A Comparison of Linear and Calendar Travel Itinerary Visualizations for Personal Digital Assistants

Masood Masoodian
Daryl Budd
Bill Rogers
The University of Waikato

Department of Computer Science
The University of Waikato
Hamilton, New Zealand
Email: M.Masoodian@cs.waikato.ac.nz

Abstract

Various graphical travel itinerary visualization systems have in recent years been developed to allow making easier references between different events such as flights and hotel bookings on a travel itinerary, thereby addressing a problem with tabular itineraries which list travel events in a chronological order of date and time, and only allow referencing consecutive events. These graphical travel itinerary systems are based on a linear visualization of travel events. Although this linear visualization deals with some of the problems associated with tabular itineraries, it is not the only form of visualization which might be capable of addressing these issues. This paper introduces a new visualization of travel itineraries, called the calendar visualization, which relies on a more familiar concept of calendars to depict the relationships between travel events. This paper also describes an empirical study undertaken to compare the calendar and linear itinerary visualizations.

Keywords

Handheld computing, mobile computing, travel itinerary, PDA, visualization

INTRODUCTION

Almost all travellers carry an itinerary of their trip which might be a simple trip including a handful of travel events, or a complicated one consisting of numerous inter-related events. The itinerary plays an important role in facilitating organization and scheduling of the activities relating to a particular trip. Although the itinerary is usually created before the trip starts, it may subsequently be modified during the trip to include changes to plans, events and so on. A normal travel itinerary is often in tabular form, listing travel events in a chronological order of date and time. Tabular itineraries are less than satisfactory to carry, use, or modify and update (Apperley et al. 2000). The main problem with conventional travel itineraries is that they do not always provide an overview of the relationships between various events of a trip (Apperley et al. 2000).

In recent years other systems have been designed to allow graphical visualization of travel itinerary information, with the aim of solving some of the problems associated with conventional itineraries. These systems which have been developed for PCs (Apperley et al. 2000), mobile phones (Masoodian and Lane 2001, 2002), and PDA devices (Masoodian and Budd 2004) depict the relationships between travel events using a linear visualization.

Although the linear visualization is effective in showing the relationships between travel events, it is unfamiliar to the users and therefore may not be the most optimal visualization, particularly for the less frequent travellers. An alternative visualization, called calendar visualization, has now been developed for PDA type devices which relies on the use of a more familiar calendar metaphor for depicting the relationships between travel events. This paper describes the calendar itinerary visualization system, and compares the calendar and linear travel itinerary visualizations.

LINEAR TRAVEL ITINERARY VISUALIZATION

As mentioned earlier, graphical itinerary visualization systems have been developed which provide a linear visualization of the inter-relationships between the events of a travel itinerary. Although these systems have been more fully described elsewhere (Apperley et al. 2000, Masoodian and Lane 2002, Masoodian and Budd 2004), this section gives a brief overview of their most important features.
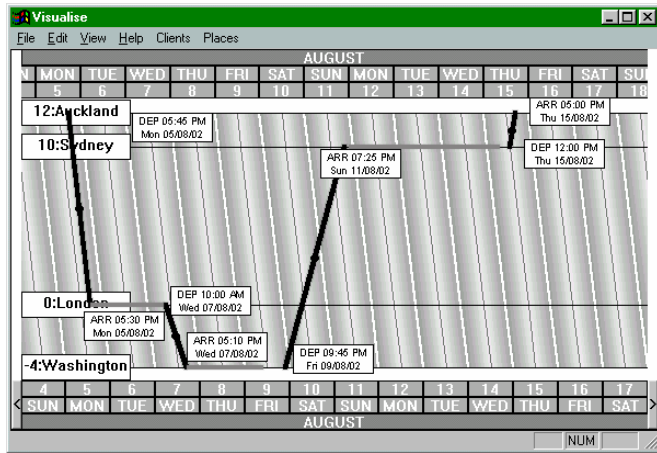
Figure 1: The CIG linear travel itinerary visualization

