order to support road safety, sustainable transportation, and compliance to traffic regulations. We explore the integration of mashup technology, knowledge discovery and business intelligence techniques, and context-aware analysis and introduced the notion of ADAptive Mobile Mashups (ADAMM) for effective persuasion on the road.

Author Keywords

Context-Aware Systems, Business Intelligence, Data Mining, Mashup, Persuasive Technology, Intelligent Transportation Systems

BACKGROUND

Our road and transportation network are swamped with data. One of the rapidly developing technologies used in transportation systems is sensor technology. Sensors are designed and created to monitor the conditions of the vehicles, the road, and the environment in specific vicinities, such as weather information and traffic conditions. This enables drivers and traffic authorities to be better informed when the information and knowledge gained from sensors are made available to them. In all the currently released vehicles, there are up to one hundred sensors on board each car (Knoll, 2006), including the range and imaging sensors used for safety purposes as shown in Figure 1 (Jones, 2002).

Communication and satellite navigation devices are becoming intrinsic features of the recently released vehicles. Global Positioning System (GPS) has been used widely in navigation, map creation, land surveying, and also tracking vehicle manoeuvres. For example, GPS is used for lane change manoeuvre detection in (Xuan and Coifman, 2006). Along with the advances of wireless communication technology, short and long range communication technology between vehicle and infrastructure and between vehicles is being developed. The standard for Dedicated Short Range Communication for vehicle based communication, the IEEE 802.11p (Wireless Access for the Vehicular Environment, WAVE) is currently being formulated (Kerry and Armstrong, 2008). It is an extension of the 802.11 wireless network standards to support ITS applications. It enables high speed data exchange between vehicles and between vehicles and road infrastructures.

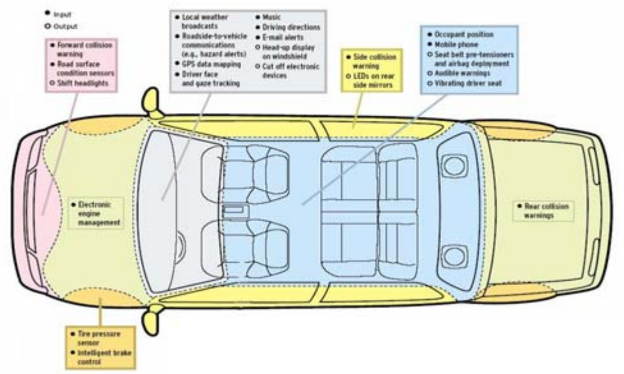

Figure 1. Sensors that enhance car safety (Jones, 2002)

In addition to large number of sophisticated sensor devices on the road and in vehicles, urban commuters are sensor carriers themselves. Mobile devices and smart phones are now equipped with GPS, accelerometers, compass (such as exhibited by the new iPhone 3GS). With their mobile devices, urban commuters are able to tap into the online resources for tasks such as travel information, route planning, getting nearest points of interests, and much more.

We identify two emerging research directions coming from the proliferation of data about road and transportation. First is the data analysis process for *knowledge discovery and business intelligence* (KDBI) from sensor data. This arises from the need to make sense of the data available on the road and transportation systems on the urban network given the wealth of data available through these sensors and mobile devices (Salim et al., 2007). Second is the *mashup* of inter-relating information from various online data sources in order to present and visualise the data contextually to the user. This arises from the need for *situational* applications that can be created “on the fly” (Jhingran, 2006). We view that the two directions are converging and cannot be viewed separately in order to tackle the ongoing issues on the road, which are discussed further in the next section. By integrating resource-aware KDBI and mashup technology, we suggest that *adaptive mobile mashups* can provide an answer to the need for effective persuasive technology on the road.

“ON THE ROAD” COMPLEX PROBLEMS

Road Safety

Every minute, on average, no less than one person dies in a crash worldwide (Jones, 2002). According to the International Road Traffic Accident Database, globally, there are likely to be 10 million road crashes every year, which claim one and a half million fatalities (Frye, 2001). The figure of the annual toll of human loss caused by intersection crashes has not significantly changed, regardless of improved road design and more sophisticated Intelligent Transportation Systems (ITS) technology over the years (U.S. Department of Transportation - Federal Highway Administration and Institute of Transportation Engineers, 2004). Human error is the major contributing factor to road safety risks. There can be various causes of human error, such as lack of situated awareness of the surrounding traffic, traffic blind spot, miscalculation of timing in performing certain manoeuvres, or a deliberate violation to traffic regulation. This can be attributed to various road users with different cognitive and physical abilities/disabilities. Thus, behavioural changes need to be advocated through effective information delivery and persuasive technology.

