ADAPTIVE APPROACH TO MOBILE CARTOGRAAPHY

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ABSTRACT:

Increasing popularity of mobile devices in past years has drawn attention of map service providers to use these devices for providing geo-information. Mobile devices are supposed to work in highly dynamic environment and demands entirely different output because of inherent mobility. The issues related to mobile usage of geo-information cannot be addressed by mere up gradation of hardware. Presence of several guiding factors which are dynamic in nature needs to be handled dynamically. These factors include user's profile, preferences, task in hand, context elements etc. Each set of combination demands entirely different information content and Human-Computer Interaction. Adaptation emerged here as possible solution to address these issues. The study is focused on finding out the suitability of various adaptive techniques in cartography to visualize the geo-information in mobile environment. The Rule based approach can automate this process up to some extent but the subjective nature of governing factors demands Human Computer Interaction to be interactive. In the present era of computing where the most of the services are being developed for static computing it is needed to pay more attention to the fast growing segment of mobile computing to make use of geo-information common not only among professionals but also among the mass population.

1. INTRODUCTION

Demand of maps is growing for decision making and performing various tasks related with spatial information. Their use is changing from supply driven product to demand driven products. People need access to the map information in order to perform their spatial tasks (Kraak et al, 1995). Cartographers have exercised their full power to control every bit of map information in the past years and user was able to extract only from these prepared maps. Recent developments in digital cartography have changed the whole scenario, now the control has shifted to users who decide which information they want to include (Robinson et al, 1995, pp. 5-6). Maps are the only means that can provide the desired information in a precise and concise way when a person is moving in an unknown area and making a search (Schmidt-Belz et al, 2002) but it would be difficult to achieve the objective if information got served without knowing user's skill level, preferences, surrounding context and current task etc.

Mobile devices have to perform in the environment where user is always on move, in the state of hurry and different situations are distracting attention of user away from task in hand (Frank et al, 2004). Presenting map content on screen of mobile device has many limitations but the main constraint of mobile computing is the mobility of user (Noble et al, 1997) and mere up gradation of hardware is unable to solve issues related with mobility (Reichenbacher and Töllner, 2004). The map supplied to mobile devices needs to be location and context aware in order to achieve objective of user. The cartographic possibilities are that map should be cartographically enhanced and user should be able to perceive what (s)he wanted to refer. Achieving this objective needs knowing user perceptive capabilities. In present scenario adaptation is the only way that can assist in producing personalized maps to mobile device user. These issues strengthen the need of research work to understand contextual elements and processing Geo-information to make it interpretable and available to all.

2. CARTOGRAPHIC MAP ADAPTATION: CONCEPTS AND ISSUES

Improving the communication of map information is limited to two approaches, one is to train the map users another is to change the map for users. It is difficult and costly to train large number of users. The choice left is adaptation of map using automatic or interactive methods (Yarnal & Coulson, 1982). The use of word Adaptation representing here changing, modifying map contents to satisfy user, based on context, user task and preferences etc. Holland, 1992 cited in Fairbairn & Erharuyi, 2003 gave a generic definition of adaptation as "*Adaptation defines any process where by a structure is progressively modified to give better performance in its environment*". Concept of adaptation is further explained by Thévenin & Coutaz, 1999 & Stephanidis et al, 2004 using two complementary system properties: '*adaptability*' and '*adaptivity*'. Adaptability is capacity of the system to allow user to customize their system to user profile and predefined set of parameters. These parameters can be category of user surrounding condition, user's activity and mobile device's characteristics or so. Adaptivity is the

capacity of the system and interaction with mobile computer to perform adaptation automatically during run time. Feeling of absence of user interface and instance of map use taking place in a natural way are the characteristics of an ideal adaptive cartographic system (Meng, 2003).

Application of any adaptive method needs adaptable map components. It requires us to understand the adaptable aspect of maps and degree of their adaptability before applying any adaptation method. Different map aspects e.g. legend, title, theme, scale, mapped area, border, symbols, place names etc. takes part in producing map output. In addition to the conventional cartographic map elements digital mapping environment also provides some elements which are file format, user interface, function e.g. panning, zooming, hotlinks, selection etc. These map aspects offer higher degree of adaptability compared to conventional map aspects i.e. legend, scale, extent etc. Adaptable aspects of map are categorized in to three main categories by Reichenbacher, 2003 (see **Table 1)**.