The first graphical itinerary visualization system, upon which the subsequent systems are based, is known as the Collaborative Information Gathering (CIG) system. Figure 1 shows the CIG itinerary visualization software, depicting an example roundtrip between Auckland, New Zealand, and Washington, USA, with stops in Sydney and London. The vertical axis is in time-zone units, showing the time difference between various locations, which are either destinations or transit points along the way. The horizontal axis shows the progression of time at a particular location, and when a trip crosses the international dateline, the difference between days on different hemispheres is shown along the top and bottom datelines of the visualization. These two different time scales can be used to compare the time of various events across different time-zones. A horizontal line depicts a stay event in a location, while the diagonal lines show travel events. The dark and light shaded stripes show the 12-hour night and day periods, while midnights and mid-days are marked with white and dark grey diagonal lines, respectively.

The CIG system was developed for computers with conventional screens, and as such it lacked support for remote mobile access. Therefore a new tool called MATI (Mobile Access to Travel Itinerary) was developed to provide access to the CIG system using WAP-enabled mobile phones (Masoodian and Lane 2001, 2002). MATI has a combination of textual and graphical visualizations, where the textual visualization provides access to specific details relating to events, while the graphical visualization provides an overview of the travel itinerary and how its events are related to each other. Figure 2 shows several sample pages accessed via MATI. In textual view MATI allows the users to access the list of all the destinations of an itinerary (2a), from which they can select a particular destination (2b) to find out information relating to that destination (2c). In graphical view, on the other hand, the users can for instance select different levels of zooming for viewing an itinerary (2d) to either get an overview of the entire itinerary or a specific time period (2e). The users can also change from graphical navigation mode to graphical selection mode, allowing them to step through different events and select to view information relating to the current event (2f).

An empirical usability study of MATI (Masoodian and Lane 2003) demonstrated its effectiveness in providing access to travel itinerary information. However, due to the input limitations of the mobile phones, and the
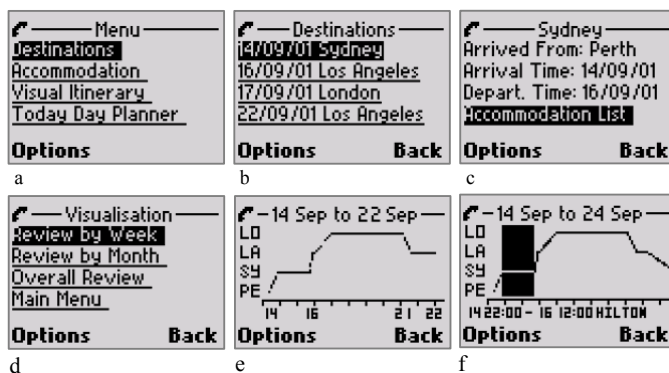

Figure 2: a) the main menu of MATI b) destinations list of the itinerary c) information relating to a particular destination d) menu for different levels of viewing e) a period of the itinerary f) selecting an activity for more information
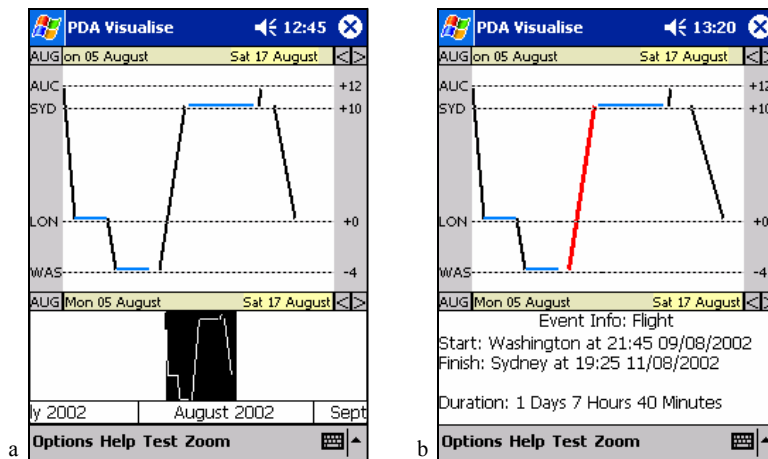
Figure 3: a) The interface of PATI which includes the main view at the top and the radar view at the bottom
b) details of a selected event

underlying WAP technology used by MATI, it is not capable of providing enough functionality to allow making modification to travel itineraries using a mobile phone.

