Dynamic Visualisation of Ski Data: A Context Aware Mobile Piste Map

Mark D Dunlop
Computer & Information Sciences
University of Strathclyde
Richmond St, Glasgow, Scotland
+44 141 548 3497
Mark.Dunlop@cis.strath.ac.uk

Brian Elsey
Computer & Information Sciences
University of Strathclyde
Richmond St, Glasgow, Scotland
Brian.Elsey@gmail.com

Michelle Montgomery Masters
Computer & Information Sciences
University of Strathclyde
Richmond St, Glasgow, Scotland
+44 141 548 4311
Michelle@cis.strath.ac.uk

ABSTRACT

Tourism has been a key driver for mobile applications. This short paper presents the design and initial evaluation of a mobile phone based visualisation to support skiers. Paper piste maps often prove difficult for skiers and provide no natural way of assessing the mountain conditions while on the slope. They are physically large and difficult to manipulate in wind, they provide no information on which runs are currently open, no indication of which runs the user may find most enjoyable, and no information about the snow and weather conditions on each run. All this information is available at resorts, usually on notice boards or screens at central meeting points. The visualisation and personalisation approaches presented here combine this information and a map overview on a mobile phone screen. Initial trials showed significantly better performance for some tasks on the mobile condition (both in terms of accuracy and time), with no clear result for other tasks.

Categories and Subject Descriptors

H.5.2 [**Information Interfaces and presentation**]: Evaluation, screen design, Graphical user interfaces (GUI); I.3.6. [Computer Graphics]: Interaction techniques

General Terms

Design, Human Factors, Experimentation,

Keywords

Visualization, mobile devices, personalisation, maps, skiing.

1 INTRODUCTION

Mobile guides have been a key player in the development of smart mobile applications since the early days of mobile computing (e.g. [4]). Recently there has been considerable work on presenting map-based information in more usable formats on small screens (e.g. [1, 2, 5] plus considerable efforts by SatNav companies to improve usability of their devices) and some work on supporting sports activities on mobiles (e.g. [3, 6]).

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2 MOTIVATION AND KEY TASK

The main aim of our tool is to support skiers in selecting ski routes (either individual runs or combinations of runs to form a route) that are appropriate to their level of ability, their preferences, their current mood and current piste conditions. We aim to do this through visualisation of appropriate information on top of a piste map, so that users make an informed choice themselves rather than being simply presented with a list of recommendations.

3 PERSONALISATION DATA

The following information is used to personalise data for the individual skier and current conditions:

- *Piste classifications*: using the European scheme pistes are graded as green, blue, red, and black – in increasing levels of difficulty from "beginner" to "expert". All runs are graded and the user sets his/her preferences on the phone for which grades (s)he would consider.
- *Grooming*: Grooming is a process of preparing a slope for skiing by packing and levelling the snow. Runs which have recently been groomed have a smooth surface that is optimal for skiing and are ideal for all standards of skier. Pistes that have not been groomed for some time tend to become rutted and may contain moguls (skier made mounds of snow). These conditions are unsuitable for beginners, but some more experienced skiers prefer these routes as they tend to be more challenging and varied. Within our system users state their preference for freshly groomed snow (*yes*, *no* or *don't mind*).
- *Ice*: Mostly independent of the piste classification, the knowledge of likelihood of finding ice can affect run choice. Ice on the piste can be a major hazard and many skiers want to avoid pistes with ice. This is especially true for novices, while more advanced skiers are typically less concerned. For personalisation, users can specify whether to avoid ice or not.
- *Maximum air temperature:* The ambient air temperature can significantly affect the surface snow. Low air temperatures mean the snow will be much lighter and faster, however the risk of ice is higher and the snow can be harder (i.e. more painful if the skier falls). The system allows users to state their maximum preferred air temperature between 0°C and 10°C.
- *Weather conditions*: Again the weather can significantly affect snow quality but also has a strong effect on visibility with cloud giving a a *flat light* that hides some contours. We modelled weather on a scale of Sunny, Light cloud, Heavy

cloud, and Snowing with users stating their preference as the worse case weather condition they would like to ski in.

- *Run and lift status*: Finally, lifts and runs are not always available and this information overrides other settings if a run cannot be skied.

User preference information is all set on a per-user basis (example widgets are shown in figure 1). Currently this information can only be user set and does not change automatically over time.

Figure 1: Sample user profile setting widgets

4 VISUALISATION

1.1 Basic Map

A standard resort map was used for a resort known to the team. The map contains run and ski lift information together with some additional information superimposed on a visual mountainscape. The data used covers 43 runs (3 green, 18 blue, 18 red and 4 black) and 22 lifts and is shown in Figure 2.

