A TRAVEL ROUTE EDITOR ON A FOCUS+GLUE+CONTEXT MAP

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ABSTRACT:

Digital map systems are used daily in order to organize and search information before a travel and to display and examine a travel record. In our previous study, we proposed the focus+glue+context map system EMMA (Elastic Mobile MAp) which provides both local detailed data and global context data in the same view, providing uniform scaling of focus and context areas by placing a glue area between the two areas. This paper presents a Web-based travel route editor on EMMA, which allows users to enlarge the areas around the waypoints and route tracks while watching the whole route. The proposed system includes the following features. (1) An intuitive interaction with the displayed objects (route tracks, landmarks) and the focus function enhance the examination and understanding. (2) The system simulates all the travel by placing a focus area at the start that automatically follows the route tracks displaying the area in detail. When a track is reached, additional information such as pictures and descriptions attached to the route is automatically displayed. (3) The system allows users to design and draw travel routes by selecting vector map data from a database. GPS data can be loaded from files and displayed as a reference. Most of the user interaction in the route drawing process is effectively reduced by implementing the following path algorithm to suggest a path. (4) There may be places without vector map data such as parks and mountains. The user is able to create intuitively new roads. This paper shows the implementation methods and a prototype of the proposed system which we developed on EMMA.

1. INTRODUCTION

Maps have always been the favorite communication language of spatial information. Daily, professionals and non-professionals access digital map systems through the Internet from mobile devices and personal computers in order to find orientation and information and plan routes. For example a company plans the most convenient routes for their delivery trucks or a tourist searches information of the interesting routes and sightseeing spots. It includes a wide range of purposes such as transport, surveillance, tourism, hiking, documentation of journeys. However, they can be generalized as planning and examining a travel route between two different points.

Routes can be displayed and examined in map browsers, which usually offer the basic map operations: scroll, zoom-in and zoom-out. When users examine the whole travel route, often the map scale does not allow them to identify the relevant information near the route. On the other hand, when users zoom-in to examine in detail the information, the map scale does not allow them to see the whole route. Besides, two different and distant areas cannot be examined in detail over the same map screen. Travel routes are usually designed and drawn in digital map systems or generated with GPS loggers. They are saved and shared in files using formats such as KML, an international standard and the dominant format to share geographic data. When users design and draw a route by using digital map systems, often some parts of the route, for example inside cities and towns, require a detailed map scale while other parts require a map scale that shows only highways and important roads. Besides, drawing long routes may require long time and dedication. As a result of the above problems, user interaction often requires too many steps and basic map operations and users may experience difficulties associating the focused information with the context.

GPS loggers are very useful when generating a travel route for purposes such as keep travel records, control and surveillance, optimization of daily routes and statistics and traffic measurement. However GPS data is often difficult to use because usually contains noise and GPS loggers often take too many points.

A system to examine and design travel routes is proposed that provides advanced viewing and drawing functions over the focus+glue+context map EMMA (Elastic Mobile MAp) (Naohisa, 2008; Daisuke, 2009). The map system displays without distortion both local detailed data and global context data in the same view, providing uniform scaling of focus and context areas by placing a glue area between the two areas. With the viewing functions users can load and examine travel route files. With the drawing functions users can design and draw travel routes by hand and by using vector map data from a database. GPS data can be loaded and displayed as a reference for the route drawing. By using GPS data as a reference, a route can be drawn that represents the GPS data but does not contain noise and the route points are minimum.

The most outstanding proposed functions are the focus function, the play function and the path suggestion function. By using EMMA, the focus function allows users to enlarge the area around one or more points of interest while the rest of the map keeps the same scale. This function enhances the user comprehension and simplifies the user interaction considerably. The play function allows users to examine a whole travel route with hardly any user interaction. The path suggestion function implements the following path algorithm (Daisuke, 2009) to suggest a path and reduces considerably the user interaction when drawing a route. From now on the following path algorithm is also referred as FPA.
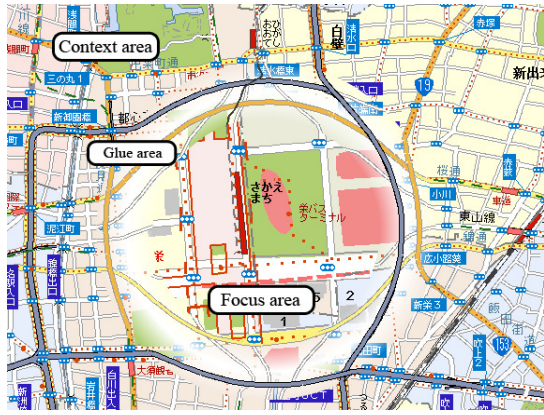
Figure 1. Snapshot of the EMMA displaying a map with a focus.

