Digital (De)signs for Real Cities – Examining Sign Usage in Real and Digital Spaces

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Abstract

Today's cities are full of signs: roadsigns, signposts, maps, graffitis, among many others. Future mobile digital information systems used in urban space will add another dense, digital layer of information on top of that, augmenting the user's view with additional visual signs. If we want these envisioned systems to enlighten instead of confuse the user and if we therefore want to understand how to design these systems to display information in a suitable way, we have to study how information is encoded into signs and how these signs structure the actions of people. In this paper, we analyze signs present in real urban spaces, and present a taxonomy of sign functions that we identified. We present our method of identifying "atomic functions" of signs, and give an outlook on how these functions can be realized adequately in digital media, avoiding "semantic pollution" and information overload.

1 Introduction

With recent developments in the areas of available infrastructure and device capabilities, we can envision reliable platforms for content-rich, ubiquitous and mobile applications that cover whole cities and provide their users with novel, previously unknown and untested kinds of services. These services and applications will add a digital layer of information to a space that is already densely populated with conventional signs and media.

If we want to take the opportunity and clarify rather than obscure by adding another layer of information, some questions concerning the *design* of these novel applications arise: Can we find ways to render the vast amounts of abstract data potentially available in an understandable, meaningful way, without the possibility of designing each possible response or state of such a system individually? Can we replace parts of the existing signs, already leading to "semiotic pollution" [10] in today's cities, with adaptive displays that deliver the information the user needs or might want to have? Can we create systems that will work across a broad range of users, diverse in age, gender, cultural and socio-economical background?

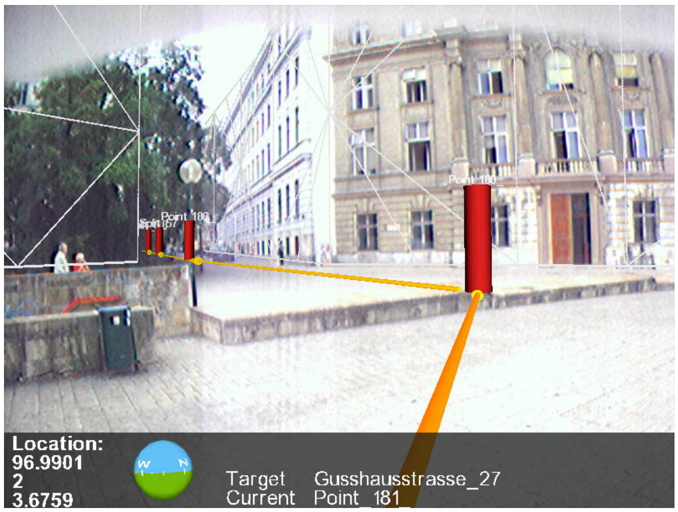

Figure 1: Our outdoor augmented reality wayfinding system. Directional arrows, landmarks, a compass and location information are superimposed on the view of the real world.

Our vision is to create rich information spaces, which can be browsed and roamed by different types of users carrying out different tasks, providing them with the required information. Some examples of the kinds of applications we are looking for are interactive tourist guides, navigation systems or systems supporting employees of the municipality with tasks requiring mobility and universal information access. To communicate relevant data to the user, determined by her profile, task and spatio-temporal context, we have to create legible representations of the abstract data retrieved from an underlying information space. A fundamental problem here is that little applicable systematic knowledge exists about the automatic generation of graphical representations of abstract information.

One of our research applications is concerned with outdoor wayfinding in a city [11]. As can be seen in Figure 1, the augmented reality display provides additional information like directional arrows, a compass and an indication of the desired target object. After experiments with early ad-hoc prototypes, it became clear that a structured approach to the design of the user interface would be necessary to make our system usable across a wide range of users and tasks. A kind of “toolbox” with different visualization styles is needed to visualize the information in the most suitable way. To design and implement such a toolbox, we need to have an overview of the information needs that might occur in our applications, and look for techniques that can successfully fulfill these needs in a flexible, context-dependent way.