In comparison to mobile phones, PDAs generally have better input and output capabilities, and reasonable processing power, making them more suitable for mobile applications. Therefore a prototype system called PATI (PDA Access to Travel Itinerary) was developed to allow retrieval and modification of personal travel itinerary information using PDA devices (Masoodian and Budd 2004). To maintain a level of consistency with the CIG and MATI systems, the initial visualization developed for PATI also utilized the linear itinerary visualization of the previous systems.

Figure 3a shows the overall interface of PATI, which is divided into two components, the main view, and the radar view. The main view which is shown in the top area of the screen is reserved for displaying detailed view of the linear visualization of the itinerary. The radar view on the other hand, is shown in the bottom part of the screen and displays the overview of the entire itinerary in linear form. The users can choose different segments of the itinerary to be shown in the main view by either selecting a period from the zoom menu of PATI, or selecting a portion of the itinerary from the radar view by swiping the PDA stylus across the desired itinerary region (the selection is shown in black rectangular area).

Because of the restrictions of the screen size of the PDAs the linear CIG visualization had to be simplified to make it more suitable for the PDAs. For instance, the city names are abbreviated and only the first three characters are shown at the left hand side of the visualization. Also, the time-zone values have been moved to the right hand side, allowing easier comparison of the local time-zone differences. The number of visible datelines is restricted to two, with one that corresponds to the location at the top and another that corresponds to the location at the bottom. Other location lines have an internal representation of a dateline based on the GMT offset of that location, so the actual dates and times of points along these location lines can also be determined.

Although the graphical visualization of the itinerary provides a useful overview of the entire itinerary (using the radar view) or a particular segment of the itinerary (using the main view), the users also need to be able to access the exact details of particular events when such information is needed. This capability is provided by a range of textual information which can be easily accessed. For instance, the users can access information relating to an event by simply tapping on it using the stylus, which replaces the radar view with a summary of the textual information related to the selected event (Figure 3b). Alternatively the users may select an event using the stylus and then choose to view its details from a pop-up menu (Figure 4).

CALENDAR TRAVEL ITINERARY VISUALIZATION

The linear visualization of itinerary information forms the basis of the CIG, MATI, and PATI systems. Although various usability studies have shown the effectiveness of this form of visualization (Masoodian and Lane 2003), it should be treated as a visualization from amongst a range of other possible visualizations which the users may find more useful for a particular task. One of the objectives of the research work presented here has been to devise and develop other itinerary visualizations.

The calendar visualization is an alternative method of visualizing travel itinerary information. Figure 5a shows the calendar visualization of an example itinerary. As can be seen from this figure, the general interface of PATI
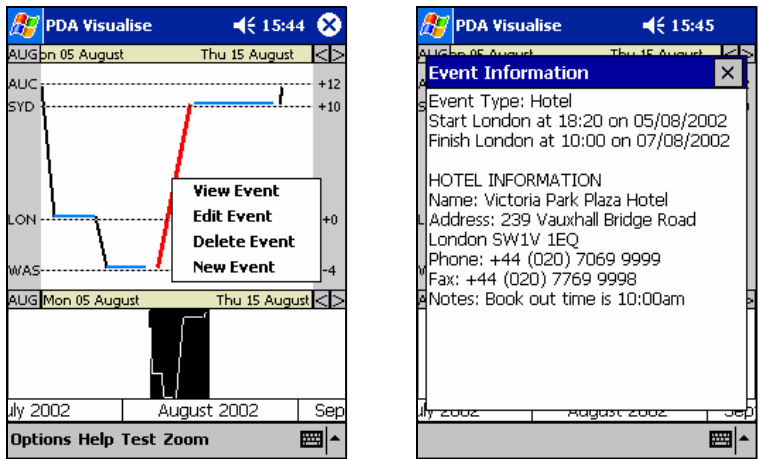
Figure 4: Selection of an event to view its details in the textual event information window
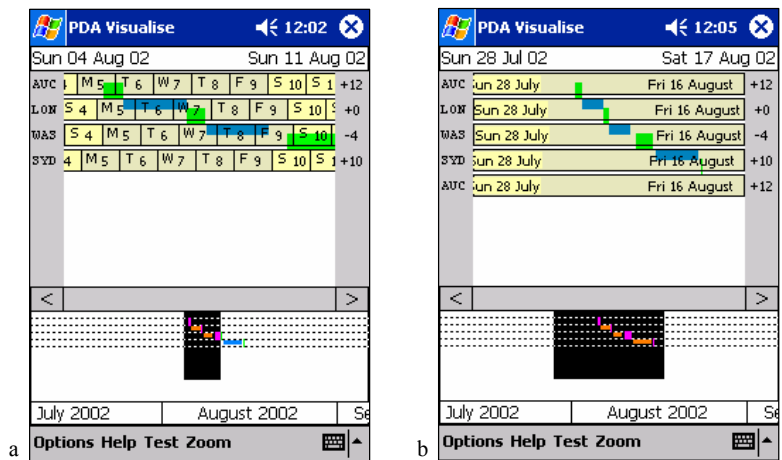