Figure 2. Proposed system diagram.

2. RELATED WORK

To solve the visualization problems on large amounts of data, there are many distortion-oriented visualization techniques (Leung, 1994). Some of them can be applied to map applications. For example one proposed technique is a variable-scale map that can expand the center of a map and reduce the periphery area seamlessly (Lars, 2002). The central part of the map is displayed uniformly and at a large scale, while the scales of the surrounding areas gradually decrease and as a result the surrounding area is drawn with a distortion. Fish-eye lens techniques, also called focus+context techniques, display both local detail and global context in the same screen and enable users to move the focus point and inspect different areas. EMMA system enhances and outstands the focus+context systems because both focus and context are displayed without distortion by implementing a focus+glue+context system, as explained in the following section. Previous works on Emma focus on drawing maps with focus+glue+context and do not treat with drawing routes on Emma, which is one of the main topics of this paper.

Nowadays many digital map systems have been developed in order to draw a travel route; most of them using the Google mapping system through its open API. They use basically one of the following methods: (1) users define start and end points and the system generates the shortest or fastest route using vector map data and (2) users define successively by hand route points over the map images. Some of the systems of the first group, after generating the route, allow users to modify the route. Examples of applications using the first method are Google Maps (Google Maps), Yahoo! Maps (Yahoo! Maps) and Bing Maps (Bing Maps). Using the second method there are applications such as WalkJogRun (WalkJogRun), VeloRouter (VeloRouter) and RouteBuilder (RouteBuilder). The systems Gmaps-Pedometer (Gmaps-Pedometer) and MapMyRide (MapMyRide) implement an alternative version of the first method: Users select the start point and then select successively route points; the shortest route is generated between consecutive pairs of points. On Google Earth (Google Earth) and MapMyRide, both methods can be used; but only in MapMyRide can be combined.

These tools are convenient and used by many users, however they do not allow users to load vector map data and display travel routes at different scales over the same map screen, which is the advanced feature of the proposed system. Several functions have been 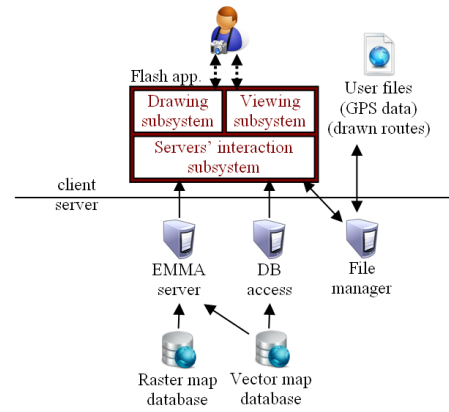developed to take advantage of that new feature. In addition, the system also implements the following path algorithm in order to suggest a path. The FPA is much easier to implement than the shortest path algorithm (Dijkstra) and requires less vector map data. Besides, the shortest path is not always good solution because (1) users not always know the destination point from the beginning and (2) users not always desire the shortest path. This solution is particularly not useful when the start and end point are near and user desires to draw a round route. For example in case a tourist wants a route that starts from the hotel, tours the city and ends in the hotel.

3. OVERVIEW OF THE PROPOSED SYSTEM

EMMA is an elastic map system that enables users to stretch a digital map as if it were an elastic sheet or a tangible device. It enhances focus+context maps, which displays both local detailed data and global context data in the same view. The system provides uniform scaling of focus and context areas by placing a glue area between the two areas. Context and focused areas are raster map images without distortion while the glue area has a distortion to absorb the scale difference, as shown in Figure 1. The glue area is generated using raster map data and vector map data (Daisuke, 2009).

The proposed system consists of a client application and several servers, as shown in Figure 2. The client application, a web-based Flash application, is divided in the viewing, the drawing and the servers' interaction subsystems. Users interact using the functions of the drawing and viewing subsystems. The user interface is composed by a map area, a panel and a toolbar. Since Flash applications cannot download or upload files directly, the File manager server helps in the upload and download process. The EMMA server provides the generated glue area images and the raster map images of context and focused areas. The client application receives those images and the focus+glue+context map is formed. Since Flash applications cannot access databases directly, the DB access server provides the vector map data used in the drawing subsystem. The new proposals of the system are included in the drawing and viewing subsystems: therefore, they are described in detail in the following subsections.