In this paper, we are taking a first step towards answering these questions by analyzing how the actions of people moving in public space are structured by media artifacts (signs), and how we can transform the already well known functions and properties of physical media and signs to future digital information systems. Our hypothesis is that people use signs in their environment to satisfy their information needs for various tasks. Looking at real-world signs in urban environments, we extracted a set of *atomic functions* of signs – fundamental information needs fulfilled by the sign, that cannot be further decomposed. From that analysis, we are developing a taxonomy of such atomic functions of signs in various media, and investigate strategies to realize these functions in digital media to satisfy the information need of the user. This can form a starting point for developing a research programme that addresses the remaining questions in a structured way.

2 Background

Augmented reality [1] blends sensations of the real world with computer-generated output. Already in the early days of this research discipline, its potential to not only add to reality, but also subtract from (“diminished reality” [8]) or change it (“mediated reality”) has been recognized. Over the past years, we have created prototypes of mobile augmented reality systems that can be used to roam extensive indoor or outdoor environments. The form factor of these devices has evolved from early back-pack systems [11] to recent PDA-based solutions [15], providing us with a system that can be deployed on a larger scale to untrained and unsupervised users and carried around over an extended time span in an extended urban environment (see Figure 2).

While augmented reality (AR) is related to virtual reality (VR) concerning the technical foundations (e.g. realtime rendering, tracking, distributed multi-user applications), it can be argued that information design for AR has to follow different guidelines. In VR applications, all of the content has to be computer generated. VR content creation is therefore concerned with creating rich, realistic environments that provide sufficient cues for the user to feel immersed in the artificial world. Sparse or abstract virtual environments can lead to users feeling lost or disoriented [12]. In contrast, augmented reality uses the real world with its usually very high density of different sensations as starting point, adding information on

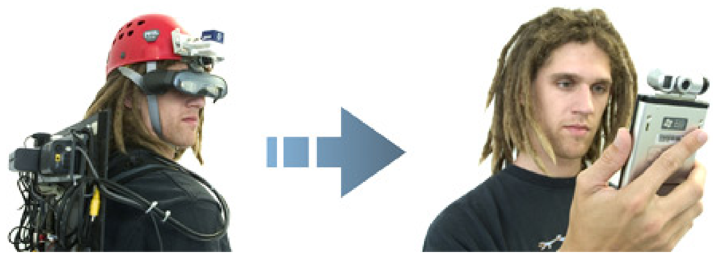

Figure 2: Evolution of mobile augmented reality systems. Early backpack-based systems (left) and our recent PDA-based handheld system (right).

top of that. In most cases, it is desirable that augmented reality displays provide clarification, overview or abstraction instead of adding more content of high sensory density to a given scene. We must therefore develop display techniques that are able to provide the clarity we are looking for.

2.1 From intention to action

The process that transforms the intention of some agent (software or human) into a legible sign that can be read and understood by users and possibly leads to some action on the user side involves a series of steps: creating a suitable graphical representation for the given intention, placing the created media artifact at a suitable location in the world, identification and perception of the sign by the user, interpreting the sign to extract some meaning and acting according to that meaning. Ideally, the original intention is preserved in this process, and the user acts exactly like the creator intended. However, in the real world these processes are complex, and understanding them is the subject of various scientific disciplines (Figure 3):

- Design theory [9] can teach us how to create aesthetically pleasing and legible signs.
- Cognitive psychology [6] deals with the perceptual issues involved in sensing and reading signs.
- Semiotics [4] is concerned with the transformation of observed facts into meaning.

The research areas mentioned above are usually concerned with far less dynamic information than present in the ubiquitous digital applications we are looking for. It is therefore not possible to directly implement the information systems

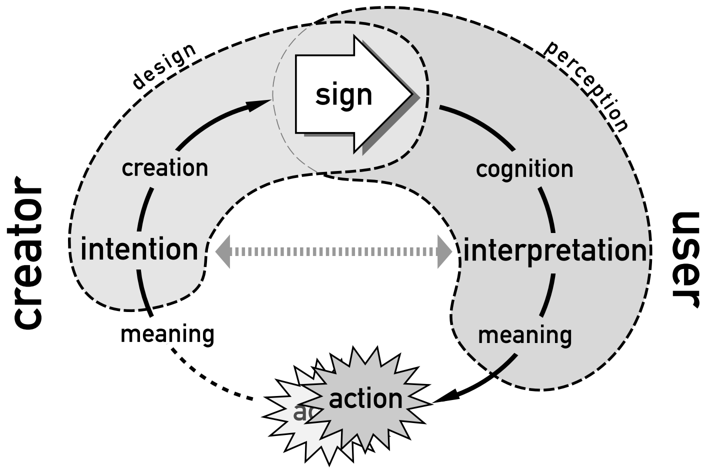

Figure 3: Sign creation and interpretation.