Figure 2: Reduced map of Val Thorens used on study

1.2 Layers

For our experimental prototype application a background mountainscape was used that included an overview of the mountains with some landmark information. This was superimposed with the following layers: run labels (user can toggle all on/off); lift labels (again all on/off); lifts (always on but drawn differently if open/closed); and runs (dynamically generated to match the user profile and drawn individually on top of other layers).

1.3 Runs

The personalisation data described above when combined with actual conditions results in a single figure for run suitability between 1 (least suitable) and 5 (most). We experimented with four different visualisations for run suitability.

Colour saturation is often used in visualisation to highlight items that match a situation well while still displaying others. Figure 3 shows an example. While clear on this example, the use of five different colour saturation scales made it difficult to assess run suitability and made some runs harder to see than others of equal suitability but different classification (primarily due to varied human perception of colours, contrast to map background colours and screen variations on mobiles).

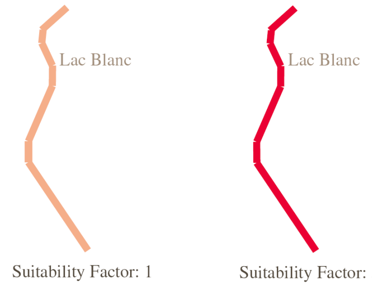

Figure 3: Colour saturation run visualisation

Direct annotation was used by either labelling the run with the suitability as a number (Figure 4 left) or as a bar graph (right). While easier to read than colour gradient and successfully used elsewhere for point-landmark appropriateness [2], the numbers and graphs added to clutter and, on busy parts of the map, difficult to associated correctly with the lengthy runs on our data.

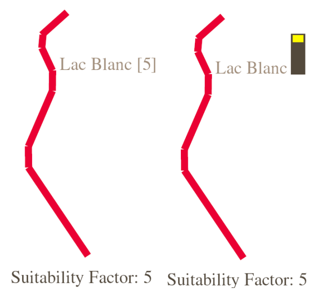

Figure 4: Direct labelling (left number, right bar-graph)

Finally we experimented with line width as shown in Figure 5. This appeared to have the best compromise between clarity and immediate comprehension to support identification of likely runs. Though were limited in the range of suitability factors displayable, this approach was chosen for experimentation.

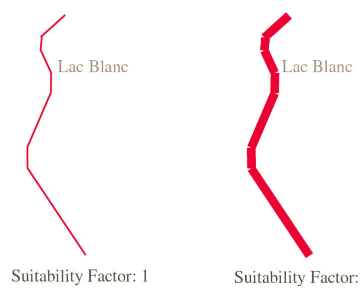

Figure 5: Width of line visualisation

Figure 6 shows a sample area of a ski resort as shown on a mobile phone screen. This screen shows the display for a user who has preferences for blue and red runs (plus 2°C max temp, avoid ice, worse light cloud). Here the two red runs (running from top-right down to bottom-centre) are both highly suitable. There are also five partial blue runs visible on this screen with the two coming in on centre-right more suitable than the lower three. Given a user preference for red and blue runs (with red being harder), the best run may well be one of the upper blue runs but if the skier was in a brave mood or knew this resort's ratings were on the safe side, it would be a good opportunity to try a red run given their high suitability.

Figure 6: Sample combined visualisation

5 IMPLEMENTATION

The application was developed in Java 2 Micro Edition (J2ME; MIDP-2.0; CLDC-1.1) targeting a typical current mobile phone screen of approx 210x175 pixels. Development was in NetBeans Mobility Pack and tested using Sony Ericsson SDK on desktop and a Nokia 6680 phone for device and user testing.

For experimental reasons, a fixed data set of weather conditions sourced from Val Thorens was used throughout tests. Overall the conditions were: as height increased the temperature decreased; the village was very cloudy and snowing with amount of cloud decreasing as height increased; pistes further away from the village were less likely to be groomed than those closer; and pistes on the glacier or north facing were more likely to have ice. This data was stored as an XML file on the phone's memory card but could easily be sourced live through a GPRS/UMTS connection. The data on weather, run/lift opening, grooming, and snow conditions are all available as standard at most resorts and could easily be provided as a suitable XML feed.

6 EVALUATION SETUP

Initial evaluation reported here was carried using 10 users who were all experienced skiers (of varying ability). Six scenarios were developed to compare two test conditions: using the mobile phone based piste visualisation alone or using traditional paper map augmented with notice-board style information on piste condition and weather (as a single sheet of data). The scenarios were designed in pairs addressing similar types of task and users were allocated randomly to two groups balancing use of electronic and paper sources per scenario.

The first two scenarios tested the users' ability to find individual runs suitable for a certain set of conditions and were as follows:

1. Find what you perceive as the best 5 runs in the entire ski area, by entering your own personal preferences into the profiler.
2. Two advanced skiers would like a challenging run to race each other on. They would like a run, either red or black, with suitable conditions for racing, i.e. freshly groomed with no ice. Find the 3 most suitable pistes for these skiers.

