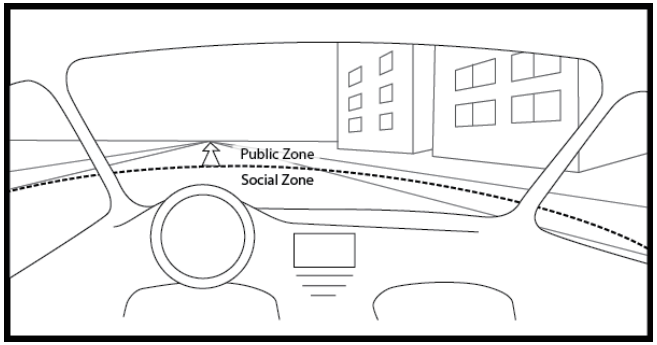
Towards a Placement Strategy for Windshield Displays

Renate Haeuslschmid
Department of Human-Computer-Interaction
University of Munich (LMU),
IAV GmbH
Munich, Germany
renate.haeuslschmid@ifi.lmu.de

Yixin Shou
Department of Informatics
University of Munich (LMU),
IAV GmbH
Munich, Germany
yixin.shou@iav.de



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Abstract
A fully spatially registered Windshield Display (WSD) will - once built - provide a very wide viewangle resulting in a wide choice of display positions for information. Obviously, information related to the environment should also be spatially registered to the environment, but where should information without a spatial reference, such as general warnings, be placed? To answer this question, we work on a strategy for information placement on a WSD which promotes fast recognition and understanding. This paper describes our current ideas in this matter and can serve as a starting point for a discussion in the community.

Introduction
Windshield Displays - large-sized Head-Up Displays (HUDs) - provide a safety benefit compared to Head-Down Displays (HDDs) [7]. Within the limits of visual and cognitive capacity, it seems reasonable to explore these opportunities and ease access to and comprehension of information by transferring often-used functions to proper positions within the WSD. These functions cannot only be provided by the vehicle but also by the smartphone. In previous work we have shown that the major interest of young drivers is being online and connected. The urge to be online can be attributed to the general psychological need of relatedness [11] and is so strong that it lets drivers ignore risks and break laws. As accident rates show, drivers access the matter of interest

Proxemic zones [2, 8]
Intimate: 0 - 45 cm
Smell, feel body temperature, wrestle or make love, excluding the enforced closeness.

Personal: 45 - 120 cm
Close enough to make physical contact; sense of body heat and the most powerful odors are lost.

Social: 120 - 360 cm
Different behaviors can be performed easily, but only what can be seen and heard is reliable; recognition of subtle aspects is difficult; the eye is able to focus on an entire face.

Public: 360 cm to infinity
Conversation is difficult; gestures are used; no subtle nuances from face or tone are recognizable; whole body can be observed at a glance.

on the smartphone despite they know better. Consequently, it is crucial to provide safe access to functions in the car. A spatially registered WSD spans a large 3D-space: it extends across the driver's Field of View (FoV) through the windshield. Thereby it provides a lot of space to display information. The established concept of a registered display suggests the placement of information spatially close to related objects in the environment. But where to place information without spatial relation, such as running out of gas, remaining kilometers, SMS, or also ambient information such as time and date, which are due to high access frequency and importance to the driver still hot candidates for placement on the WSD? To approach this problem, we work on a strategy for information placement based on the theory of Proxemics, the three zone model, the information context and priority.

Proxemics Theory
Edward Hall introduced Proxemics as a theory of the usage of interpersonal distances when we communicate with other people [2]. Four distances have been defined: Intimate, Personal, Social, and Public Zone (see side column). Proxemics has successfully been applied to interaction based on self-motion in a defined area to control a fixated display (e.g. wall displays [4]).

Three-Zone Model
The three-zone model proposed by Prante et al. [9] describes a distance-sensitive display reacting to the user according to the notification, interaction and ambient phases. It provides seamless transition from one phase to another, as each phase has specific requirements for interaction.

Information Context
The word "context" is used in a wide variety of disciplines and defined considerably different. Amongst various reviewed collections and categorization approaches [1, 5, 10, 12], we identified context categories and elements as most suitable for in-vehicle displays (see table 1):

Category	Context	Example Information
Identity	Vehicle	Power, security & comfort system
	Driver & Co-driver	Physiological and mental state
Physical	Environment	Driving- and driver-relevant information (e.g. traffic & ad signs)
	Location	Absolute (GPS) and relative (other cars) location of the vehicle
Time	Time	Precise time, range of time

Table 1: Context Categories and Elements [10, 12]

Priority
In the context of driving, three task levels are defined which already present their priority (see table 2). Further, we allocate priority according to safety-relevance in the following order: alert (e.g. crash), warning (e.g. speed limit), notification & interaction (e.g. SMS), ambient (e.g. clock).