Sustainable Transportation

Public transport and personal motor vehicles are major contributors to greenhouse gas emissions and air pollution in urban cities. The City of Melbourne recently issued a publication that presented various strategies to reduce carbon emission to fifty to sixty percents across the municipality by the year 2020 in various areas, of which passenger transport is identified as one of the key areas (City of Melbourne, 2008). In 2003, 73.6% of total greenhouse emissions in Australia is comprised of CO2, of which 56% is contributed by the electricity and heat production, while 15.9% is contributed by public transport and passenger cars (Australian Greenhouse Office (AGO), 2003 in Coutts et al., 2006). The major cause of air pollution in Australian urban context is motor vehicles (Australian State of the Environment Committee, 2001 in Coutts et al., 2006) as traffic contributes to 75% of the total urban air pollution (Simmonds and Keay, 1997 in Coutts et al., 2006). There is a need for a mechanism to quantify the impact made by individuals’ choice on their travel modes and leverage the public awareness of the impact of their decision in a positive way.

Traffic Regulation Compliance

As previously stated, traffic infringements impose road safety risks. Therefore, behaviours such as speeding, drink driving, and red light running are unacceptable and need to be regulated. The imposed regulations are not effective enough to encourage road users to keep them since such means do not change users’ behaviours. Voluntary travel behaviour change cannot be fostered merely by imposing regulations or external compulsions, but through social marketing and community development approach (Ampt, 2003). Therefore, there is a need to understand people’s behaviour before we can design a system with the intention to contextually persuade them towards a targeted behaviour. The next section presents the notion of Adaptive Mobile Mashups to potentially handle the complex problems presented in this section.

ADAPTIVE MOBILE MASHUPS

Computer applications, when designed with the intention to modify user behaviours, have a great persuasion power (Fogg, 2002). Fogg stated that a computer application can play the role as a persuasive social actor by rewarding the users with constructive feedback, simulating a targeted user behaviour, or giving social support (Fogg, 2002). Persuasive ability of computers need to be utilised for the purpose of social marketing for targeted behavioural change (Chinn and Artz, 2008). The rapid advancement of Web 2.0 technologies has pushed the edge for online persuasion, given the ability of social marketers to “outreach” to larger online social players (Chinn and Artz, 2008). The advances of Web 2.0, including web services, web APIs, and online data sources have leveraged the growth of Web mashups for information integration.

Mashup is intended for contextual information representation for a situated purpose through “ingestion, augmentation, and presentation” of online information sources (Jhingran, 2006). Jhingran noted the two approaches adopted in integrated enterprise mashup (Jhingran, 2006). First is the business intelligence approach, where multiple non-structured data is processed and presented as structured data. Second is the content and search technique where filtered information retrieval is performed on structured data. However, the notion of business intelligence presented by Jhingran does not represent the depth of the meaning of business intelligence as known in the KDBI community.

Business intelligence (Figure 2), in a nutshell, is a process of transformation of data to information through data management (such as Database Management or DBMS), which then generates information that need to be translated to knowledge and business intelligence through application of data mining techniques and optimisation (Michalewicz et al., 2007). The integration of mashups and business intelligence provides a powerful edge for enterprise information integration through visualisation of intelligent and relevant knowledge that are useful to support decision making.

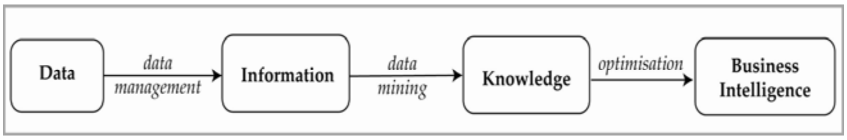

Figure 2. Transformation of Data to Business Intelligence

Maximilien (Maximilien, 2008) suggested the significance of mobile mashups given the rapid development time and the inherent contextual information that can be used to filter the information presented to the user based on contextual information such as the user's location and preferences. Mobile mashups provide users with information they require at a spatial and temporal context. Therefore, given the social presence of mobile mashups, a mobile mashup application can act as a social actor to persuade users towards behaviour change. Examples given by Maximilien (Maximilien, 2008) include persuasion towards online cross-selling of products and services from inter-related online businesses.

Given the mobility and "situatedness" of mobile mashups, adaptivity should be an intrinsic feature of mobile mashups. Mobile mashups need to be aware, not only to the inherent contextual location contained in the mobile device, but also to the changing contexts of their environment. A system is considered as "adaptable" when the users are given the control via tools or open interface to change the behaviour of the system; whereas, a system is deemed as "adaptive" when the system itself is in charge with making changes to their own behaviours (Oppermann, 1994). Mobile mashups need to be able to change their own behaviours, at least by reasoning the situation they are in and adjust themselves accordingly to the contextual parameters.

