GoraNiNora: Context-Dependent Information for Safe Mountain Visits

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Abstract. The rise in mountaineering accidents, notably from snow avalanches, highlights the need for enhanced safety measures in mountain tourism. This study leverages mobile computing to address the gap in mountaineers' practical knowledge through GoraNiNora[3], a mobile app providing context-sensitive educational content. Developed on the basis of survey results involving 950 mountaineers and in collaboration with eight professional mountaineering experts, GoraNiNora utilizes real-time location and weather data to offer tailored advice improving a user's safety and knowledge. A usability evaluation confirms the app's effectiveness and user-friendliness, suggesting that GoraNiNora could contribute to safer mountain tourism by enriching mountaineers' knowledge and experience.

Keywords: mountain safety · context-aware notification system · mobile application · Android · mobile sensing

1 Introduction

The allure of mountaineering has significantly grown, driven by the search for adventure and escape from the rapid pace of daily life. This increase in mountain tourism has, however, led to a rise in mountaineering accidents, particularly problematic in the context of winter mountaineering without proper experience. Accident statistics of the Mountain Rescue Association of Slovenia (GRZS) show that the number of interventions in the mountains has doubled in the last ten years. If in 2010 there were only around 300 GRZS interventions, in 2020 there were already more than 600. [11, 15]. The integration of Information and Communication Technology (ICT) in outdoor activities presents a promising avenue to address montaineering safety, as ICTs, thanks to ubiquitous connectivity and sensors embedded in mobile devices can provide timely and context-relevant information. Nevertheless, the existing mountaineering-oriented mobile apps often lack context-awareness, failing to deliver real-time, location-specific, and quality educational content and safety information.

[3] GoraNiNora literaly translates to "The Mountain is Not Crazy"

In this paper we present the design and development of *GoraNiNora*, a mobile app that bridges the above gap and provides dynamic, real-time montaineering advice based on the user's current location and weather conditions, while conserving battery life. GoraNiNora was designed after a comprehensive study that includes in-depth interviews and surveys with mountaineers to understand their needs and the practical knowledge gaps that exist. Based on these insights, a context-aware app was designed and developed. Our evaluation of the app focuses on its usability and effectiveness in delivering educational content. By addressing the limitations of existing solutions and incorporating advanced mobile computing technologies, GoraNiNora represents a promising research direction within the field of human-computer interaction, particularly in the context of outdoor safety and education. The implications of our findings extend beyond mountaineering, offering insights into the design and development of context-aware mobile applications for a variety of outdoor activities.

2 Background and related work

The increasing popularity of outdoor activities, particularly mountaineering, has been accompanied by a corresponding rise in the development of mobile applications aimed at enhancing the safety and experience of participants. In 2012, three apps appeared: iSis, Snøg, and SnoWhere [9], which the developers touted as life-saving apps. The applications detected whether the user was involved in an avalanche and notified the contacts and competent services in that area. These apps did not warn the users of the dangers in the mountains and did not educate them, but only took action when the a user was already in danger. The Canadian Avalanche Center was well aware of this, and very quickly issued a warning and advised against the use of such applications instead of avalanche beacons [10]. The following year, 2013, the applications were withdrawn from the market due to the realization that people's lives depended on their correct functioning. In summary, the solutions mentioned above are either *reactive* focus on rescue or are a source of very general educational content that prevents their practical use. With GoraNiNora, we develop a versatile practical *proactive* tool that improves the safety of participants in the mountains.

The fields of context-aware computing and resource-efficient mobile computing have made significant strides in past decades due to advancements in mobile sensor technology and algorithms enabling applications to adapt their behavior based on the user's context [14], [17]. These technologies offer the potential for creating more personalized and relevant user experiences, for instance, by adapting to a user's physical activity [18]. However, their application in the domain of outdoor safety and education remains challenging. Critically, it is important to fully understand the domain in which the app will be used, so that the key dimensions of the context and the key affordances of mobile computing and sensing can be identified.

