

Navigating Haystacks at 70 mph: Intelligent Search for Intelligent In-Car Services

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ABSTRACT

With an explosion of in-car services, it has become not only difficult but unsafe for drivers to search and access large amounts of information using current interaction paradigms. In this paper, we present a novel approach for visualizing and exploring search results, and the potential benefits of its application to the current in-car environment. We have iteratively developed and tested a prototype system that enables the seamless and personalized exploration of information spaces. In a number of eye-tracking studies, we analyzed user satisfaction and task performance for factual and explorative search tasks. We found that most participants were faster, made fewer errors and found the system easier to use than traditional ones. We believe that this approach would improve the traditional in-car interfaces - to search and access large number of services with rich information. This would reduce driver inattention to the road and improve road safety.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces - *Graphical user interfaces.*

General Terms

Design, Experimentation, Human Factors, Intelligent Transport System Services, Road Safety, Theory

Keywords

Contextualization, Personalization, Exploration, Search, Context Interfaces, Contextual User Interfaces

1. SafeTRIP

Satellite-based communication systems [10] for use in homes [1][13] and cars have been adopted by consumers in many parts of the world. The SafeTRIP project aims to build on this success and utilize a new generation of satellite technology to improve the safety, security and environmental sustainability of road transport.

SafeTRIP uses S-band satellite technology, which is optimized for two-way communication for on-board vehicle units. The S-band

communication requires a small antenna making it suitable for the mass market. Existing solutions that use other frequency bands (for e.g. Ku-Band) require larger antennas [12] thus being less suitable for integration in vehicles or in handheld devices. An open SafeTRIP platform will be implemented to host services for improved safety and navigation, but also entertainment and advertising to vehicle occupants.



Figure 1 - The SafeTRIP concept

During the requirements capture, we discussed with drivers, operators, emergency technicians, operation managers, technologists and the management from road operators, insurance companies, fleet operators, freight forwarders and coach operator to understand their needs.

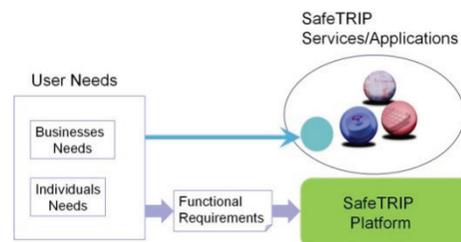


Figure 2 - User needs defines the SafeTRIP platform

The SafeTRIP platform's definition - based on key functionalities elicited from business (such as road operators) and individual stakeholders - is shown in Figure 2. The platform enables services that can provide access to rich information that might be useful to drivers. At the same time, this creates a risk of overloading drivers with information, and distracting their attention which should be focussed on the road. In this paper, we present a new paradigm for accessing rich media and information in a vehicle which has minimal impact on the driver's attention while driving.

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2. SafeTRIP Services

From our requirements capture, a set of safety and comfort services were identified, including:

- Road safety alert service – hazard and incident warning;
- Speed limit service – display variable speed limits in-car;
- Collaborative alert service – allow drivers to share information about road incidents and traffic information;
- Entertainment service - provides access to Streaming media and TV channels;
- Assistance service - remote assistance and diagnostics;
- Parking guidance service - for hazardous goods vehicle and coaches;
- Location-Based services – access and present localised information to driver such as petrol stations, restaurants, hotels, local events.

These services will provide numerous benefits to the drivers. For instance, it will allow them to access rich and timely traffic information from various sources in the vehicle. Commercial systems such as Coyote have proven very popular amongst drivers who share information about speed cameras in Europe. Through SafeTRIP, drivers will also be able to share information about road incidents with each other. Our user requirements capture shows that individuals are interested in accessing richer information. Through the above services, they will be able to access localized information about parking spaces, hotels and petrol stations – along with rich information – to allow drivers to search for the cheapest place to be refueled or for a restaurant with a cuisine of their liking.

Whilst this type of information could have many benefits for drivers, there are risks associated with delivering them into vehicles. In 2006, a study by the U.S. Department of Transport (DOT) reported that the leading factor to 80% of crashes and 65% of near-crashes is driver inattention [9]. The SafeTRIP platform will partly address this through a driver alertness service that monitors driver alertness and support warnings to drivers [8].

However, with access to a large number of services, the driver's attention will be required to:

- Access a service through the navigation interface
- Interact with a specific service - which may involve searches that would require further interaction from the driver

Current icon-based interfaces to in-car systems and virtual keyboards are too taxing to the driver's attention – and it can only get worse with an increasing number of services. This has led us to consider alternative paradigms for driver interaction with information delivered into vehicles.

3. INFORMATION EXPLORATION

In this section we describe a novel information exploration technique to search and access information on the web. Experiments have clearly demonstrated its benefits and we believe that this approach will prove beneficial for drivers searching and interacting with information in their vehicle.