We introduce the notion of ADAptive Mobile Mashup (ADAMM) as shown in Figure 3. ADAMM will encapsulate KDBI techniques and mashup fabrics, such as Web APIs, Web services, RSS , and REST, and apply context-aware filter for contextual and persuasive information visualisation and presentation. Using sensory data and mobile devices' usage data, users' behaviours can be learned online on the resource-constrained environment using ubiquitous data mining (UDM), introduced by Gaber (Gaber et al., 2005). The knowledge base can continually be built from offline mining of historical data from a database management system. And with the live connectivity with sensor devices and real time stream from mashup fabrics, knowledge can be mined online using UDM that performs classification and clustering analysis on sliding windows of data streams instead of stored data sets. With the continual learning of user behaviours and environmental contexts, mobile mashups are capable of adaptive persuasion towards a targeted behaviour. The knowledge and intelligence can be integrated with the structured data retrieved by search and selection from mashup fabrics. The integrated information then needs to be selectively presented or visualised by applying context-aware filter. The context-aware filter may be comprised of various context attributes, such as the available computational resources in the mobile device, user profiles or preferences, location, time, nearby resources, and so on.

RELATED WORK AND OPPORTUNITIES FOR ADAMM

The Vehicle Data Stream Mining System (VEDAS) was proposed for analyzing onboard streams of vehicle data (Kargupta et al., 2004). Data from sensors in moving vehicles was analysed in real-time for monitoring vehicle's health and recognising driving patterns. An event management service is developed to notify users of unusual events (Kargupta et al., 2004). VEDAS is an in-vehicle system prototype. If VEDAS is re-developed as ADAMM, vehicle owners would be able to monitor the vehicle's health at anytime, anywhere, and get automated notification of the major or minor service requirement along with the map of the closest or the most economical service dealers, depending on the contextual user preference and budget conditions.

Algorithms to identify drink driving behaviours in real-time were proposed by Horovitz (Horovitz et al., 2006). The result of an online clustering and offline labelling of the simulated sensor data was three clusters of drunk driving behaviours', from least drunk to most drunk. The drink driving behaviour model is used to predict driver behaviours in real time. The system was emulated on a PDA emulator and can potentially be extended as an effective mobile persuasion tool. If ADAMM is employed in the system, positive reward system and online recommendations to dissuade drunken behaviours by mashing up relevant information to the users may have the persuasion power for voluntary behaviour change.

UbiGreen (Froehlich et al., 2009) is a persuasive mobile application to encourage participants' engagement in using green transportation, such as carpooling and bike-sharing. UbiGreen collects users' behavioural data using semi-automated sensing and self-report questionnaires. UbiGreen uses trees or polar bear avatars to visualise the degree of 'eco-friendliness' by analysing the user's weekly transportation choices. The study reports that the visual design employed is effective and compelling enough to create awareness of green transportation options and to encourage users to start the new green behaviours. Participants in the study requested for more information to be presented along with the visual design. Participants also requested for quantifiable social and environmental impact measures for comparison. In this context, the ADAMM approach is potentially useful for delivering comparisons of various travel choices based on quantifiable information such as cost, distance, travel time, and carbon emission.

CONCLUSION AND FUTURE WORK

This paper has briefly reviewed the opportunities and challenges for persuasive technology on the road.

Through combining business intelligence and mashup fabrics, information can be integrated rapidly and presented to the user in a contextual way. We propose the notion of ADAptive Mobile Mashups (ADAMM), which is an integration of web mashings techniques for information retrieval and data assimilation, offline data mining and ubiquitous data mining for knowledge discovery, and optimisation techniques for business intelligence.

The road and transportation networks will benefit from adopting the ADAMM approach for targeted persuasion towards road safety, sustainable transportation, and traffic regulation compliance.

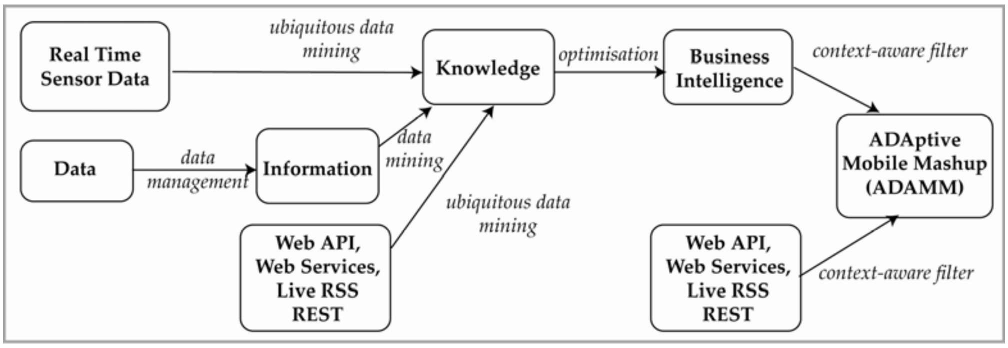

Figure 3. Conceptual Framework of Adaptive Mobile Mashup

REFERENCES

Ampt, E.: 2003, Understanding voluntary travel behaviour change. European Transport Conference 2003. Strasboug, France, The Association for European Transport (AET).