3 Methodology

The development of "GoraNiNora" was informed by a comprehensive research methodology that included surveys, in-depth interviews, and usability testing. This approach enabled the collection of valuable insights into the needs and preferences of mountain tourists, as well as the practical challenges they face.

3.1 Survey

The success of the development solution is also influenced by the interaction between the users and the developers of the solution [16]. To obtain a detailed overview of the habits of users regarding the use of avalanche devices, their education in the field of mountaineering safety, and the equipment used while in the mountains, we conducted an online survey. We used the online tool 1KA for the survey and published it on the Slovenian mountaineering association website and in two Facebook groups (*Turno smučanje – Snežak* and *Ideje kam v hribe*) geared towards local mountaineers and touring skiers. We have collected answers from 950 respondents (72% male, 28% female, avg. age 36.9 years).

The most common activities that the respondents engage in are mountaineering and ski touring. We are interested in how well-equipped the mountaineers and touring skiers are. *The avalanche trio*, which consists of an avalanche beacon, shovel, and a probe, is used by as many as 85 % of the touring skiers and only 65 % of the mountaineers. *The avalanche backpack* is also more common among touring skiers. From this data, we can conclude that people think that avalanches are dangerous only for ski touring, which is far from the truth, since avalanches threaten all visitors to the mountains in winter. The mountain climbers are very well equipped with crampons (95%) and ice axes (88%), while 80% of touring skiers use the above equipment. Finally, our survey shows that a first aid kit is also commonly present. We can estimate that Slovenian mountain visitors often go to the mountains relatively well equipped. Only the avalanche backpack is a relatively less used piece, probably due to its price, as it is the most expensive of all the listed equipment.

Regarding to use of tracking technology, somewhat surprising is that as many as 64% of respondents use GPS to track their route. This means that a mobile application that we develop would not consume additional energy to obtain the location, since it would not be the only one that would request the location from the Android system via the *Location API* (Application Programming Interface) [6]. On the other hand, such a prevalence of mobile phone use is problematic, as nearby electronic devices may disturb the avalanche beacon. This is not generally known, and, of those surveyed, 46% believe that electronic devices do not disturb the avalanche beacon, while among those who believe that electronic devices disturb the beacon, only 35% knew that the disturbance is the highest when the beacon is in the reception mode. We can conclude that users of avalanche beacons are not well acquainted with its operation, thus that there is an opportunity for improving the general training and education when it comes to the use of mountaineering equipment.

When it comes to obtaining relevant information, 99% of respondents get information about snow conditions online; 55% of respondents inquire about the situation from friends; 34% of respondents use mobile applications; and 12% of respondents use the radio. As many as 88% of respondents follow the report on the risk of avalanches before each tour, which means that information about the current situation is important to them. 93% of respondents go to the hills in pairs or groups, so the application could take into account that a user often does not venture into the mountains alone. Finally, only 55% of our respondents review the avalanche safety information every year. Those who do, usually attend avalanche safety lectures and full-day workshops in the field.

We believe that the respondents' lack knowledge about avalanche safety, confirmed by their answers indicating that the operation of the avalanche beacon necessary for a successful rescue is not widely understood, that the avalanche safety information is generally not revisited every year, and the fact that, on the average, users rate their experience level as 3.1 out of 5, point to the need of providing concise in-context information through our mobile app solution.

3.2 Interviews

We conducted interviews with eight experts in the field of mountain safety. We looked for people who are professionally engaged in work related to mountains or who have many years of experience in mountaineering. The purpose of the interviews was to learn as much as possible in the field of safety, technologies and in general the use of mobile devices in the mountains, so to identify critical information that should be supplied to our users. The interviews were up to one hour long. We spoke with experts from the Environmental Agency of the Republic of Slovenia (ARSO), the Mountaineering Association of Slovenia (PZS), the Administration of the Republic of Slovenia for Protection and Rescue (URSZR), the head of the Zelenica-Tržič Avalanche Protection Service, two volunteer mountain rescuers, guide and head of the Crossrisk project [8].