Approaches such as contextual search [3], search result clustering [16] or personal search [2][15] aim to overcome some of the shortcomings of “traditional” search engines. However, none of those approaches challenges the current paradigm of how users interact with search engines. To us, it is obvious that the traditional interaction model using search engine result pages

(SERPs) does not work well for more complex information problems.

To get a broader view, users need to consult different sources and understand contexts. Most of the time, a single resource will not be able to satisfy this need. Traditional SERPs fragment the relevant bits of information, rather than help users to contextualize them in meaningful ways. Users have to “crawl” site after site, foraging for meaningful bits [12], emulating the behavior of a search engine robot. The **search engine interaction model** (Figure 3, left side) illustrates users' interaction with SERPs, moving back and forth between search results (A, B, C, D) and the actual SERP (central point).

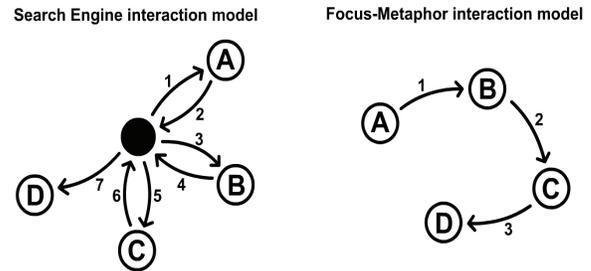


Figure 3 - Contrasting Interaction Models

3.1 Information Exploration UI

In contrast, users' interaction with our information exploration interface – also referred to as Focus-Metaphor Interface (FMI) [4] - enables seamless exploration of the underlying information spaces (see Figure 3, right side). This approach combines a contextual navigation with the actual display of information (see Figure 4) and particularly facilitates orienteering behavior [14].

When visualizing search results, the FMI replaces traditional search engine result pages (see Figure 4-A). Its contextual interface elements contain snippet-like information previews of the actual search results, and are arranged around the central content element which displays details of the currently selected search result (see Figure 4-B).

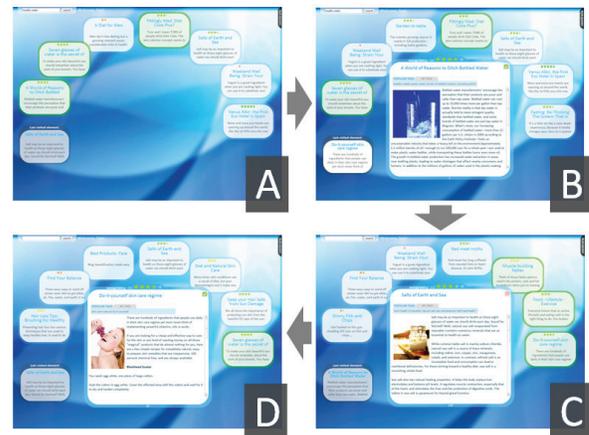


Figure 4 - FMI prototype for social tools evaluation

When selecting another contextual element, its state changes: it enlarges into a content element and moves to the centre of the screen, replacing the previously displayed search result (see Figure 4-C). This approach allows “browsing” through search results whilst preserving contextual awareness of the other search result snippets. In addition, the chosen layout enables a less

hierarchical and more concurrent display of the “top X” search results, without requiring any scrolling.

However, the key strength of the FMI model becomes apparent when none of the presented search results meet the user’s information need. Rather than having to re-formulate another search query hoping for more promising search results, the user can simply pick one of the existing results that she thinks comes “closest” to what she is looking for, and request similar/related results. This enables the dynamic adaptation of contextual elements to the currently displayed content element, without requiring the user to articulate their information need precisely.

This approach represents a break from traditional search behavior, as the user does not need to constantly go back to a search interface to (re-)start a new search session. Instead, an initial search query is the starting point for a seamless and personalized orienteering and exploration process that guides the user from one information nugget to the next. Although Google search provides related functionality through a link called “similar” available with some of its search result snippets, this functionality mostly works at a very abstract level (e.g. sites related by topic), but not on the actual content level. Microsoft search (live.com) provides “related searches” through a list of similar search queries. However, this functionality again seems to only work on a rather abstract level with more generic search queries.

Another key benefit of the FMI model is that its layout and interaction paradigm lends itself to novel interaction techniques, such as touch or even eye-gaze. In an earlier study, we have demonstrated the effective use of our information exploration interface with eye-gaze only [6].

3.2 Experimentation

Over 3 years, we have conducted a number of lab-based studies of various FMI prototype iterations. We evaluated the performance of and user satisfaction with our prototype against a range of existing tools, such as individual blogs, blog spaces, Google news, Google Reader and PARC’s StarTree [4][5][7].

Throughout those studies, task completion times were significantly faster and error rates were significantly lower using the FMI than in blog environments (see Figure 5) and on a par with PARC’s StarTree (which only works for well-formed information spaces).