Figure 5: Calendar visualization of PATI with a) part of the itinerary selected, b) entire itinerary selected

remains the same as with the linear visualization, with the main view at the top and the radar view at the bottom of the screen. Furthermore, the main view is still used to show the selected segment of the itinerary, while the radar view makes it possible to select different regions of the itinerary to be shown in the main view (Figure 5b). In fact PATI allows the users to dynamically interchange between the linear and calendar visualization to choose the most suitable form of itinerary visualization for a particular task.

Despite having similar interface components, however, the calendar visualization of PATI is radically different from its linear visualization. The location lines for the destination cities of the itinerary are drawn on the visualization in the order they are visited during the trip, rather than their geographical time-zone locations. PATI displays the itinerary information by firstly selecting the events that lie within the range of the visible section of the itinerary, and then the events are ordered on a chronological basis. The events are sequentially processed and when a flight event is encountered a new location line for the destination city is drawn followed by the drawing of the flight event itself, which is shown as a green line between the location lines of the origin and destination cities. Stay events, on the other hand, are associated with a particular location, and therefore are drawn on the location line for that particular location (shown as blue lines). This process generates a visualization that looks much like a waterfall.

For example consider the following itinerary, which is shown in the usual chronological order:

1. Flight from Auckland to London.

2. Hotel stay in London.

3. Flight from London to Washington.

4. Hotel stay in Washington.

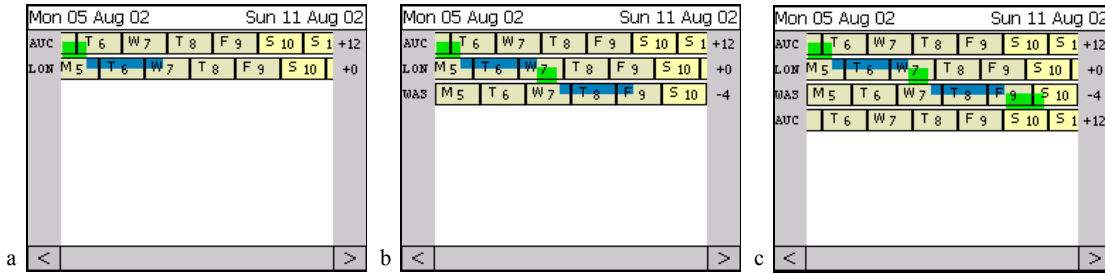5. Flight from Washington to Auckland

Figure 6: Creation of an itinerary in the calendar visualization

Initially when the visualization is being generated there are no current location lines visible, and it is not until itinerary events are processed that they appear. The flight from Auckland to London is the first event to be processed, during which Auckland is made the current location and a location line for Auckland is drawn. This flight changes the current location to London and a location line for London is also drawn, followed by drawing a green event line to represent the flight between the two cities. The hotel stay in London (event 2) is processed next, but as hotel stays occur in single locations, there is no need to draw a new location line and only a blue line representing a hotel stay is drawn on the current location line of London (Figure 6a). Event 3, the flight from London to Washington, indicates a location line change which means that a location line is drawn for Washington, followed by drawing a line representing the flight between London and Washington. Event 4 is a hotel stay in Washington, so a hotel stay line is simply drawn on the current location line (Figure 6b). The trip back to Auckland (event 5) changes the current location line yet again, but instead of reusing the already existing location line for Auckland, a new line is drawn and a flight event line is drawn to link Washington and Auckland (Figure 6c). If the existing Auckland location line was reused, the flowing waterfall effect of the visualization would be disrupted.