Task	Example
Primary	Only controlling the vehicle
Secondary	Driving-related tasks, e.g. signaling, navigation
Tertiary	Not driving-relevant tasks, e.g. radio, SMS

Table 2: Three levels of the driving tasks

Information Placement Strategy

Depth Zones: Proxemics & Information Context
Based on the theory of Proxemics but adapted to the vehicle, we propose four display zones: Private, Vehicular, Social and Public Display Zone (see figure 1). To each zone we assigned one of the previously described contexts. As

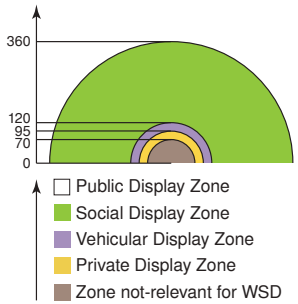

Figure 1: Proxemic zones applied to the context of driving

diverse functions can have more than one context (e.g. navigation: vehicle, environment, location), contexts may have to be prioritized to derive the most suitable zone.

Private Display Zone (70 - 95 cm): According to Hall's distances, there should be an Intimate and a Personal Display Zone. As the average distance between driver and windshield is higher than 45cm (approx. 70cm), these zones are merged to one zone called 'Private Display Zone'; starting at 70cm. This zone contains information about social interaction at a high level of detail; with driver and time context. *Examples:* SMS, Facebook Messages, photos, notes

Vehicular Display Zone (95 - 120 cm): Also the vehicle itself is categorized as an 'identity', but as vehicle-related information is not related to the driver as a person, separate zones will promote differentiation and understanding. We therefore propose to define a Vehicular Zone presenting vehicle-related information at a distance which approximately meets the dimensions of the vehicle. This zone contains information with vehicle and time context. *Examples:* gas tank, braking system, turn signal

Social Display Zone (120 - 360 cm): This zone is for interaction with other people on a lower level of detail or lower personal relevance. All information of the passenger is located here, as well. This zone contains information with driver, passenger, or time context.
Examples: Tweets

Public Display Zone (360 cm to infinity): Information related to the environment is displayed in a spatially registered manner within this zone. The zone displays information with environment, location, and time context. *Examples:* navigation hints, traffic lights, headway

Within each zone except Public Display Zone, one layer should be defined for all information. Further, we think the layer should be close to the outer border to decrease physical strain and reading times by a low distance between current and target focus point.

Display Areas: Three Zone Model & Information Priority
Previous studies showed that the WSD can be subdivided into different areas representing the human perceptional capabilities; e.g. [6]. Results suggest not to place information on the top part of the windshield; above the driver's focus point. In general, we further do not recommend to overlay display areas on different depth levels. Based on the three zone model, we propose four kinds of display areas:

Notification: For information which is due to high priority of particular interest and importance (e.g. crash warning, driver state warning), we think notification areas should be very salient and in the central FoV.

Interaction: As interaction often requires visual tracking of the system's responses, we propose interaction areas should be placed at locations where fast access and reading times and good road tracking are enabled. Interaction areas only include secondary and tertiary task-related information. As alerts should be placed superimposed to ensure visibility and to induce a direct reaction, it is not very useful to allow interaction with it (e.g. hiding).

Ambient: Ambient information is everything, that - at a given moment - is not of particular interest or of low priority. Fast reaction time on new information is not required but access time and glance duration should be low. To be perceived fast, ambient information should be of low level of detail, limited to simple graphics (symbols). Symbols can even be extracted by peripheral vision and recognized without the need of a direct visual focus on this stimulus [3].

Discussion Points

- Applicability of Proxemic distances to a closed vehicle
- Separation of Private and Social Display Zone
- Perception of peripheral information
- Perception and understanding of information on diverse depth levels and switching around of depth layers and areas
- Road situation, gaze direction, driver's state, experience and habits as further factors
- Other models or theories applicable to this approach

Reading: In addition to the areas based on the three zone model, we want to introduce a specific reading area. This area is particularly for tertiary tasks such as E-Mail or SMS reading. Reading is a complex and visually demanding task which requires a lot of glances towards it, when not performed as primary task. As finding the next line in a paragraph with long text layout, also high distances between road and text impede reading performance. Hence, we propose to place this area close to the focus point.

Discussion

In this paper we described a first approach to structured information placement on a spatially registered WSD. As a scientific basis, we considered the Proxemics theory, the three zone model as well as the information context and priority. At the workshop we would like to discuss the described approach with the community. The side column contains a few points to start the discussion.

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