When users start drawing a route, the first step is to select the route start point. Then users can draw using vector map data and/or drawing by hand. Every time users draw, the path suggestion function suggests a path that continues the drawn route. Users can intuitively accept the suggested path, accept a section or ignore it. When the user decides to save the route,
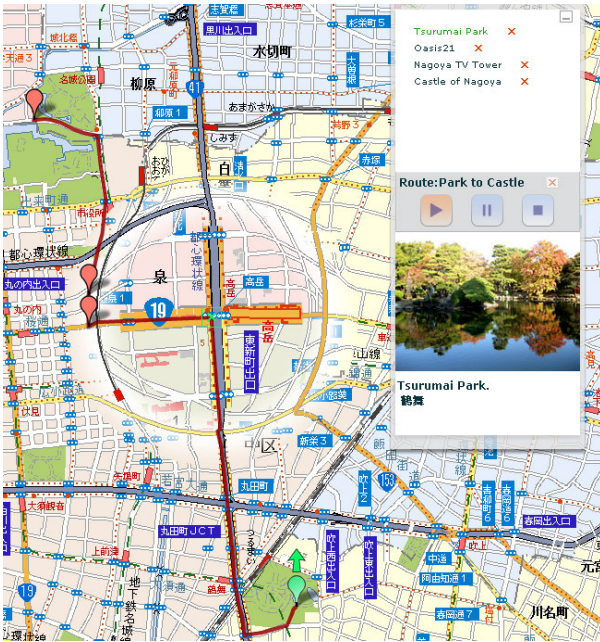
Figure 3. Snapshot of the proposed system examining a route.

KML code is generated from the drawn route. The KML code can be copied into the clipboard and downloaded into a file. In order to examine and compare travel routes, users can load KML. When a file is loaded, it is parsed and the routes and waypoints are displayed over the map. A route consists in a sorted set of locations or route points and it is drawn by connecting with a string pairs of consecutive locations. When the direction needs to be represented, an arrow is placed instead of a string. The waypoints are represented with clickable markers. A waypoint can be selected over the map and its information, such as description and photos, is displayed in the panel. Users can take advantage of the focus function and the play function anytime to examine the drawn and loaded routes.

4. VIEWING SUBSYSTEM

4.1 Overview

The main functions included in the viewing subsystem are:
- the focus function
- the play function
- the fit data function
- the fade function

First, let us define the concepts route point and route waypoint. A route point consists of a location (latitude and longitude). A route is formed by a succession of route points. A route may contain waypoints, which are route points that include information such as description and photos.

The proposed focus function and play function are explained in detail in the following subsections.

When a travel route is loaded, or after successive basic map operations, it may happen that part of the route data has been left outside the map screen and consequently hidden. To solve this problem, the fit data function changes the scale and center of the map to ensure that the travel routes are displayed as big as possible while any element is hidden outside the map screen.
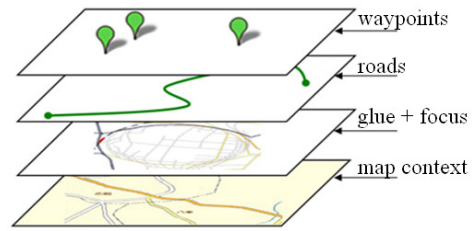

Figure 4. Map screen layers on the proposed system.

In order to avoid confusion between the displayed routes and the background map images, users use the fade function to fade the map images and standout the routes.

In Figure 3 some of the viewing subsystem functions can be observed in a snapshot of the proposed system. A focus is placed and the play function is being used in a displayed route. A waypoint is selected and its information is displayed on the panel. The fit data function has been executed previously.

4.2 Focus function

To solve the map visualization problems presented in the introduction and provide a global perception while examining a detailed area, the focus function is proposed, which implements the client side of EMMA. Using map areas without distortion is very important for two main reasons: (1) When drawing and viewing, the routes must be displayed over the map without distortion in order to understand the length and shape of a road. (2) When drawing a route, the kind of vector map data loaded depends on the map scale; therefore, systems without a constant scale on the map areas cannot be used. Besides, not distorted map images can be cached and prepared in advance.