Another difference between the calendar and linear visualizations is that in the calendar visualization the location lines are no longer represented as dashed lines, but have been replaced with datelines because locations are no longer sorted on time-zone values when they are displayed. The fixed top and bottom datelines of the linear visualization are no longer present, and the location lines now appear according to the order which the itinerary demands. This means that time-zones are not necessarily in order. However, to make it possible to effectively approximate and compare the time of various events, datelines drawn for each location take into account the time-zone differences between that location and other locations shown on the itinerary. For instance, in Figure 7a the London dateline has an offset of 12 hours east of Auckland, which shows that Auckland is 12 hours ahead of London. Therefore, taking any point on a dateline and looking vertically up or down at another dateline will give a time comparisons between the locations of those datelines.

The position and width of event lines, as well as their colour, indicate the type of a particular event, which is either a travel or a stay event. Travel event lines (such as lines for flights) are drawn in their set colour (flights are shown in green) in the lower half of the dateline of the city of origin and reach out to touch the dateline of the destination city (see Figure 7b). Stay events are drawn in their colour (hotel stays are blue) in the upper half of the dateline of the location they refer to. All event lines have a degree of transparency so that the portions of the dateline underneath them remain visible.
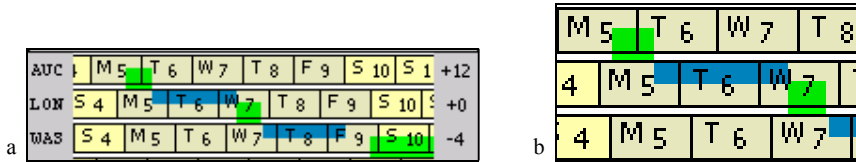

Figure 7: a) Time-zone differences between locations, b) event type differences between travel and stay events

PATI displays only the minimum number of the datelines necessary for a selected region of the itinerary in the main view. This preserves space and prevents clutter from unnecessary itinerary information. For instance, consider the view of an entire itinerary presented in Figure 8a where five datelines are present, and then compare it with the view of the same itinerary in Figure 8b where only the datelines for the first three locations are visible, as the remaining events are not in the selected region of the itinerary and therefore are not visible in the main view. The number of visible location lines is automatically adjusted to the minimum level whenever the user scrolls, zooms, or does a modification to the itinerary, such as adding or deleting an event.
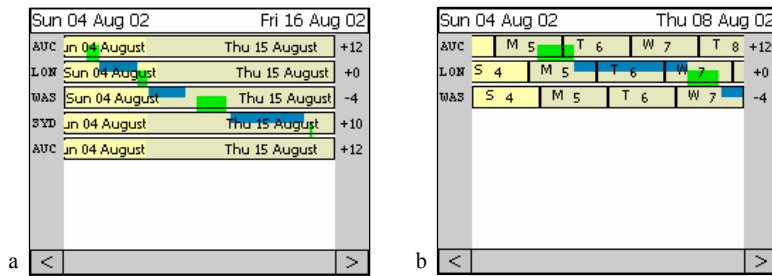
Figure 8: Minimal number of location lines shown when a) the entire itinerary is selected, b) part of the itinerary is selected

USER EVALUATION OF LINEAR AND CALENDAR VISUALIZATIONS

An empirical study was conducted to compare the effectiveness of the linear and calendar visualizations in providing users of PATI with easy access to their travel itinerary information. The aim of this study was also to identify as to whether the users preferred either of these visualizations over the other one in terms of their effectiveness in general, or in particular for providing a good overview of the itinerary or access to specific details of the travel events.