The next two scenarios test the users' ability to plan routes taking into account a given profile and that some pistes or lifts may be closed:

3. Find the most suitable route from the Val Thorens village to the restaurant at the top of the Col lift. In this scenario you are an intermediate skier, preferring mainly blue and red runs, and having no preference about temperature or condition of runs. However, sunshine is preferred for maximum visibility.
4. Find a route from the Val Thorens village to the top of the Cime Caron lift for a novice skier. The chosen pistes should be preferably green or blue, have no ice and be freshly groomed. Weather conditions and air temperature are not important to this skier.

The final two scenarios test the users' ability to plan the shortest route (with fewer constraints but still with some lift/run closures):

5. An advanced skier that can handle any run would like to get back to the Val Thorens village as soon as possible. Currently the skier is at the top of the Boismint lift. There are no preferences to which runs are used, but the shortest route is critical.
6. An intermediate skier is at the restaurant at the top of the Moutiere lift. However, she has realised it was the restaurant on the Dalles piste (at the top of the Cascades lift) she was supposed to meet her friends at so she has to find as quick a route as possible. Since she will skiing fast she would prefer blue or red runs that have been groomed and have no ice. Weather conditions are not an issue to her.

7 EVALUATION RESULTS

For finding appropriate individual runs (scenarios 1 and 2), times were similar between conditions with no user errors in either condition. Scenario 1 proved to have a significant timing result in favour of paper (at 0.05 level using two-tailed t-test), while there was no significant result for scenario 2. The mean time for task 1 and task 2 was almost identical (2 minutes 27 compared to 2:28, when average across both conditions per task), thus it was felt that the two simple finding scenarios could be safely combined for analysis. This combined analysis resulted in no significant difference being detected ($p=0.208$) for task completion time.

For planning a suitable route (scenarios 3 and 4), times varied more than for scenarios 1 and 2, with the mobile phone version being approximately 40% faster than the paper condition. This difference proved statistically significant ($p=0.023$) for scenario 3. Again, as mean times across both conditions were almost identical (04:21 vs. 04:18) we carried out a combined analysis for these tasks that led to a strong statistically significant combined result in favour of the mobile condition for suitable route planning tasks ($p=0.007$). In the mobile phone condition, no users picked a route that was unsuitable given the scenario but 3 out of 10 users picked an unsuitable route when working on paper.

For scenarios 5 and 6 on finding the shortest route, the results differ between task 5 and 6. Completion times in task 5 were not significantly different. Task 6 took noticeably longer than task 5 overall and was statistically significant in favour of the mobile condition. No overall test was conducted as the task complexity was not similar enough. Both conditions showed high accuracy with no errors.

Results are summarise in table 1 together with p values from t-tests, statistically significant results are shown in bold.

Table 1: Average task times per scenario in min:secs with two-tailed t-test probabilities of difference being random

	Scenario					
Condition	**1**	**2**	**3**	**4**	**5**	**6**
Mobile	**02:50**	02:27	**03:42**	03:32	03:57	**04:12**
Paper	**02:13**	02:31	**05:01**	05:05	03:40	**05:40**
p	**0.050**	0.823	**0.023**	0.113	0.502	**0.020**
$p_{combined}$	0.208		**0.007**		n/a	

8 DISCUSSION AND FUTURE WORK

The overall aim of this work was to produce a mobile phone system that combined piste maps with notice-board information on weather and piste conditions that was easier to use than current approaches. To achieve this we used personalisation and visualisation techniques to overlay runs on a ski resort map where the width of run lines was determined by run availability and user preferences on difficulty, snow conditions and weather conditions. We conducted a small study comparing our mobile implementation with a full sized resort map and printed condition information. The results showed either no clear difference between conditions or, in the case of finding a route suitable for a given profile, higher accuracy combined with significantly lower task times for the mobile condition.

Due to implementation issues (primarily the complexity of memory management for large images in J2ME), the map was split into 4 quadrants with users required to zoom out, change quadrant on an overview screen then zoom in to the new quadrant. Although not recorded separately, time spent zooming did appear to slow users down (most noticeably on tasks 1 and 2). Better memory management should alleviate this and further speed up tasks done on the mobile platform. Linking the map to GPS information would also be useful as would using this GPS information as implicit feedback to improve suggestions by boosting the ratings for the conditions reported on any runs that the skier actually took (c.f. for example implicit feedback within a restaurant guide [5]). Finally, larger trials should be conducted to assess the suitability of the system. In particular, on-piste tests using live data coupled with skiers wearing ski gloves would provide new insights into the presentations and their usefulness.

In conclusion, we feel that this work has been successful with results showing that despite the very small size of screen used, the personalised mapping approach successfully replaces the traditional sources of information and allows users to satisfactorily complete fairly complex tasks.

9 ACKNOWLEDGMENTS

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