

User Interface Architecture of a Mobile Guide for exploring the Wild

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ABSTRACT

Mobile guides can assist us on tours through cities, museums and universities but besides their application in urban centers they also have the potential to serve us as an instrument of environmental communication while exploring the wild. This paper proposes an extended context model for such a mobile guide system. As a mobile guide for exploring the wild needs to be highly context-aware, the adaptability of the user interface based on the available context is a key aspect of the development. User interface design issues, as well as results gained while testing a specific design approach in the field, will be discussed. Finally a user interface architecture suitable for such a system will be presented.

Keywords

Mobile Nature Guide, baby interfaces, paper prototyping, designing for the wild, SVG, templates, XML user interface languages

1. INTRODUCTION

Throughout the last years a variety of mobile guide systems has been developed for a spectrum of application areas [2]. The Cyberguide System, as one of the initial prototype mobile guides, was designed as an indoor and outdoor guide to a university campus [1]. The GUIDE system [6] should be mentioned as an early representative of a large group of research and commercial systems, which serve tourists as a city tour guide. There are also numerous systems, such as Hippie [13] that can be used as an exhibition guide in museums. However, few mobile guide systems have been developed to assist the user while wandering off the busy roads and hallways of cities and museums, seeking to learn more about their natural environment. Those systems which guide the user through natural areas focus mainly on providing tourism services, offering navigation assistance, basic information as well as personal safety warnings [4]. Beyond location-based services for environmental-tourism, context dependent systems like mobile guides offer many opportunities for environmental communication. Defined as the interchange of environmental data and information between various audiences, Environmental Communication does not only imply the presentation of plain facts. Such communication should be the foundation for establishing relationships between people and the environment and a means for enhancing environmental awareness [14]. In order to put mobile guides to an effective use in the field of environmental communication an extension of existing context models as well as a set of nature guide specific services is

required. Furthermore, such mobile guides need highly adaptable user interfaces in order to fulfill the promises of context-aware systems.

This paper discusses research issues related to the design of the Mobile Nature Guide (MobiNaG), a mobile guide system specifically designed as an instrument for environmental communication in natural areas. The paper will present an extended context model for the Mobile Nature Guide currently being developed. Further a set of Nature Guide Services that will be part of the system will be introduced and interface design issues will be discussed. At the end, the technical architecture of the system, meeting the defined requirements, will be presented.

2. CONTEXT MODEL FOR A MOBILE NATURE GUIDE

The MobiNaG project is carried out as a joint project with the Naturschutzzentrum Rappenhörs, an environmental education institution in Karlsruhe, Germany. As a visitor center to a floodplain conservation area along the Rhine River, it is an ideal testbed for the prototyping and evaluation of MobiNaG. As one of the initial steps of the project it was essential to become familiar with environmental communication procedures and the visitor. Thus a Front-End-Evaluation, was conducted with representatives of the target groups. In addition environmental interpreters and visitors were shadowed during guided tours. The analysis resulted in default user profiles for each target group (highschool students, adults interested in nature, families).

Prior to the actual development of a context-aware application it is necessary to consider the types of context that are required and represent these in a context model [5]. Following the analysis of scenarios, this step was also performed for the MobiNaG system. Furthermore a variety of context models from the literature [17], [12] was taken into account while building the model. Based on the definition of context by Dey and Abowd [7] the context model for the Mobile Nature Guide, as shown in Figure 1, characterizes the situation and environment that the system and its user are in. Dey and Abowd [7] suggest location, identity, activity and time as the primary context types, which answer the “who, what, when, where” and act as indices to other sources of contextual information. The Context Model presented here proposes more general primary context types fulfilling a similar function. The Geographical context answers the “where” question, subsuming all features related to location, but also accounting for the entire Navigational History of the user. The User context answers the

“who” and to some extent also the “what” question, similar to the identity type of Dey and Abowd [7]. The “what” and “when” questions should be answered by the Environmental context. The model further shows that the three primary context domains are not independent. Features, like User Location, may belong to two domains and contextual information of features, such as Environmental Resources may be linked to the location of Points of Interest (POI).