Geo-information	**User interface**	**Visualization**
Encoding-Format	Functions	Map section
Amount of data-Content	Interaction mode and style	Map Scale
Classification		Methods-static/dynamic
Grouping		Dimensions
Level of details		Graphical elements
Geographical area		(Symbols & text styles)

Table 1: Adaptable map components
(Adapted from Reichenbacher, 2003**)**

There are several techniques to perform adaptation and these methods are controlled by several factors. These techniques are related with modification of different aspects of map incorporating user profile and objective, adaptability of the system and users' adaptation to the system can be addressed and vice versa. Real application can consist of any one or combination of them. These map adaptation techniques can be classified as follows:

- **Adaptation of Geo-information:** Changing Level of details and generalization degree, changing map file format, classification, changing map extent & information filtration (Robinson, 1995 & Reichenbacher, 2004).
- **Adaptation of user interface:** Adapting User Interface by restricting access level or simplifying the interface etc. (Reichenbacher, 2004), web like functionalities using different type of zooming, panning, rotating, selection, hotlinks etc. (Frank et al, 2004)
- **Adaptation of visualization of map content:** Orientation of map (Meng, 2004), change in map scale (Reichenbacher, 2004), changing colour scheme (Zipf, 2002) Changing symbolization style (Reichenbacher, 2004), changing position of user on map, focus on area of interest (Brown et al, 2001)

Adaptive techniques of visualizing Geo-information can provide the possible solution to solve the problem related with mobility characterized by continuously changing context around user which includes user's activity, task, surrounding environment, culture, preferences. Handling such kind of demands adaptation is required at several stages (Reichenbacher, 2003). Adaptation improves the use of mobile GIS and overcome the limitations of mobile computing (Frank et al, 2004).

3. ELEMENTS OF CONTEXT & CONTEXT AWARE COMPUTING

Adaptive system needs to be aware about context elements and it is possible only when system identifies the context parameters and then finds their values. A user wants relevant information which should be personal and context sensitive and also expect that his/her mobility do not got affected during information retrieval process. On the basis of these requirements Gökker & Myrhaug, 2002 classified context into environmental, personal, task, social, spatio-temporal context categories (see **Figure 1**).

A context aware system is one which provides relevant services by using context information for a given task. Abowd & Dey, 1999 defined context-awareness or context-aware computing as the use of context to provide task-relevant information or services to a user. Context-aware computing describes the situation where a mobile computer is aware of its user's state and surroundings, and modifies its behaviour based on this information.

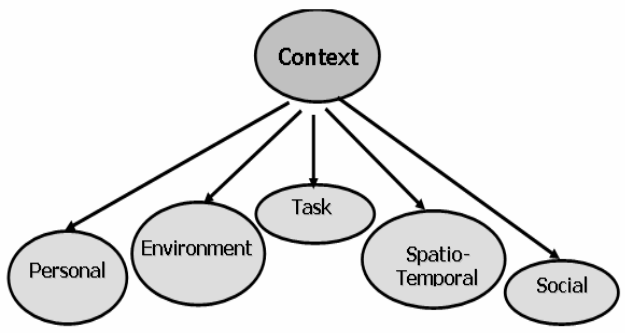

Figure 1: Context in mobile environment and its components (Gokker & Myrhaug, 2002**)**

Adaptive system needs to be context aware and it is only possible when the system senses the context elements either actively or passively. In the passive sensing of context user provides information about context elements. This approach has some benefits but human being cannot sense all the element parameters required for making the system context aware. Hence use of sensors that can sense the context element is required. Context and its elements are the directors of the adaptation process and major factors responsible for Human Computer interaction. Context elements are difficult to interpret and incorporating it in to empirical analysis. Its highly dynamic behavior also adds fur-

ther complexity. Collecting context information might be easy but it is difficult to manage them. Use of context sensors helps in making system context aware as well as reducing human perception. Sensing context needs sensing Location, Time, nearby objects, Network bandwidth, Orientation, Change in context parameters, other low-level contexts context elements etc (Chen & Kotz, 2000).

4. EVALUATION OF ADAPTIVE TECHNIQUE

There are many adaptive techniques that can be applied in mobile GIS computing. Most of them are being used on web and controls the process but these techniques have to be evaluated in mobile environment that has different usage requirements and accessed on entirely different hardware. The focus of study concentrates on methods which are governed by context elements.