Chinn, S. J. & Artz, N.: 2008, Social Marketing, Social Networking. IN Oglesby, R. A. & Adams, M. G. (Eds.) Business Research Yearbook: Global Business Perspectives. Beltsville, MD, US, International Academy of Business Disciplines.

Fogg, B. J.: 2002, Persuasive Technology: Using Computers to Change What We Think and Do (Interactive Technologies), Morgan Kauffman.

Froehlich, J., Consolvo, S., Dillahunt, T., Harrison, B., Klasnja, P., Mankoff, J. & Landay, J.: 2009, UbiGreen: Investigating a Mobile Tool for Tracking and Supporting Green Transportation Habits. Proceedings of CHI2009. Boston, MA, USA.

Frye, C.: 2001, International Cooperation to Prevent Collisions at Intersections. Public Roads Magazine, 65,1, July-August 2005, Turner-Fairbank Highway Research Center, United States Department of Transportation - Federal Highway Administration.

Gaber, M. M., Khrisnaswamy, S. & Zaslavsky, A.: 2005, Resource-aware Mining of Data Streams Journal of Universal Computer Science, 11,8, 1440-1453.

Horovitz, O., Krishnaswamy, S. & Gaber, M. M.: 2006, A fuzzy approach for interpretation of ubiquitous data stream clustering and its application in road safety. Intelligent Data Analysis - Special Issue on Knowledge Discovery from Data Streams, 11,1, 89-108.

Jhingran, A.: 2006, Enterprise information mashups: integrating information, simply. Proceedings of the 32nd international conference on Very large data bases. Seoul, Korea, VLDB Endowment.

Jones, W. D.: 2002, Building safer cars. IEEE Spectrum, 39,1, 82-85.

Kargupta, H., Bhargava, R., Liu, K., Powers, M., Blair, P., Bushra, S., Dull, J., Sarkar, K., Klein, M., Vasa, M. & Handy, D.: 2004, VEDAS: A mobile and distributed data stream mining system for real-time vehicle monitoring. Proceedings of the SIAM International Data Mining Conference. Florida, USA, Society for Industrial and Applied Mathematics (SIAM).

Kerry, S. J. & Armstrong, L.: 2008, "Status of Project IEEE 802.11 Task Group p: Wireless Access in Vehicular Environments (WAVE)". Available from: http://grouper.ieee.org/groups/802/11/Reports/tgp_update.htm. (accessed 29 May 2008)

Knoll, T.: 2006, "Robert Bosch GmbH - Business / Information - Press information". Available from: http://www.bosch-presse.de/TBWebDB/en-US/PressText.cfm?id=2567. (accessed 1 May 2008)

Maximilien, E. M.: 2008, Mobile Mashups: Thoughts, Directions, and Challenges. Proceedings of the 2008 IEEE International Conference on Semantic Computing. IEEE Computer Society.

Michalewicz, Z., Schmidt, M., Michalewicz, M. & Chiriac, C.: 2007, Adaptive Business Intelligence Berlin Heidelberg, Springer-Verlag.

Oppermann, R.: 1994, Adaptive User Support: Ergonomic Design of Manually and Automatically Adaptable Software, Hillsdale, NJ, USA, Lawrence Erlbaum Associates.

Salim, F. D., Loke, S. W., Rakotonirainy, A. & Krishnaswamy, S.: 2007, U&I aware: A framework using data mining and collision detection to increase awareness for intersection users. IN Barolli, L. (Ed.) The 21st International Conference on Advanced Information Networking and Applications Workshops. Los Alamitos, CA, USA, IEEE Computer Society.

U.S. Department of Transportation - Federal Highway Administration & Institute of Transportation Engineers: 2004, "Intersection Safety Briefing Sheet ". Available from: http://www.ite.org/library/IntersectionSafety/BreifingSheets.pdf. (accessed 12 January 2005)

Xuan, Y. & Coifman, B.: 2006, Lane change maneuver detection from probe vehicle DGPS data. Proceedings of the Intelligent Transportation Systems Conference 2006 (ITSC '06). Toronto, Canada, IEEE Intelligent Transportation Systems Society.