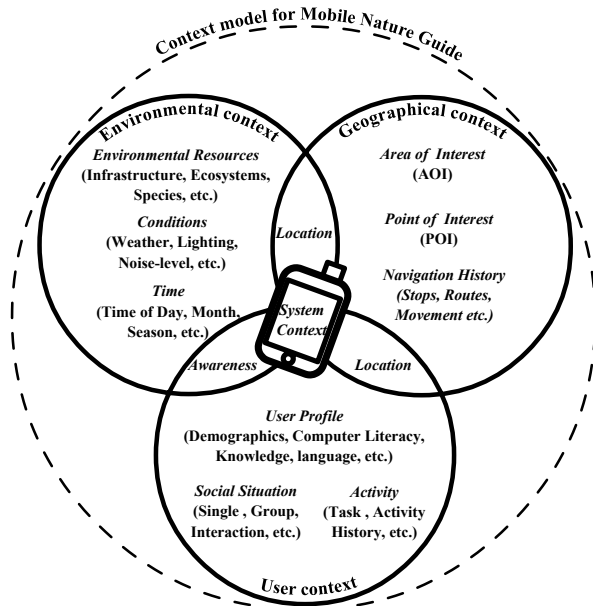


Figure 1 Context Model for Mobile Nature Guide

Location is frequently referred to as the most important aspect of context [2], [12]. The Geographical context subsumes all features related to Location including the Area of Interest (AOI) and POIs. The Navigation History can give an account of the user’s spatial pattern. Thus Navigation History is the foundation for a variety of services related to orientation, adaptation to spatial behavior and post-visit interpretation of routes taken.

The features of the User context including the User Profile, Social Situation and Activity, largely corresponding to that of other models proposed by [17], [12]. But one special feature of the Mobile Nature Guide Context Model with regard to the User context is the Environmental Awareness of the user. The Environmental Awareness connects User context and the Environmental context. Environmental Awareness is used as a representation of Environmental Knowledge, Environmental Attitude and Environmental Behavior. This is a very crucial contextual information for the MobiNaG, which aims at furthering this Awareness by means of informing the user about his natural environment and guiding him to a direct and positive experience with his natural environment.

The Environmental context comprises a Conditions feature, which is also common in other context models and is important to all systems designed for outdoor use. While in other systems Infrastructure and Resources are mainly taken into consideration for the Environmental context, the model proposed here, specifically includes natural Environmental Resources, which are crucial to “exploring the wild” like Ecosystems and Species or even Soils and Geology. This should also imply that sensitive

areas are avoided. POIs in natural areas may be difficult to recognize. Unlike streets and buildings they usually lack additional labels or signs and thus require a precise description. Time is also an important feature for the Mobile Nature Guide context model, as the natural environment tends to be highly dynamic. Other than cities or exhibitions the conditions can change dramatically with the time of day and especially with the season of the year.

In addition to the primary types of context addressed above, Nivala and Sarjakoski [12] also attribute contextual information to the system itself. Mobile devices still have several limitations [2]. Limitations, which are of particular significance for mobile guides to natural areas encompass issues related to network connectivity and operating time. With a growing diversity of mobile devices the System context needs to be taken into account in order to provide device independent services to the user [12].

3. NATURE GUIDE SERVICES

A context aware system, as defined by Dey and Abowd [7], uses context to provide relevant information and /or services to the user, where relevancy depends on the user’s task. Consequently the MobiNaG should provide its users with services that support him in exploring and learning more about his natural environment (see Figure 2).

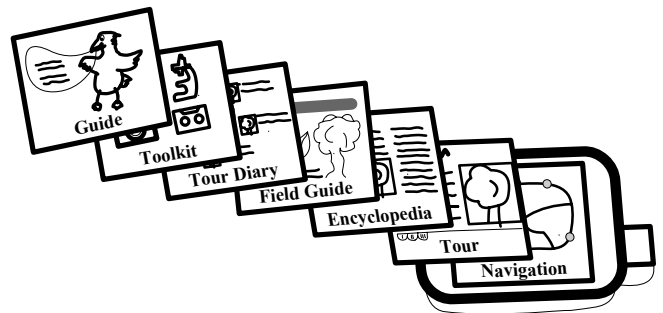


Figure 2 Nature Guide Services

The Mobile Nature Guide will offer a set of basic services that can be found in most mobile guide systems. These include a Navigation Service and a form of location-based information service. The MobiNaG Navigation Service incorporates the display of maps, routing and location tracking. The Tour Service is another basic service of the system, but its abilities exceed the plain display of information and contains guided tours as one central component. In cooperation with the Navigation Service it enables the user to take predefined guided tours through a natural area, where background and context information are embedded into a thematic tour context. The Tour Service uses features from all primary types of context to adapt the presentation of tour information to the user’s needs. This includes a user profile, which the visitor should select from a default list at the beginning of the tour. Eventually the system is to refine the user’s profile throughout the tour, based on the Navigation History and the interaction of the user with the system. In case the user is not satisfied with the presented information and would like more details on the topic he can make use of the Encyclopedia Service. Via a wireless internet connection this pull service can potentially access the extensive information resources of Web-based Environmental Information Systems (EIS), such as the EIS of the