4.1. Map Orientation

Orientation of map plays a major role while user wants to navigate or trying to establish their position with respect to surrounding. Tourist/visitor often found it difficult to identify the landmarks and get orientation while moving in unknown area (Hunolstein & Zipf, 2003). This problem can only be overcome by orientation of map. To orient the maps following approaches can be applied i.e. keeping North up (conventional approach), keeping target position up, orienting with reference to important land marks (Hunolstein & Zipf, 2003), aligned with reference to long linear object on the map (Zipf, 2002 & Meng, 2004), orienting along with direction of movement and orientation using Least Bounding Box (LBB) (Hermann et al, 2003). In day time when user is able to recognize the direction the North can be kept up as per standard map convention and user can orient the map mentally (Hermann et al, 2003). In other cases the user may needs to orient the map by keeping the target position in up side.

The use of LBB to orient the map also helps in getting optimal scale display where user can opt for keeping target position in up direction (Zipf and Richter, 2002). If Axis of route be displayed oriented along diagonal of the screen then display scale will be maximum compared to any other orientation (See Figure 3), for further zooming in/out use of lens tool or texture filter as suggested by Kraak & Ormeling, 2003 can be used. This approach to orient the map is much better because both start point and destination point can be seen at a glance and for this diagonal of screen is most suitable to get optimal scale to save time. Zipf, 2002 & Meng, 2004 suggested for orienting the map along the longest linear feature in the map. This approach is also suggested by Uhlirz, 2001 for orientation of map with respect to largest extension of route, this concept enables user to move along the route much longer without changing or refreshing the display. Orientation along to the direction of movement will prove suitable where user is accessing the map while moving in the same locality, especially when walking in

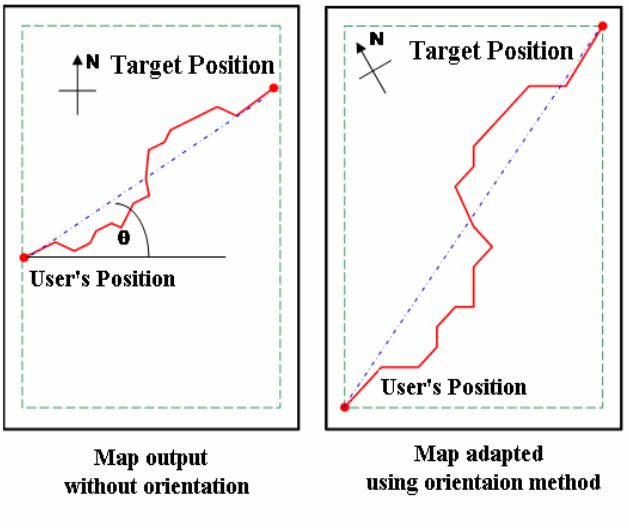

Figure 3: Map orientation using LBB

the streets. Another case may arise that user do not recognize the North direction and moving in the streets in this case position of nearby land marks can be used for map orientation (Kraak et al, 2001) User can refer his/her path with reference to the visible nearby landmarks.

4.2. Focusing User Attention and Content Generalization

Focusing on feature of interest can help in transferring desired information and interpretation of map. Focus area can be Area of a country, province, city, colony etc., map layer, map feature etc. Small screen of mobile computers have requirement of displaying simple map for easy interpretation by user. State of always being in hurry also limits interpreting power of user. The information display on mobile display needs special adaptation to counteract the small screen size and time constraints of user (Baus et al, 2001) The maps need to highlight the required information in order to ease the geo-information communication (Zipf & Richter, 2002). The user's attention can be focused by using following methods:

- **Changing contrast and colour used:** Bright and shiny colours are more noticeable than grey colour (Zipf & Richter, 2002). The colour of feature that needs to be focused can be of higher contrast while other features can be subdued (Meng, 2004).
- **Dynamic methods**: Using dynamic visualization, animation i.e. blinking the feature, animation effect etc. required feature can be focused.
- **Changing the size of feature** like increasing the width of road, size of building feature to draw attention etc.
- **Map generalization:** Generalizing the map feature other than required layer can also be used for drawing the attention. (Zipf & Richter, 2002).