we are envisioning based only on existing knowledge – we first have to examine how these aspects could play together in the context-sensitive applications we want to create. As a first step, we need an overview of what kinds of information can possibly be communicated through signs – an attempt presented in this paper.

3 Signs in today's cities

Urban environments are full of signs – either explicitly and consciously created or left behind without intention. Examples for the first category would be roadsigns, signposts, labels, doorsigns, but also stickers and graffitis, which use public surfaces as ground for articulation and discourse. The signs that are unconsciously created include traces of all kinds, like a path through the grass in a park or the garbage left behind after a barbecue, picnic or rock concert. Also the design of an object or building can indicate some meaning or suggest some usage that is not explicitly encoded there, but presented as an affordance [9], a feature that is suggesting some way of usage in a more implicit way.

The starting point for our research are signs present in public space. We take existing signs and significant visual features of the environment as indicators for a demand for the information encoded in the sign and/or the individual or political will to create the sign. Therefore the sign becomes the documentation of the action of its creation, and an indicator of possible actions that can be carried out by using the encoded information.

By collecting a large number of examples, we obtained an overview of sign usage in public space and were able to structure intentions and actions into categories, which we could analyze further and relate to each other. In the envisioned ubiquitous augmented reality applications, space and time will be fundamental aspects for structuring the presented information. We therefore focused on signs that are related to spatial or temporal aspects of the world – media created purely for information or the attraction of attention, without any reference to their location or temporal context (like, for example, advertisements) do not fall in this category.

The collection of examples has been gathered in the city of Vienna, Austria, in public space, public transport facilities and some public buildings. The research was constrained to include only visual information, and most of the examples were originally photographed with a built-in mobile phone camera. This allowed the spontaneous gathering of new example images in everyday situations, and avoided the necessity to embark for specific "signspotting" trips, which would probably have biased the collection in some direction. An unstructured collection of example images is shown in Figure 4.

Figure 4: Some examples of images taken in our study. a) Annotated safety button b) Number plate c) Signposts d) Roadsign e) Graffiti f) Map

Obviously, the collection of examples is heavily biased by the photographers view of the city, his routes, tasks and knowledge. An improved approach would include several persons with different demographical backgrounds, especially age, cultural and professional background and of various familiarity with the city. However, our study covers a good part of the explicit signs present in urban space, and allows us to draw conclusions that will be valuable for future research by us and others.

3.1 Analyzing signs and their functions

It becomes clear very quickly that most signs in public space cannot be assigned to a single category of function. A lot of signs fulfill multiple purposes, be it for the same user or for members of different user groups. As an example, we present a detailed analysis of the possible functions present in a car license plate (Figure 5).

The primary function of a car license plate is identification of the car, which can be used by a restricted user group (the police) to gain access to additional information like the name of the license holder or the location where the license was issued through a database. Besides this primary function (which is present in all license plates throughout the world), one can identify several secondary functions of austrian license plates[1]. The first one or two letters are a code for the municipality where the license was issued. The information necessary to decode this information is publicly available, and easy to remember as the first letters of the name of the municipality are often used. This code is followed by the emblem of the county of origin. This is redundant information, since the county can always be deduced from the municipality information, but it adds some regional context besides the mere technical municipality code. The emblem is also not part of the license number, and can therefore be seen as purely decorative regarding the primary function of a license plate. Similarly, thin red-white-red stripes (the colors of the austrian national flag) are printed at the top and bottom edges of all austrian license plates – adding some national identity to the standardized european license plate. Finally, the number on the plate can be either assigned randomly or, for a small fee, the license holder can choose the text of the plate freely (according to some syntactical and semantical rules). This can add the function of individual expression to the plate artifact. Finally, the physical properties of its surfaces make the license plate an additional reflector and increase traffic safety.