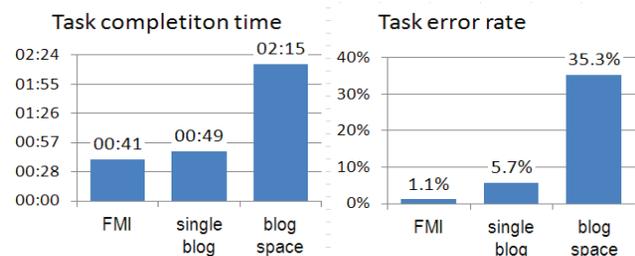


Figure 5 - Cross-study comparison

Participants using the FMI had short and very consistent average fixation durations, which indicate lower cognitive load than in all compared systems. User feedback through questionnaires and informal interviews confirmed the ease of use and learnability of the FMI prototypes for most users.

3.3 Social Tools Study

In our latest study, we used a corpus of domain-specific blog entries to evaluate a range of **social tools**, namely the ability to tag, rate and bookmark any of the articles. We looked at the impact of 1) ratings on contextual search snippets and 2) tags on search result presentation (see Figure 6).



Figure 6 – Screenshot of FMI with social tools

The eye-tracking experiment involved 21 participants, 13m/8f, 20-46 years (avg. 25.7). We used a range of factual and explorative search tasks. For factual search tasks, participants had to identify a specific article; for explorative search tasks, participants had to explore a certain topic for a few minutes. In both cases, we used small scenarios to facilitate intrinsic motivation in the participants.

For the contextual search result snippets, our analysis of post-experiment usability questionnaires (Likert scale, 1-6) revealed that participants found the “5 star rating” functionality very quick and easy to use (5.5). The ability to have ratings displayed in the contextual navigation elements was rated significantly higher than the perceived impact on users’ navigational decisions (4.8 vs. 4.0, $t_{20} = 2.09, p < 0.02$).

But, analysis of the eye-tracking data shows that participants’ awareness of the actual ratings was substantial, considering its actual size within the contextual search snippet (see Table 1).

Table 1 - Search snippet attention distribution

Attention Distribution (relative gaze time)	
Rating	17.1 %
Title	54.4 %
Description	28.5 %

Within this study of social tools for the FMI, selecting a “new” central content element automatically updated the contextual elements to display the most similar/related articles to the newly activated content element. However, user feedback showed that the automatic contextualization of relevant search snippets is too volatile for users’ taste. For future studies, we have therefore settled on a static/persistent contextual visualization that (only) adjusts to the currently displayed content element upon request by the user.

4. SafeTRIP FMI

With the large number of services available through SafeTRIP, searching through services and information, using traditional

methods and interfaces in in-car systems, can prove to be time consuming. Inefficient search therefore has a detrimental impact on the driver's attention and thus on road safety.

As FMI has proven to be an effective tool for searching and presenting information, we believe that its application to the in-car environment would be beneficial to the driver. We have identified some application areas for the SafeTRIP in-car interface that could benefit from this approach.

Service Search

SafeTRIP is an open platform, allowing third party applications/services to be made available to the drivers. With typically dozens of services planned already and new ones appearing with time, the traditional icon/menu based interface in most in-car systems may not be appropriate. With FMI, the drivers will be able to search through 100s of services and locate the ones that are most relevant. As our studies show, precise search criteria may be difficult to formulate – especially when searching for a new service. Also, if the user goes down the wrong search path, he can explore information sets that look relevant, without reformulating the search all over again.

Search Traffic Info

Typically, drivers combine traffic information from various sources to make decisions while driving. With new services in SafeTRIP, traffic information will be available from yet more sources – namely road operators, other drivers, authorities and traffic information providers. The reliability and timeliness of such information differs across sources – and drivers know how to exploit these differences. FMI can be used to provide an efficient mechanism to search for the most appropriate information, given that complete automation is unlikely as drivers use a mix of information sources based on their personal preferences.

Display Traffic Info

With SafeTRIP, we plan to provide rich traffic information to the drivers. On the motorway, variable speed restriction (e.g. in the event of a road incident) will be sent to the vehicle (instead of being displayed on a Variable Message Sign) with some details about the incident. It is expected that drivers would be more likely to respect the new speed restrictions if they are aware of the underlying reason. However the display of rich information can lead to information overload or inattentive blindness – causing the driver to ignore the important information in the messages. The layout of information in the FMI is designed to be minimalistic, providing as much relevant information as a user can process effectively, allowing for easy decision making and exploration of further relevant information.

Entertainment Selection Interface

Remote controls fitted to the steering wheel are a definite improvement that allows drivers to interact with the in-car entertainment system without taking their eyes off the road. However, with the explosion of entertainment options – both audio and video – through the SafeTRIP platform, it is likely that such solutions will quickly show their limitations. We believe that the FMI approach would allow the driver to quickly and efficiently search through the entertainment options.

5. CONCLUSION

It is clear to us that web based search benefits from the FMI approach as demonstrated by the results obtained from experimentation. With the increase in number of services available in the car – such as the ones through SafeTRIP, there is

a real need for an effective and efficient way to search and interact with those services. We therefore believe that in-car systems would greatly benefit from the FMI approach by decreasing search time, thereby improving driver's attention on the road and contributing towards road safety.

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