To provide the focus function and be able to display travel routes, the proposed system uses four layers to compose the map screen. Starting from the deepest layer, the layers are: (1) map context layer, (2) glue and focus layer, (3) road layer and (4) waypoint layer, as shown in Figure 4. In the context layer are displayed raster map images from EMMA; basic map operations such as scroll and scale change can be used anytime. When users use the focus function and click over the screen, raster map images with a detailed scale are loaded on the area around the clicked point, called focused area or focus. Besides, a glue area is generated dynamically by EMMA and placed surrounding the focused area. Several focuses can be placed on the screen. The focus provides an intuitive interaction to change anytime the focus area size, the glue area size and the focus scale. Besides users can move the focus position over the map screen by just drag-and-drop. Over the two layers that contain the map images, the travel route elements are pasted according to their position. A translation between the coordinates of the real world (latitude, longitude) and the positions over the map screen (pixels x,y) is made according to the scale: if the element is over a focused area, the focus scale is used; otherwise the context scale is used. Besides, when the element is pasted over a glue area, it is pasted with a distortion in order to match it with the glue area image and offer an understandable global view.

4.3 Play function

When users want to examine all the route information and the route surroundings in detail, it often takes a long interaction, despite the fact that the focus function simplifies the interaction

considerably. To solve the above problem and provide and attractive viewing function, we propose the play function. With one single click, the play function shows sequentially all the information of the route waypoints and simulates the travel of the route. The play function places a focus at the route start point and moves it forward along the route at the simulation speed until the end is reached. When a waypoint is reached, its information is displayed on the panel. Users can pause the simulation, change the speed and change the focus size anytime. An algorithm decides the position where the focus should be moved and the time to wait until the next movement. The objective of the algorithm is to ensure a constant pace regardless the frequency of points in the route. This objective is especially important when (1) the route contains points very distant and (2) the route contains too many points very near, which is a problem often found in GPS data generated by GPS loggers. Besides, all the waypoints must be reached.

We state the algorithm of this function. The algorithm input are the route and two parameters. The first parameter, *speed*, is the simulation speed. The second parameter, *m*, is the maximum distance of one movement. The parameter *m* is related to the focus size, i.e. its width. If *m* is very small, the focus is moved too often and the glue and focus images may not be loaded in time. If *m* is too big, the focus is moved too far and as a result some areas of the route may not be displayed in detail. From the experiments, a third of the focus width is a suitable value for *m*. Since the speed simulation and the width are defined by the user and can be changed anytime, the algorithm parameters are updated every iteration. The algorithm steps are three:

1st step: The focus is set in the route start point.

2nd step: The focus is moved following the route a distance *d*. This distance *d* is always *m* except in two cases: (1) the distance from the current location to the end of the route is less than *m*, then *d* becomes the distance to the route end; (2) the distance from the current location to the next route waypoint is less than *m*, then *d* becomes the distance to the next waypoint.

3rd step: The algorithm waits (*d* / *speed*) and then iterates again from the second step.

5. DRAWING SUBSYSTEM

5.1 Overview

The main functions included in the drawing subsystem are:
- the road selection function
- the path suggestion function
- the hand-drawing function

First, let us define the concepts path and link. A link is a fragment of a road between two neighbouring crossing points. A path is a sequence of connected links. The vector map data loaded is a set of links. The road selection function allows users to draw a route by selecting links from vector map data. When drawing a route, the path suggestion function suggests a path that continues the drawn route by implementing the following path algorithm.

Although vector map data is very convenient, as explained in the following subsection, it cannot be used: (1) when a link is too new and has not been updated yet in the vector map database and (2) when an area does not contain vector map data, for example inside buildings, in parks and in mountains. Therefore, the hand-drawing function allows users to draw a link by clicking on the screen successively the points that form

Figure 5. Vector map data on the context and focus map area.

the new link. Links selected from the server map data and links drawn by hand are all combined and form the drawn route.

During the drawing process all functions from the viewing subsystem can be used. The focus function allows to draw links in a focused area and to see at the same time all the previous drawn links in the context. Besides, a file with GPS data can be loaded and displayed as a reference for the drawing process.

5.2 Road selection function

As stated in the introduction, travel routes are very important and are widely used daily for many purposes. Although GPS loggers are very useful when generating a travel route in several situations, GPS data is often difficult to use because usually contains noise and GPS loggers often take too many points. It is difficult to use for navigation because the changes of direction are not clear. On the other hand, vector map data does not contain noise and the links are built with the minimum points.