This analysis makes clear that any approach to replace an artefact such as the discussed number plate by other, maybe more advanced, technical means has to take care not only of the primary function, which may be obvious, but also take into account the other functions that are covered by the respective sign. Failing to do so may result in irritation, misunderstandings and/or decreased social acceptance of the proposed new technology.

[1] Note that the design of car license plates is unified to some extent in the EU (for example to have black letters on a white background), but some room is left for national differences – for a different country, this analysis may yield different results.

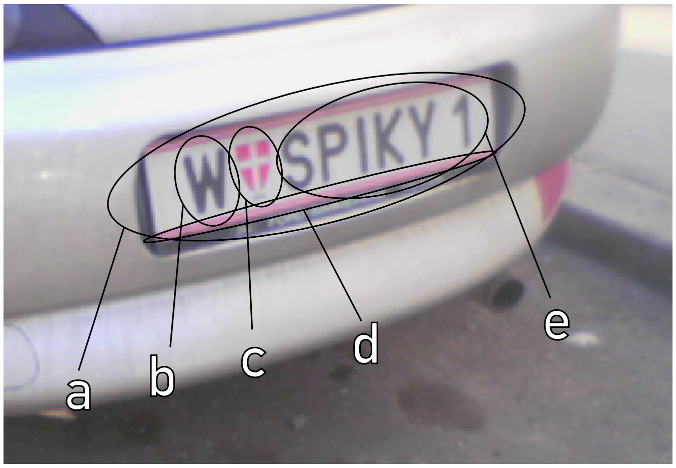

Figure 5: Different functional parts of an austrian license plate: a) identification b) municipality code c) regional identity d) national identity e) articulation (by optional possibility to choose text on plate)

As in the licenseplate example, we analyzed all identified instances of signs and sign systems with regard to their “core” or “atomic” functionalities. The following section gives an overview of the found categories.

4 A taxonomy of sign functions

In this section we give an overview of all atomic functions identified in our study. While it is impossible to prove that a given set of categories covers all possible examples without examining every single instance, these categories could already be successfully applied to a number of newly found examples. Therefore, there is some indication that the proposed set of functions covers at least a good part of the use cases that can be found in an urban, public space scenario.

We choose to arrange the functions in 5 fields, resembling what in our opinion are fundamental aspects of future context sensitive ubiquitous applications: Object metainformation, object relationships, temporal information, spatial information and communication. Inside the respective sections, the identified concepts are set in *italics* to make them stand out.

4.1 Object Metainformation

Adding metainformation to existing objects in the real world is a fundamental function of both real and digital information systems. *Naming* establishes a linguistic reference for an object in a specific context. This means that it is highly user dependent if a name can be understood. *Identification* is a more technical concept, that allows to identify a specific entity, usually in a global context. *Explanation* is important if it is not clear from an object's design how to use it, or if the user just wants it for informational purposes. Sometimes it is sufficient to name the object, if the name already implies the mode of operation. A special class of explanation that we identified is *type information*.

As these kinds of object-related information are mostly textual, the primary problem for displaying it in a digital system is that of automatic layout. The placement and size of labels has to be calculated to be legible, unobtrusive and not conflicting with other elements of the display. Lok and Feiner [7] examine different strategies of automatically generating appropriate layouts, knowledge which was used by Bell et al. in [2] to automatically place labels for objects in an augmented reality application.

Accentuation means to emphasize a specific object by increasing its visibility. In the real world, accentuation is mostly performed to permanently improve the visibility of objects or regions for safety reasons by using bright, high contrast colors. In digital systems, image-based methods like partially increasing the contrast or saturation could be used, as well as two- or three-dimensional rendering of overlay graphics. An approach found in some systems [5], however never formally evaluated against other techniques, is to superimpose a wireframe model of the object to be highlighted on the object – if the object in question is occluded by other things, dashed lines are used to indicate this. This approach is inspired by technical drawings, where dashed lines are often used to indicate invisible features.