State of Baden-Wuerttemberg (<http://www.lfu.baden-wuerttemberg.de/lfu/uis/info/>).

On top of these basic services the Mobile Nature Guide equips the user with additional “field gear” helping further to enrich his experience beyond that of a paper-based guidebook. A field guide on the wildlife of the area is a good example of how a context-aware application can facilitate the exploration of natural areas. By taking advantage of the Geographical context as well as the Environmental context, the number of species, that match the specimen, may be significantly reduced. Making use of the Navigation History and the Activity History the Mobile Nature Guide can provide a Tour Diary service. Along the way, the user can annotate the “history log” with personal comments and impressions utilizing components of a toolkit service like the digital camera or audio recorder. Eventually the user of the Mobile Nature Guide should be able to use an optional virtual Guide. An emotional pedagogical agent can be employed as virtual Guide to assist the user in interacting with the system. Furthermore such a guide agent can fulfill an important function with regard to an effective environmental communication. Based on the User context the Guide agent should be able to provide a specific mode of interaction to facilitate the emotional binding of the user with his natural environment and thus promote responsible environmental behavior.

4. USER INTERFACE DESIGN ISSUES

The selection of an appropriate interface metaphor should grant the users an intuitive interaction with the system. It needs to combine familiar knowledge with new knowledge in a way that will help the user understand the system [15]. Usually visitors to natural areas make use of paper-based guidebooks to learn more about a given area. As a more interactive alternative they frequently seek the assistance of a human guide. Since the guidebook and the human guide are concepts familiar to most users, they lend themselves very well as an interface metaphor for the MobiNaG. The possibility of combining the characteristics of both metaphors can be considered a key advantage of the MobiNaG over traditional means of environmental communication. The user should be able to apply the system mostly self-determined similar to a guidebook but at the same time he should also be able to rely on the system as a guide who adapts the presentation to his needs and leads and advises him.

The designer of interfaces for handheld devices face a number of challenges [18]; [9]. The small size of the display is considered as one of the most prominent issue, which has led to the term babyfaces for these devices [9]. Important for the user interface design for the Mobile Nature Guide is that the system should support the different target groups, mentioned above. Members of these target groups show different levels of computer expertise as well as differences in the familiarity with mobile devices. Further it can be assumed, that the system will frequently be employed by first time users. As a consequence the user interface of the system should be dynamically adaptable to different target groups. Based on a user profile or preferences the system should be able to change both the overall layout of the user interface as well as parts of the presented information elements, like for example exchange a text suitable for adults with one easily understandable by children.

Furthermore, the information presented as part of the Nature Guide Services, such as information from an Encyclopedia, Field guide or Tour Service, will be highly multimedia based. This also entails the use of audio information such as audio navigation instructions. As people trek along a path, intending to explore their natural environment, they may not want to constantly keep an eye on the display. Hence this suggests a user interface design more geared towards that of a web-based information system.

4.1 Iconic communication

With regard to the interaction means of the system, a direct manipulation interface based mainly on icons integrated into SVG presentation screens will be used. Icons have been suggested as one possible solution to address some of the challenges of baby interfaces [18]. A key advantage of icons in the context of limited screen real estate is, that they take up less space than the equivalent text would. Further they are intuitively recognizable and they are a language independent mean of communication [10].

For the MobiNaG interface icons should be used as the main interface controls, including menus items, control elements, status indicator and dialog identifier. In order to compensate for the limited input modalities of the handheld device, Pop-up menus or lists as well as check boxes and radio buttons should be used for user input.

For the development of the Mobile Nature Guide system a user-centered design approach is taken. This implies involving the user in an iterative design process. Mobile guide system like MobiNaG, which are being designed for the use in the wild should also be tested under realistic conditions in the field. During the early phase of the interface design process an evaluation was carried out to verify the proposed concepts.