The vector map data loaded from the database contains not only the link points but also the kind of link, for example highway, national and rural area. The vector map data is filtered by kind depending on the scale of the map area to be in accordance with the map images; for example in large-scale maps only important links such as highways are loaded.

By combining the vector map data filtering and the focus function: (1) different kind of links can be selected over the same map screen (2) the amount of vector map data loaded in the context is reduced. It is shown in Figure 5, where the black points represent the bounds of the vector map data links.

When a new link is selected, it must be connected to the last drawn link or to the start point, in case any link has been selected yet. That way, gaps and bifurcations are avoided. Beside, passing several times for the same link and drawing route loops is possible. To select a link, users move the mouse over the map screen using the background images as a reference. When the mouse moves, the vector map data links that are connected to the last drawn link are considered and the nearest one to the mouse is highlighted on the map screen. Then, the highlighted link is selected by clicking with the mouse.

5.3 Following Path Algorithm (FPA)

Basically, the FPA suggests the path that a human would follow along a road without turning even if an intersection is reached. The FPA input are the link we are following, the length (number of links) of the suggested path and the vector map data.

(a) Snapshot before selecting the arrowed link (red).
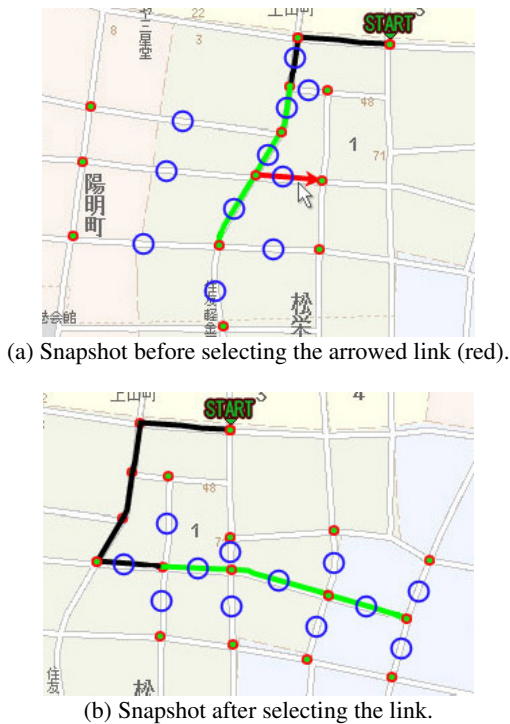

(b) Snapshot after selecting the link.

Figure 6. Snapshots of the drawing system.

The algorithm returns a path formed by links from the vector map data by following three steps:

1st step: Select from the vector map data all links connected to the last point of the input link. If a selected link is very small, its connected links are also selected.

2nd step: Calculate the deviation between the input link and each of the selected links. The selected link with the smallest deviation is suggested.

3rd step: While the suggested path length is not reached, iterate again from the first step using the last suggested link as input.

5.4 Path suggestion function

Although the drawing process interaction basically requires one single click per link, usually travel routes are formed by many links and therefore the user interaction often takes too much time and effort. We propose the path suggestion function based on the following path algorithm in order to solve the above mentioned problem. Every time a link is selected, the path suggestion function suggests a path by implementing the FPA. The suggested path length is defined by the user and the FPA input link is the last selected link. The FPA is simple and very effective for the purpose of drawing a travel route, since human behavior when reaching a destination is usually going in the direction of the destination trying to follow a straight path.

The suggested path is displayed on the screen on a different color than the drawn route. Then users can (1) select a new link connected to the last drawn link (ignore the suggestion), (2) select a new link connected to the last point of the suggestion (accept the whole suggestion) or (3) select a new link connected to any point of the suggested path (accept a section of the suggestion, until the connection). In all cases the interaction is just selecting a new link and users do not need to use a different way to interact; therefore, dealing with the suggestion is very intuitive and simple. By using the suggestion function, basically users just need to select the start link, the changes of direction and the end link.

(a) Number of points to be stored

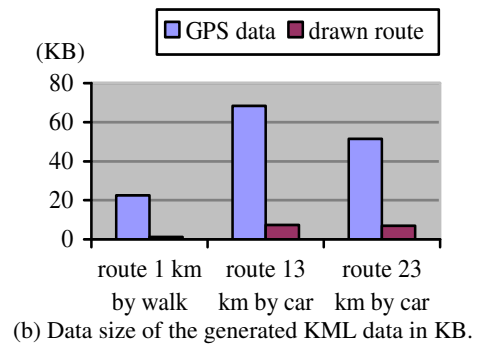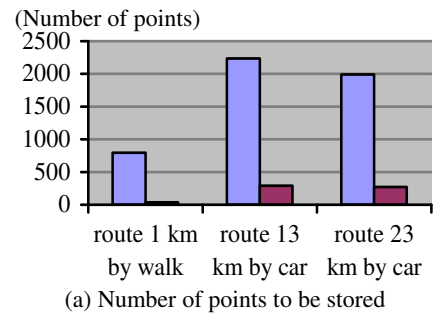

(b) Data size of the generated KML data in KB.