4.3. Map Display Scale

Scale of map is very important aspect of map and most frequently used operation in digital mapping. The mobile device users always have lack of time and therefore the map content should be delivered at optimal scale. Two option are possible one is providing map at the scale such that the all desired content seen at once. Second option is map delivered at scale predefined by user (Brown et al, 2001). Three methods can be used here for scaling the map display first is using Least Bounding Box (LBB) for optimal scale (Zipf & Richter, 2002), second is use of lens or texture filter (Kraak & Ormeling, 2003) and third is use of variable scale maps (Harrie et al, 2002). On the basis of map content zooming can be performed by three different ways static linear zooming, static stepped zooming and dynamic zooming (Brown et al, 2001). The later one will prove better in mobile environment because the content will remain readable at smaller scale while static stepped and linear zooming will result into non readable data at smaller scale. The concept of Least Bounding Box can provide map at optimal scale for default retrieval. Another approach to visualize maps without changing scale of whole map to see a portion of map at larger scale is the use of magnifying lens/texture filter (Reichenbacher, 2001). This tool provides closer view of the feature without changing the map scale and thus provides overall view of map (Kraak & Ormeling, 2003, pp 270). The zooming using click event suitable with novice user while zooming with track rectangle command may prove much better with the users who are familiar with computing. The slider control can provide the smooth transition between two scales. Using variable scale map devised by Harrie et al, 2002 for visualizing geo-information in personal navigation system is able to provide an overview map in the vicinity of user. This approach displays area in the vicinity of the user at bigger scale than the area that is farther. This method of map representation can provide better output and panning and zooming can be avoided up to some extent. (See **Figure 4**)

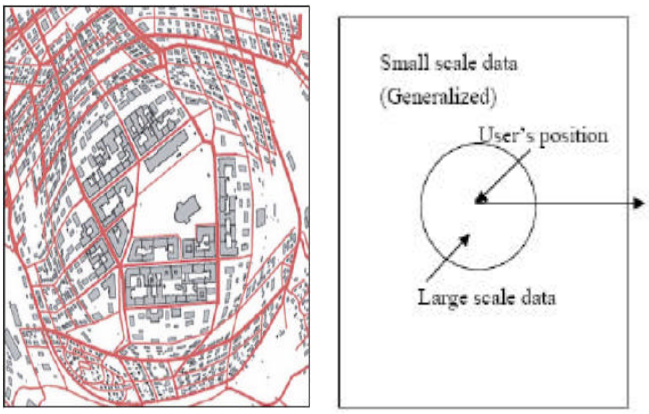

Figure 4: Variable scale map area in the circle near to user's position is shown at larger scale and rest of the data is shown at small scale (Source: Harrie et al, 2002)

4.4. Colour Scheme and Cascading Style Sheets

Colour scheme of map helps in better visualization and interpretation of map. The factors responsible for colour scheme are user preference, experience of map use etc. The age and gender of the user also plays role in likeness of colour scheme but this issues will further leads to special research. Zipf, 2002 gave the idea of adapting colour scheme on the basis of cultural background. The colors are not interpreted in the same way by persons who are belonging to different countries. Individual user's preferences are also requires different colour scheme. User's physical characteristics i.e. colour blindness, impaired visibility also requires use of special colour scheme. The background colour or image file enhances map experiences of user and help in drawing attention of user on feature of their interest.

Visualization style change the map output in drastic way. Every user likes different of styles. Use of CSS (Cascading Style Sheets) can help here and can thus help in better user experience. CSS is a method of creating one file that stores the entire theme of user like background colour, font type, size, style, spacing etc. to web documents (URL 1 & URL 3). This file stores all statement/rule that governs the rendering properties of the web document (URL 2). Use of CSS while presenting maps on mobile device can help the user, to choose the appropriate colour scheme or any other aspect of maps with relation to their chosen map aspect.

4.5. Map Symbology for Mobile Devices

These are the Symbols that play very important role in phrasing map document. Symbols may or may not be self explanatory and legend may be required to interpret the information hidden behind the symbols. There are various elements that affects the symbolization style i.e. user task, perception capability, cognition power, physical characteristics etc. Pictorial symbols are self explanatory while geometrical and letter/number symbols requires legends to convey the meaning. Hence in the case of using these symbols over mobile devices pictorial symbols are more suitable as later requires legends to explain and switching legend on/off will require extra input from user. Visually impaired persons require large symbols and less detail. Children like picturesque symbols and don't like abstract symbols and information (Zipf, 2002). Changing the symbology for whole map can be done with exchange in style sheet or XSLT (Reichenbacher & Tollner, 2004). Symbolization of map has big potential to explore from the adaptation aspect of visualization.

4.6. User's Position in Map

Position of user on map plays an important role in performing task in mobile environment and help greatly in getting orientation. For a user moving in unknown area it is very difficult to get oriented if his/her position is not shown on the map (Baus et al, 2001). In these conditions user can get orientation with reference to features in front of them. The position of user is

mainly governed by task. If position of user is not chosen accordingly map scale will got affected severely. It is recommended to place user's position for navigational task on bottom portion of screen. For other task like searching for something user's position on the screen should be decided as per the map retrieval and orientation of map, but identifying and locating (own and others) task will be more effective if user's position will be shown in the centre of the screen.