5. MOCKUP EVALUATION IN THE WILD

As a proof of concept for the proposed iconic interface for Mobile Nature Guides, an evaluation of a low-fidelity prototype was carried out in the field. The study was conducted based on the paper prototyping procedure as it has been proposed by Weiss [18] for applications on handheld devices. Prior to the actual testing, this involved generating a test scenario based on the task “taking an exploration tour through the natural reserve”. The Mobile Nature Guide screens, required for the completion of the task where sketched out on paper (see Figure 5), including alternative designs for certain screens, as well as a set of control elements like lists on post-its and transparent interface elements on transparencies.

The study itself was performed at the Naturschutzzentrum Rappenwört during an open house event. The tests were carried out at a “Mobile Nature Guide booth” located in the vicinity of the visitor center (see Figure 3). Test users were recruited from among the people, participating in the open house event, who would pass the booth on their way through the surroundings of the facility. As visitors to this institution they automatically pertained to the target groups defined throughout the requirement analysis process. A total number of 10 users (8 male and 2 female) participated in the evaluation of the paper prototype. This included three students below the age of 15 and five adults between the age of 20 and 49 as well as two adults above the age

of 50. All of the participants had some prior experience using computers and all of the adults were accustomed to using a mobile device (at least a mobile phone). The study included a test of the iconic interface elements, as well as a comparison between different variations of the MobiNaG interface and an evaluation of the proposed guidebook/guide user interface metaphor.



Figure 3 Visitors interacting with the paper prototype

To determine, if users prefer text-only or iconic buttons, three alternative variants of the same interface screen were presented to the test subjects (see Figure 4). Alternative A was based on “text only” buttons, while Alternative B was solely based on icons and Alternative C presented the user with the same icons supported by static text. The results of the test were unambiguous. The majority of test users decided for the iconic interface supported by text (Alternative C), whereas only one out of 10 test candidates preferred the “text only” alternative (Alternative A) and none of the participants voted for the purely icon-based design (Alternative B).

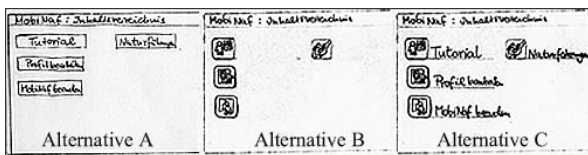


Figure 4 Alternatives for testing iconic interface approach

Concerning the iconic interface approach, the results of the field study confirmed the findings of Hirst [8] pointing out, that despite of some difficulties that occur with individual icons, the majority of users see iconic interfaces as an attractive way to interact with the computer. The evaluation showed that this also applies to mobile guides on small display devices. However the results have also made it clear that users do not feel comfortable interacting with an interface based solely on icons. Especially icons which the user encounters for the first time have to be supported by text. But having to use text support could imply the sacrifice of the key advantages of icons, their compactness as well as language independence, making them valuable control elements for mobile guide interfaces. Thus support in the form of static text, permanently placed with the icon, is not an adequate solution. An alternative can be found in dynamic text which usually appears in form of a tooltip when the user moves the pointer over the icon [16]. On the PocktPC platform the tooltip can be accessed via a “tab and hold” interaction with the stylus.

The icon test performed as part of the study yielded important results with regard to the selection and design of icons for a Mobile Nature Guide. A total number of 26 icons was used in the mockups of which 18 icons were successful as defined by Beardon [3]. For most of the successful icons the test subjects could not only recognize the associated function but also correctly identified the icon image sketched by the designer. Where possible standard icons, that the user is already familiar with, should be used. This has also been suggested in guidelines for the design of icons by Richards et al. [16] and Preece [15]. Still Beardon [3] argues that it is more important that the meaning of an icon can be remembered than its intuitive recognition and Richards et al. [16] point out that icons should relate to the particular interface metaphor. Thus because a new interface metaphor has been suggested for Mobile Nature Guide systems it is also necessary to design new icons for certain functions of the system. These should use metaphors closely related to the context of use and should at the same time be easily memorable. In general, when designing iconic interfaces, there is a need for “off the shelf”, tried and tested icons relating to a particular interface metaphor [16]. Based on the experiences from the evaluation of the iconic MobiNaG interface it appears reasonable to propose the development of a standard set of icons for mobile guide applications as well as for specific interface metaphors like the guidebook/guide metaphor.