Methodology

The primary objective of this study was to evaluate the performance of PATI when used in linear and calendar visualization modes. Participants completed two independent tasks, one with each of the two visualizations. Comparisons between the visualizations were based on the performance of the participants as indicated by the tasks, and their satisfaction as shown by the post-task and comparative questionnaires.

The study had a *within-subject* design, where each participant performed tasks within each environment (see Table 1). The design was counterbalanced so that any transfer of learning did not influence the results. The tasks, based on realistic fictional itineraries, were randomized across the two visualizations. The 2^1 (2) design used required at least 2x1 (2) participants for each group. Each test group was replicated 6 times leading to 12 participants in the study.

Participant	Linear Visualization	Calendar Visualization
1	Task 1	Task 2
2	Task 2	Task 1

Table 1: Within-subject design of the experiment

Participants were asked to fill out a background questionnaire at the beginning of the session, providing details such as age, prior travel experience, and PDA usage. Then after doing a tutorial based on the visualization about to be used, the tasks were performed. The participants interacted with PATI using a Compaq iPAQ™ PDA. This gave users full realism of the system, where they were able to hold the PDA in one hand and use the other hand for operating it with the stylus. The only unrealistic aspect of the PDA was a bulky video capture device that doubled the width and weight of the PDA. This capture device also had a video signal cable coming out of the side of it which made the PDA less portable. The users therefore had to sit the PDA on a desk in an accessible place and use it there.

Subjects

Subjects were mainly local university students, and each received a book voucher for their participation in the experiment. All but one participant had travelled abroad, nearly half had travelled six to ten times, and one-third had used a PDA previously. Table 2 gives a summary of the profile of the subjects.

Average Age	31 years	
Occupation	Students	50%
	Administration/Lecturer	17%
	Other	33%
International Travel Experience	Yes	92%
	No	8%
PDA Users	Yes	16.5%
	No	83.5%

Table 2: Profile of the subjects

Tasks

Two tasks were used in this study, each consisting of eleven questions. Both tasks had a similar level of difficulty. A fictional travel itinerary of an international trip to multiple countries was allocated to each task. Each task contained activities that required interaction with the interface, and interpretation of the visualization information. Table 3 shows a summary of the questions for Task 1.

Questions
1. Looking at the itinerary, which city is your home? i.e. which city does the itinerary start and finish in.
2. What are the time and date details of your arrival in London?
3. Is the flight between London and Washington longer than the duration of your hotel stay in Washington?
4. Please write the name of the hotel that you will stay at in London.
5. Look at the details of the first flight on the itinerary which goes to London. Name the airline which will carry you on this flight and state how many stops the airplane will make on the way.
6. You are a major fan of European soccer. There is a special soccer game kicking off at 17:00 on Monday 5th August 2002 in London. You know that you are arriving in London on that day and may be able to see the game. Are you able to go to the entire game?
7. Your family has asked when you are expected to get back in to Auckland as they are happy to come and collect you from the airport, no matter what time it is. What time and date do you arrive back in Auckland?
8. The travel agent who designed your itinerary calls you on your mobile phone just before you board the plane in Auckland and tells you that an extra event has been mistakenly put into your itinerary. The event has been put on your itinerary somewhere near the 5th of September 2002. The travel agent tells you to delete this event. Please attempt to delete this event and indicate below if you were able to delete it.
9. During your travel you make a phone call to your friends in Sydney who you expected to stay with while you are in the city. Unfortunately they tell you that you are now unable to stay with them. You contact your travel agent to make a booking at a hotel in Sydney for you. These are the details of the hotel stay: *Arrival Time: 14:00 on 11/8/2002*   *Departure Time: 10:00 on 15/8/2002*   *Hotel Name: Stellar Suite Hotel*   *Address: 4 Wentworth Ave, Sydney*   *Phone: (02) 9264 9754*   Please add this event to your itinerary. We do NOT wish you to enter the hotel name, address or phone number into the itinerary, just enter the arrival and departure times.
10. Choosing from the hotel stays in London and Washington, which is the longest stay?
11. Choosing from all flights you take in your trip, which is the shortest flight?