4.7. Adaptive User Interface

The user interface acts as translator between the system and the users. It establishes dialogue between two entirely different entities. User interface needs adaptation to handle different categories of users belonging from different background and preferences. The objective of designing a user centric and task oriented interface. User's personal profile which includes age, sex, Language, Eye sight colour-blindness and computing and map reading skill etc. needs to be stored in system. The concept of using unique ID helps to store the information about user and also helps in securing the data and access level. The rule based approach applied to respond the system in an automated way and interactive methods used to handle situation where system is unable to predict the user's preferences and behavior. The mixed approach of automated response for predictable adaptation parameters and interactive methods is used for the parameters which are subjective in nature and where automated approach can not leads to user satisfaction. The parameters which are quite subjective in nature need to be asked in terms of their target map aspects. The font size, colour scheme etc are not to be adapted on the basis of age of user, sex and eyesight directly because such parameters are quite subjective and a common rule base can not be developed for all users in general. The user interface is designed to provide different level of access to different categories of users.

4.8. Rule Base for Adaptivity

The rule based approach to the adaptation of interface is adopted here (**Kraak & Ormeling, 2003,** pp-187). The use of *If …Then…else* conditional programming (**Reichenbacher, 2003**) is used for adapting the interface according to the user profile. The knowledge base stored at server side/client side is the main basis of this kind of adaptation. This knowledge base needs to be updated from time to time based on the user survey and their satisfaction level incorporating new technology. It is very complex to decide which adaptive method should take place under a particular set of condition. The most important factors responsible among them are user profile and context information based on that a particular type of adaptation will take place. Adaptation can take place based on a particular type of user or a group of users belonging to same categories. It can be said here that Interface style or type is a function of set of defined factors/parameters. Mathematically it can be represented as

$$I = f(Xi) \quad \ldots\ldots (1)$$

Where **I** = interface type, f = some function or rule base, Xi = input parameter. It can also be represented as:

[Interface(x)] = [Rule Base(x)] [User Profile (x), Device Characteristics(x), ……] ……. (2)

Where for all x ? 0, x belongs to real Number and x ? complex number

4.9. Evaluation of Adaptive user Interface

The goal of designing a user interface is good usability of system (Welie et al, 1999). There are various methods to evaluate

Figure 5: **Mobile User Interface**

the usability of user interface i.e. questionnaire method, interview with experts and direct observation etc. The following conclusion has been drawn on the basis of above methods of evaluation of prototype GUI:

- Login through User ID concept for securing the access to the data is also useful for storing user profile and preference to adapt the system accordingly but the User Id must be chosen by user.
- Input parameters used for interface adaptation in registration form does not require age and sex input instead dependent variables e.g. font size/type and colour scheme can be asked directly from users. It is better to choose the font size/ type by visual selection instead of numeric/text input.
- Categorization of knowledge base/back ground should not be based on user's age.

- Using eyesight for changing font size is not required instead option of choosing font size directly is more suitable.
- Tools bars (Graphic tools) option should be given to all categories of users and more tools should be added to the tool bar as tools bars occupy less space and much liked by users.
- Use of tool tips and auto run demo showing full functionality can help in user to know about application.
- Pictorial symbols are more liked by persons who use maps occasionally or navigating for sight seeing. Graphic symbols are more liked by persons who use maps very often.

5. CONCLUSION

This research work has discussed about adaptation and various adaptive techniques for mobile devices. Maps displayed on Mobile devices needs to provide access of geo-information to the diverse group of users for decision making and performing various user tasks during mobility. The information content delivery on mobile devices needs to be context sensitive and the interactive system needs to intelligent enough to understand user behaviour and adapt the system accordingly. The adaptable aspects of the map require identification of adaptable aspects of map and their degree of adaptability. The adaptable aspects of map will vary depending on the objective and type of information requirement. Different map aspects take part in different situation. Adaptation of maps is required mainly because of two reasons one is technical limitations of mobile devices and another is usage of geo-information during mobility. The technical advancement will overcome the limitations of mobile devices in near future but the usage issues can only be solved by theoretical approaches.

Mobile computing requires dynamic computing behaviour which changes with change in context elements. It can be achieved by making system context aware. Some parameters can be sensed by special sensors like location, time, QoS etc. but parameters like personal profile, mental state of user etc can only be accessed by interactive GUI. Rule based approaches for developing adaptive GUI can be used effectively and has enough scope to meet changing context requirements. The mixed approach of automatic approach for objective and interactive approach for subjective nature of parameters is applied to design the GUI. Most of the parameters responsible for adaptation of map visualization are quite subjective and behaves differently in different situation. It requires adaptive system to respond dynamically during run time.

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