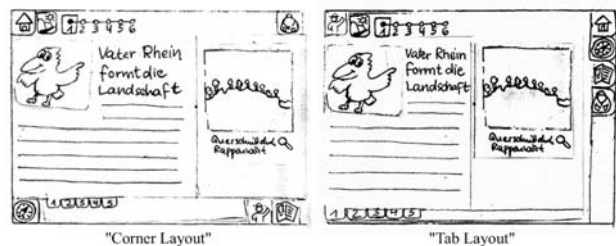


Figure 5 Paper mockups of the alternative designs

The field study was also used to involve users in a crucial design decision. The participants were asked to vote on alternative designs (see Figure 5). Due to limited time resources only two alternatives could be prepared for the evaluation. The designs had to adequately represent the guidebook/guide interface metaphor and make effective use of the limited screen real estate, while keeping the main services accessible at all times. The “Corner Layout” (left) was designed as an approach, reserving as much of the central screen area as possible for content display, while each corner is devoted to one of the main services. In the “Tab Layout” (right) on the other side the central services are placed on individual tabs. This way slightly less space is available for content display but the design resembles a classic book or brochure metaphor more closely. As it turned out, the majority of users voted for the “Tab Layout”, experiencing it as more concise and intuitive.

In general the mockup evaluation worked better than anticipated and the results as well as the experiences, the test team collected during the evaluation support, the findings of Nielsen [11], that much can be learned from bringing the lab into the field. Participants were highly motivated and even though the tests took up 20-45 minutes of their spare time, they still seemed to enjoy the exercise. On top of the input from the test subjects additional comments could be gathered from other visitors indirectly

attending the evaluation as bystanders. It is generally acknowledged that paper prototyping is a quick and cheap way to gather user feedback throughout the interface design process [15], [18]. Beyond that this study has shown that paper prototyping methods can also be successfully applied in the field. This is of particular importance for guide systems like the MobiNaG, which are specifically designed to be used in “the wild”, meaning natural areas, which are difficult to recreate in the lab. As it turned out throughout the evaluation another bonus of conducting an evaluation of mobile guides in the field, is the publicity factor, as interest for the project can be spurred among a broad audience of potential users. Furthermore the evaluation indicated that the proposed interface metaphor based on a combination of guidebook and virtual guide character was principally accepted by representative users. By involving the users in the design decision, letting them choose between alternative layouts, it was also possible to find a suitable representation of the interface metaphor.

The results of the paper prototyping test further illustrate a clear difference in the usability of iconic baby interfaces depending on the age group that the user belongs to. Thus the interface should also be adaptable to the needs of different target groups, which should among other things include the use of different metaphors for the control elements. This requirement further stresses the need for an implementation technology of the user interface which allows a high degree of adaptability of the presented screens including the interactive (iconic) user interface elements.

6. USER INTERFACE ARCHITECTURE

The limitations of small displays, which have been discussed above, call for technology to present information in a flexible and compact fashion. As has been shown by the presented mockups and requirements, interaction styles and models based on the desktop paradigm are not suitable for the design of the Mobile Nature Guide user interface. The application context requires a tight integration between control icons and information elements. This results in an interface more similar to a web-based application interface, containing interface elements and content in one screen area which resembles a web page. But the design of the mobile guide user interface in HTML is not a good solution either. HTML lacks essential features to build real interactive, animated and iconic user interface elements which work well on small devices. This calls for the use of vector graphic based technologies such as Macromedia Flash or SVG (Scalable Vector Graphics). Both technologies support the creation of presentation screens in which interaction and content elements are tightly integrated. Furthermore, both technologies grant the dynamic animation of interface elements as well as a rich interface to display and interact with different multimedia contents.

For the MobiNaG project it was decided to use SVG for the user interface because SVG makes use of XML technology, which allows the different software components (Nature Guide Services) to exchange data with the rest of the application based on one central technology.

6.1 Using SVG templates in the mobile guide

While the mobile guide application uses a native C++ based application as the primary interface between the PocketPC operating system and the user, many of the GUI components are actually implemented as SVG elements. These elements are

embedded into the SVG data presentation screens displaying the content information for the user. SVG presentation screens are represented by SVG documents, which are transformed into a DOM (Document Object Tree) while parsing. The resulting DOM tree is then dynamically modified to fill data into empty content areas of the SVG document before the document gets displayed.