Table 3: Summary of the questions of Task 1

A post-task questionnaire was completed after each task, asking the users to rate various aspects of the visualization which they had just used. Table 4 gives a summary of the relevant parts of this questionnaire. After users had completed both tasks they also completed a comparative questionnaire, which aimed to find out their preference for each of the two visualizations. Table 5 gives a summary of this questionnaire.

Questions
1. How much information did you think was represented in the interface to assist you with completing the tasks?
2. How difficult did you find it to get time and date details of an event?
3. How difficult did you find it to get details about the hotel events?
4. Rate your difficultly of navigating the interface.
5. Rate your difficulty of understanding what section of the itinerary you were looking at.
6. Rate your difficulty of comparing hotel events.
7. Rate your difficulty of comparing flight events.
8. Rate your difficulty of zooming using the radar view.
9. Rate your difficulty of zooming using the menus.
10. Rate your difficulty of locating an event.

Table 4: Summary of the post-task questionnaire

Questions
1.   I found the following visualization easiest to determine the overall schedule from.
2.   I found the following visualization easiest to determine the length of a flight from.
3.   I found the following visualization easiest to determine the length of a hotel stay from.
4.   I found the following visualisation easiest to understand overall.
5.   I found the radar view associated with the following visualization the clearest to understand.
6.   I found the following visualization easiest for comparing two flight events.
7.   I found the following visualization easiest for comparing two hotel stay events.
8.   I found the following visualization easiest to add an event to.
9.   I found the following visualization easiest to delete an event from.
10. I found the following visualization easiest for getting specific information about an event (e.g. name of a hotel).
11. I found the following visualization easiest to do zooming with.

Table 5: Summary of the comparative questionnaire

Data Collection

The experiment was conducted in a usability laboratory, where video recordings of the sessions were made using digital video equipment. Video feeds from (i) the PDA screen capture device, (ii) a camera pointing at the subject's face to capture facial expressions, (iii) and a camera pointing at the subject's task sheet were combined into a single tiled video image and recorded onto tape.

RESULTS

A range of analyses were carried out on subjective and objective data collected during this study. Objective measurements included the time taken to complete each of the task questions and the accuracy of the answers, while the subjective measurements included the users' satisfaction with each of the visualizations. The objective data collected were analysed on a participant basis, as well as a question basis.

Means Analysis by Participant

Table 6 shows the average time taken to complete each question of each task by each participant, and the accuracy of task completion. These results indicate that not much difference exists in the average time taken to complete the task questions. The average time to complete a task question for the linear visualization is only six seconds less than the average time for the calendar visualization. The accuracy of task completion for tasks done with the calendar visualization were slightly higher, as eight participants, compared to five for the linear visualization, found the correct answers for all the questions. However, incorrect answers from two participants caused the average for the accuracy of the calendar visualization to be one percent lower than the linear visualization. The p-values calculated in Table 6 have a null hypothesis that population means for each visualization are equal. P-values less than 0.05 reject the null hypothesis. Therefore there is no significant difference between the time taken to complete a task question with the linear visualization or calendar visualization, and there is also no significant difference between the accuracy values.

	Linear Visualization	Calendar Visualization	p-value
Average time taken to complete a question	52.1 seconds	58.2 seconds	0.530
Accuracy of task completion	93%	92%	0.867

Table 6: Summary of means analysis by participant

Means Analysis by Task Question Type

The tasks used in this study consisted of a set of questions with similarities existing between some of the questions across the tasks. This allows a comparative analysis of questions between the two visualizations. Table 7 shows the results of the means analysis for each question type. For all, except two questions, there are no significant differences between the two visualizations. One of these significant differences between the visualizations is for one of the time and date details type questions (question type 2), while the other one is for a deletion task. However, both of these questions are related to an isolated event within the task itinerary. The analysis indicates that the calendar visualization is not very effective for finding short events near the end of an itinerary, and the participants took longer to find them.