Display of an object's *status* is the most dynamic metainformation found in conventional signs – the current state of an object or a subsystem is displayed to the user by using LEDs or alphanumeric displays. In today's cities, this is used for example in public transport systems to display the time until arrival of the next bus.

4.2 Object-relationship Information

Linking an object in the real world with another entity is another often-found purpose of signs. In augmented reality applications, one of the two objects (or both) might be virtual objects placed at real world locations.

Rendering a link to the user depends on how the user is supposed to use that information. If the user should be guided from the one object to the other one,

Figure 6: Examples for accentuated objects. a) fire extinguisher b) first step of descending stairs c) important announcement in public transport system

arrows can be used to give directional information (see section 4.3 below). If the objects are related in some other way, it might be sensible to display the name, an image or a symbolic representation of the second object, if available, and denote the type of relationship as suitable. If the two objects are close together and both are visible from the users point of view, a straight line can be rendered to connect the objects directly – an approach also used by Bell et al. in [2] to connect labels with the objects they are related to.

Browsing means to give the user an overview of all entities that are available for a specific interaction. Real-world examples for browsing opportunities would be signs in the entrance areas of buildings that list all available rooms or persons.

4.3 Spatial Information

The term "navigation" is often used casually for some of the concepts in this section. In our research we found out, however, that we have to break this term down into subconcepts to get an insight into the motivations and demands of users.

Wayfinding is what is most often referred to as navigation – finding the way from the current location to a specific target object. Note that for wayfinding only, other aspects of the user's spatial context like overview or orientation can be ignored – the user could be guided by arrows, without having any mental representation of the space she is moving through. In real spaces, wayfinding is supported by arrows and signposts, labelled with the destination object or area. In digital applications, a single arrow can be used that changes direction as needed.

Overview supports the ability to build a mental model of the area and is useful for generic wayfinding – finding targets for which no explicit wayfinding information is available, or finding fuzzy targets like areas in a city or district. Traditionally, overview has been supported by maps. In digital maps, several new possibilities emerge, one of them being the possibility to mark areas that have been visited by the user before. To be useful for wayfinding, overview has to be complemented by *orientation*, the ability of the user to locate herself on a map or in her mental model of the environment. Maps installed at fixed locations in the world can be augmented with static “You are here” markers, a feature that can be implemented in a dynamic way on a digital map [14].

Marking of districts or territories is another example for spatially related information. Real-world examples include roadsigns or marks on the ground marking the beginning and ending of certain zones (see Figure 7 for example images). One of the problems that conventional signs have here is that a human needs to keep track of the current state of the zones she is in as she moves through the city. Ideally, the beginning and ending markings are accompanied by *spatial awareness* information that provides continuous, ambient feedback of which zone the user is in. This can be found in some buildings, where different areas are marked by using differently colored marks on the walls. Obviously, in digital information systems, there are more advanced ways to keep track of and visualize the zones a user is currently in.

Figure 7: Marking of zones. a) Beginning of a speed-limit zone b) Dashed border surrounding a bus stop c) Location awareness by colored marking on the wall

Traces are often created by crowd behavior and are indicators for usage or demands. A classical example are paths through the grass in a park, indicating that the provided paths are not sufficient to fulfill the needs of the visitors. In the digital domain, traces can be much more dynamic, collected at each use of the system and annotated with metainformation like date or current task. Some research exists on how traces can be used to aid wayfinding and overview in large virtual environments [13].

4.4 Temporal Information

An area where the limitations of conventional signs become clearly visible is information that changes over time. Temporal change has to be marked in advance if the validity of a sign changes over time (for example, parking limitations constrained only to specific times). This additional information can lead to cluttered and overloaded signs (see Figure 4d).

Temporal marking can be accomplished much easier in digital systems – if the sign is not valid, it can simply be hidden from the users view. Care has to be taken, however, that information that might be relevant for the user in the future (for example, the beginning of a parking limitation) is communicated in advance to allow the user to plan her actions. Which information is relevant to the user in these cases depends highly on the task and activity. Similarly, *temporal change* means the temporary change of a situation (for example, due to construction work) with an undefined ending.

A good example for *synchronization* of different parties are traffic lights. This is also related to *sequencing*, where the user is guided through a series of steps to fulfill a task.