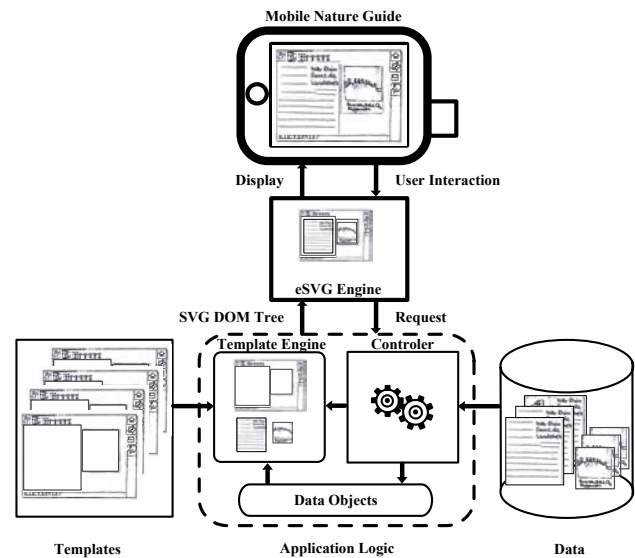


Figure 6 MobiNaG SVG Template Engine

Figure 6 shows the basic architecture of the Mobile Nature Guide application. If the user has chosen a given tour from the menu of available tours, the mobile guide application interacts with the user through a series of SVG based screens (a navigation screen with a map and GPS navigation, several content display screens for POI data and information about a tour and its stops). These are displayed in a horizontal layout in fullscreen mode on the PocketPC display. These screens are drawn by the eSVG engine, a commercial SVG rendering engine, which can be embedded into one's own application. If the user interacts with one of the user interface elements embedded into such a SVG screen the eSVG engine forwards the interaction to a central controller component in the main application logic of the mobile guide application. The controller decides, which data objects are needed to fulfill the user request, and initiates the creation of these objects by a dedicated application logic module related to the user request type (for example the navigation module). It then decides, which SVG based screen should be used to present the results of the user's request. After that it calls a template engine component, which will eventually load a new SVG based user interface screen from a corresponding SVG file (a so called SVG template) and/or merge the data objects into an already loaded DOM (document object model) tree representing a SVG template in memory. The template engine then calls the eSVG engine to display the new or modified SVG DOM tree to the user.

This kind of model-view controller logic in the mobile guide application is analogous to the usage of this user interface pattern in web based application, called model-2 architecture of a web-application. But SVG templates substitute here for HTML templates and the mobile guide is not a web application but a native C++ application. The usage of this architecture in the mobile application has several advantages beside the SVG based

user interface. First, the use of the model-2 architecture allows for a clean separation between user interface code (situated in the SVG template) and application logic contained in application logic components of the C++ application. But more importantly, it is now easy for the mobile guide application to supply several SVG template sets, such as visual interfaces for different user groups. For instance, one template set can be developed especially for children with a colorful, game-oriented interface while another template set may be more unobtrusive and as such better suited for older people. The mobile guide could decide which template set to use based on a user profile which the user creates when starting the application. Because the SVG standard supports the creation of reusable components, which can have behavior and can also be animated, it is easy to create a library of reusable user interface elements with a consistent look and feel. Such libraries could be used in different templates thus reducing the development time of templates and providing a consistent user interface experience across different templates.

In current user interface design research SVG based user interfaces play an important role. With such projects as the Mozilla XUL user interface language and the Microsoft XAML technology, which will come with the next generation of Microsoft operating systems, the creation of user interfaces with the use of highly adaptable XML based user interface specifications will become a widely used technology. But the rendering of such user interfaces with HTML technology does not lead to an adequate visual design of such user interfaces. Therefore, current research efforts in this field elaborate on how the use of vector graphics technology, like SVG could, lead to better rendered user interfaces based on XML defined user interface specifications. It can be assumed, that especially for mobile application, such user interface will be a great success.

7. CONCLUSIONS

Mobile guides as tool for environmental communication should be based on a specific context model for this domain and need to offer particular set of services for exploring the wild. Developing such applications requires the design of highly context-aware and adaptable user interfaces. A template technology based approach for such user interfaces based on a XML application can provide for the needed flexibility. As demonstrated in this paper, an SVG based approach is well suited for building highly adaptable user interfaces for mobile device applications, such as a Mobile Nature Guide. Finally it was shown that systems for exploring the wild can also be successfully evaluated in the wild.

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