The approach to reducing accidents in the mountains with a mobile app that is supposed to replace the beacon and notify contacts in the event of an accident is flawed, was unanimously voiced by the experts. The experts are of the opinion that such an application gives the user the impression of safety, as the user is sure that the application will notify the emergency services in the event of an avalanche. Not only can such application fail to react in case of an avalanche, it can also give the user a false impression of safety and reduce the motivation for keeping oneself informed and prepared.

Our intention is develop an application for use in the mountains, thus, it is very important to know what the limitations of using mobile devices in the mountains in winter. Our interviewees noted that due to low temperatures and poor signal coverage in the mountains, the battery drains faster. Furthermore, the mobile device is usually kept as close to the body as possible due to heat and is therefore inaccessible. We also wear gloves in winter which makes it difficult to operate a mobile device. Therefore, *the interaction time with the device should be as short and infrequent as possible.*

Regarding the content, our interviewees agreed that the most important thing is to educate people, as in this way mountaineering-related accidents can be avoided naturally. There are swaths of educational materials about safety in the mountains, yet they are scattered around the Web and people have to locate the info themselves. Since a user may not even know which information is relevant for a particular situation, it may be difficult to extract the important knowledge before the trip. Thus, *there is an opportunity for a mobile app to provide relevant content to a particular use at a particular place and time.*

3.3 System requirements

Based on interviews and survey analysis, we formulated functional requirements focusing on the user's point of view and the desired affordances of the app:

- **Display contextually-relevant and general alerts.** The main purpose of the application should be to deliver context-dependent information to users when visiting the mountains, as well as information of more general importance, on the basis of which the user can decide to visit the mountains. Thus, we positioned alerts at the core of GoraNiNora. We decided to split the alerts into general and contextually-relevant alerts. *General alerts* are pertaining to a wider geographical area a user plans to visit. With these alerts, we want to warn the user in advance about various dangerous situations one can expect based on the general properties of the area. *Contextually-relevant alerts*, on the other hand, are to be displayed only when the application detects that the user is in the mountains.
- **Automatic context detection.** To issue relevant alerts, the app must accurately detect the context of a user. We identified a user's physical activity and her location as the key aspects of the context that need to be detected. Furthermore, there is a need for the app to automatically detect that a user is indeed venturing into mountains, as well as the need to obtain latent context, such as the information about the slope that a user is on, weather, and other factors.
- **View alert history.** To support the educational side of the engagement, the app should allow the user to revisit the earlier alerts and inspect them in more detail.
- **Usability in the outdoor environment.** GoraNiNora is to be used predominantly in outdoor winter environments, where there is a need for larger font size and a stronger contrast among elements. Due to this, additional restrictions are placed on the amount of content that can be shown in a single interaction instance.

4 System Design and Implementation

This section describes the system architecture, including its components and functionalities, and highlights the application's innovative approach to context-aware computing and battery efficiency.

4.1 Perception of relevant context

Mobile devices have a multitude of built-in sensors, such as accelerometer, gyroscope and GPS, which, combined with machine learning, allow the device to accurately determine the context of the user. In our application, the relevant context is determined by the location, current weather and avalanche conditions in the area where the user is located. The 1 table describes more precisely the data that the application captures to define the context, where the data is acquired through a mix of on-device sensing and remote API querying.

An important part of the context detection is the automatic recognition of hill walking. GoraNiNora monitors the GPS signal and a user's physical activity, and in case the user has walked at least 50 meters in elevation in the last 30 minutes indicates hill walking. This is signaled to a user through a notification. Furhter, the application enables manual toggling of the hill walking mode.