4.5 Communication

The surfaces of a city enable *articulation* in the form of graffiti and posters. While mostly illegal, it is an important property of physical surfaces that they can be altered, extended or even destroyed. Digital environments are usually much more constrained in what their users are able to do – the rules of the system are often directly mapped to the interaction possibilities that are offered to the user (not taking into account the possibility of hacking the system and bypassing the provided interaction mechanisms). If we replace physical signs by digital content, we should keep in mind that users may want to interact with the information provided, leaving marks and comments for other users.

Discourse through signs and writings involving two or more parties is much rarer observed in public space. The capabilities of networked information systems could improve the ability to support processes of negotiation and communication between multiple parties in public space.

4.6 Mapping the taxonomy

As mentioned above, a linear representation of a taxonomy cannot reproduce a multi-dimensional arrangement of concepts and the relationships between them. To create a more intuitive overview, we have created a 2-dimensional map of the concepts of the taxonomy (Figure 8). Four of the main fields identified above are

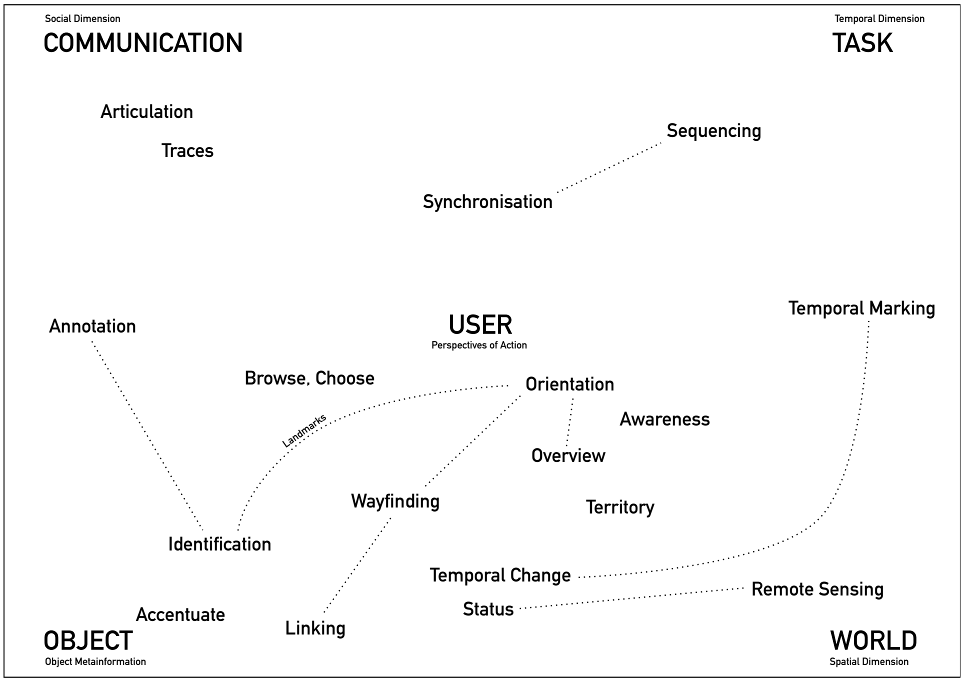

Figure 8: An arrangement of the identified concepts on a conceptual map.

represented in the corners of the map, and the individual concepts are arranged to represent their relation to these fields. In addition, related concepts are linked in the diagram.

5 Conclusions and future work

We believe that the presented overview will be useful for researchers and practitioners that are concerned with the implementation of next-generation digital information systems for digital cities. Our taxonomy allows to structure existing and future research and create representative use-cases for upcoming systems that put it to practice.

Obviously, this is only a starting point. The overview made clear that many aspects of the implementation of such a proposed toolbox of display techniques remain unclear as of today, and will be the subject of future research that evaluates some of the proposed display techniques in greater detail. Also, our research focused only on visual techniques, leaving the evaluation of auditory feedback to future studies.

We hope that this work will also influence the ongoing work of creating formal ontologies for ubiquitous computing [3]. After all, these formal ontologies have to be rooted in real-world practices, and this is what we tried to provide an overview of.

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