Question Type	p-value Task 1 (Linear) vs. Task 2 (Calendar)	p-value Task 2 (Linear) vs. Task 1 (Calendar)
1. Find event time and date details (1)	0.417	0.990
2. Find event time and date details (2)	0.241	0.011
3. Find a hotel name	0.726	0.759
4. Make a decision to attend a sports game	0.715	0.400
5. Delete an event	0.147	0.004
6. Create a hotel stay event	0.142	0.225
7. Longest event search	0.632	0.971
8. Shortest event search	0.218	0.299

Table 7: Summary of means analysis by question type

Responses to Post-Task Questionnaires

Table 8 gives a summary of the analysis of the post-task questionnaire results. This shows that overall the linear visualization has been rated favourably for all tasks, except zooming using the radar view, and having sufficient information to complete the tasks. This means that the calendar visualization can be considered to have a slight information representation advantage over the linear visualization, while being generally more difficult to use. The activities marked as much more difficult to do with the calendar visualisation, when compared to the linear visualisation, are navigating the interface and locating an event. These difficulties are not surprising given that the calendar visualization scrolls in such a way that takes much more getting accustomed to than the linear visualisation. Also short events are sometimes drawn very small on the calendar visualisation, especially at a wide zoom level.

Questions	Linear Visualization	Calendar Visualization
1. Having sufficient information to complete the tasks	1.92	1.75
2. Difficultly in getting time and date details of events	4.42	4.00
3. Difficultly in getting details about the hotel events	4.58	4.17
4. Difficultly of navigating the interface	4.15	3.67
5. Difficulty of understanding itinerary sections	4.17	3.83
6. Difficulty of comparing hotel events	4.58	4.33
7. Difficulty of comparing flight events	4.67	4.25
8. Difficulty of zooming using the radar view	4.00	4.17
9. Difficulty of zooming using the menus	4.33	4.00
10. Difficulty of locating an event	4.58	3.92

Table 8: Summary of the analysis of the post-task questionnaire results

Responses to Comparative Questionnaire

Table 9 shows the results of the analysis of the comparative questionnaire. These results indicate that generally the users either preferred the linear visualization, or found both visualizations to be equal. The only activity for which the calendar visualization was preferred was finding the length of a flight. This result is rather expected as in the calendar visualization the length of a flight is shown as a horizontal line, in a similar manner to the length of a hotel stay and other events. In the linear visualization, on the other hand, the length of a flight is determined by projecting a diagonal line onto a horizontal timeline for a particular destination.

Questions	Linear Visualization	Calendar Visualization	Both
1. Easiest to determine the overall schedule from	75%	0%	25%
2. Easiest to determine the length of a flight	33%	42%	25%
3. Easiest to determine the length of a hotel stay	42%	8%	50%
4. Easiest visualisation to understand overall	58%	25%	17%
5. Associated radar view clearest to understand	42%	17%	42%
6. Easiest to compare two flight events	67%	17%	17%
7. Easiest to compare two hotel stay events	50%	8%	42%
8. Easiest to add an event to	33%	17%	50%
9. Easiest to delete an event from	25%	0%	75%
10. Easiest to get specific information about an event	25%	0%	75%
11. Easiest to do zooming with	33%	25%	42%

Table 9: Summary of the analysis of the comparative questionnaire results

CONCLUSIONS

This paper described a new calendar travel itinerary visualization, developed as an extension to an existing system called PATI which also provides a linear visualization of itinerary information. Both of these visualizations allow accessing and modifying personal travel itinerary information using PDA type handheld devices. An empirical study of PATI was also conducted to compare the linear itinerary visualization with the calendar visualization.

The user study identified various issues related to the overall usability of the systems, but failed to find major differences between the two visualizations in terms of the time taken to complete the experimental tasks or the accuracy with which the tasks were completed. However, minor statistical differences in doing certain itinerary activities were identified. The users also perceived the calendar visualization to be less favourable than the linear visualization. Participants preferred using the linear visualization because they thought its components were easier to identify.

These results are to some extent against our expectations, which predicted that the calendar visualization would be more familiar to new users as they use calendars regularly. It was felt that this familiarity would be beneficial to the use of the calendar visualization.

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