Figure 7. Comparison of the drawn route and GPS data.

Figure 6 shows two snapshots of the drawing system. Drawn links are represented in dark trace (black) and suggested links are represented in light trace (green). An arrow (red) represents the nearest link to the mouse pointer. The big circles have been placed after taking the snapshots. The circles indicate the links that the user can select in the current state, i.e. the connected links. The small points indicate the bounds of the connected links. The upper snapshot shows a state during the drawing process, two links have been drawn and the path suggestion function is suggesting a path of three links. The lower snapshot shows the state reached when the user selects the link represented by an arrow on the upper state.

6. EVALUATION

A practical tool has been developed that implements the proposed functions and completes the user interaction with useful functions such as undo and KML file upload and download. This prototype system is hosted in our laboratory and can be tested through the Internet. A demo movie* of the prototype is also provided. The vector map data adopted by the prototype system are Standard Road Map 2007 and Navigation Road Map 2007 obtained from Yahoo Japan Corporation. The proposed functions has been tested and evaluated in the prototype system.

One of the purposes of drawing a route is to improve a GPS trace. By drawing a route using GPS data as a reference, the route generated represents the GPS data and is clean of noise and the shape of the roads and the changes of direction are clear; therefore, it is easier to visualize and understand than the GPS data and is more suitable to navigate. The charts on Figure 7 show the comparison of the drawn route and the original GPS data used as a reference in terms of the number of points and the size in KML format. Three real routes are considered, one have been taken by walk and two by car; in all the travel routes the GPS logger took route points every second. After the route

*http://tk-www.elcom.nitech.ac.jp/demo/fisheye.html

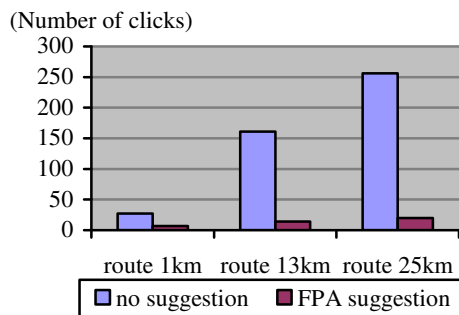Figure 8. Travel route drawn by using the suggestion function.

Figure 9. Effectiveness of FPA suggestion.

drawing process, which in any route took more than five minutes, the number of points and the size have been drastically reduced. It is very convenient for route sharing and for processes that use the route as an input, for example route queries such as determine whether a point belongs to the route.

In order to facilitate and speed up the drawing process, the system suggests a path by implementing the following path algorithm. To measure the effect of the proposed path suggestion function, an evaluation has been made in terms of the number of clicks the user needs to draw a travel route, i.e. the number of links the user selects. Figure 8 shows visually the effect of using the suggestion function. The links that the user had to click and select are pointed with an arrow. The rest of the links were suggested and accepted. Figure 9 compares the number of clicks made when drawing three real travel routes of different sizes using the path suggestion function and without using it. In all examples the suggestion has reduced drastically the number of clicks needed. The path suggestion can never produce a negative effect since users can just ignore it, accept a section or accept the whole suggestion.

7. CONCLUSIONS

This paper has presented a novel and effective method to examine and draw travel routes by implementing a focus+glue+context map system. Several areas with different scales can be displayed over the same map screen without distortion; therefore, users receive a global perception of the route and its elements while dealing with local areas. Two advanced functions that successfully take advantage of the f+g+c map system have been described: the focus function and the play function.

This paper also proposes a simple and very effective method that reduces notably the user interaction in the route drawing process by suggesting a path using the following path algorithm.

In addition, the convenience of drawing a travel route using as a reference GPS data as a way to improve the GPS data has been outlined.

As a future work we propose: (1) combine the proposed path suggestion function with the current methods used to assist the route drawing and (2) develop a method to match automatically GPS data to vector map data and generate a route.

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