4.2 Defining and triggering warning alerts

In the previous section we identified the need for showing relevant alerts to the user. In GoraNiNora we achieve this through the notification mechanism. If, and which, alerts will be shown is defined through a set of rules that describe the conditions that must be satisfied for the application to display a certain alert or warning to the user. We obtained these rules from discussions with experts and professional literature in the field of mountain safety. As detailed above, the warnings are divided into *contextually-relevant* and *general* alerts. Contextually-relevant alerts take into account the current location, slope, slope orientation, and altitude. The context is further expanded with the weather forecast, current avalanche problems, patterns, and known hazards. More specifically, using the user's current location GoraNiNora queries remote APIs of the avalanche bulletin and the weather forecast. The application then matches the acquired information with the predefined rules for displaying warnings, and displays any contextually-relevant warnings to the user.

General warnings are the ones that the user can look at every time she opens the application, even if she is not in the mountains. Depending on the geographical area that a user selects using a drop-down menu, the app displays general alerts for the region. With general warnings, we want to warn the user in advance about various situations in the mountains. For example, in case of rain or newly fallen snow, we want to inform the user in advance so that he can adjust the upcoming winter tours.

The rules for displaying general and current warnings are shipped with the app in a JSON file and are written to an on-device database when the application is first started. In the current prototype, the application will not retrieve new rules from an external source, yet, at a later stage, this rules could be handled by a public authority in charge of mountain safety.

4.3 User Interface

In accordance with the best practices of Android application development, the user interface is based on Fragments created in the context of various activities. The basic Fragments of the application are shown in Figure 1, and a detailed description of the warnings is shown in Figure 2.

Fragment for displaying warnings (Figure 1b) takes care of displaying contextually-relevant and general warnings fired during the current day. The Fragment also displays information on whether uphill walking has been detected and enables manual switching to the walking mode, if needed. *Fragment for displaying history* (Figure 1a) is responsible for displaying contextually-relevant and general alerts that the application has detected in the previous days. *Fragment to display settings* (Image 1c) ensures that the user can view the application's permissions, read the instructions again, and enable energy saving.

Activity to show current alerts by clicking notification notifies the user of currently detected alerts via a user-clickable Android notification. Clicking on the notification, the current contextually-relevant warnings are displayed (Image 2). *Activity to display alert details* takes care of the detailed description of the alert when it is clicked.

4.4 Use of sound and vibration to deliver alerts

From the analysis of user needs, we learned that the mobile device can be inaccessible while walking in winter, as we want it to be as close to the body as possible in a warm place. Even handling the device is very difficult due to the use of gloves. Therefore, we opted for an audio signal and vibration to be triggered when warnings are detected to signal potential danger. In this way, the user is informed about the received current alert can read it, or the application itself reads it with the help of the automatic text-to-speech translator. In the current version of the application issues the default notification sound and vibration, thus does not allow the user to distinguish between GoraNiNora-related and other notifications. In future, we plan to analyze the most appropriate warning methods in the context of a winter visit to the mountains.

Table 1: Data available for context recognition.

Data	**Description**	**Source**	**Sampling frequency**	**Availability**
Altitude	Height above sea level	GPS	60 s, when in mountains.	GPS signal coverage
Location	Geographical coordinates	GPS	60 s, when in mountains	GPS signal coverage
User physical activity	Walk or still.	Activity Recognition Transition API [1]	Handled by the underlying API, no control over it	Always

Slope	Angle of the slope in degrees °	ArcGIS API [2]	60 s, when in mountains.	GPS signal coverage, Internet connection
Exposure	Exposure in degrees from (0° to 360°)	ArcGIS API [2]	60 s, when in mountains	GPS singal coverage, Internet connection
Temperature	Altitude-dependent temp	ARSO weather [4]	Low (at least once per day)	Internet connection
Wind	Altitude-dependent wind speed	ARSO weather [4]	Low (at least once per day)	Internet connection
Weather	Cloudiness, weather events, and precipitation intensity	ARSO weather [4]	Low (at least once per day)	Internet connection
Problem	Avalanche problem in the snowpack	ARSO avalanches [3]	Low (once per day at most)	Internet connection
Pattern	Typical avalanche patterns	ARSO avalanches [3]	Low (once per day at most)	Internet connection
Danger	Avalanche danger level from 1 to 5	ARSO avalanches [3]	Low (once per day at most)	Internet connection

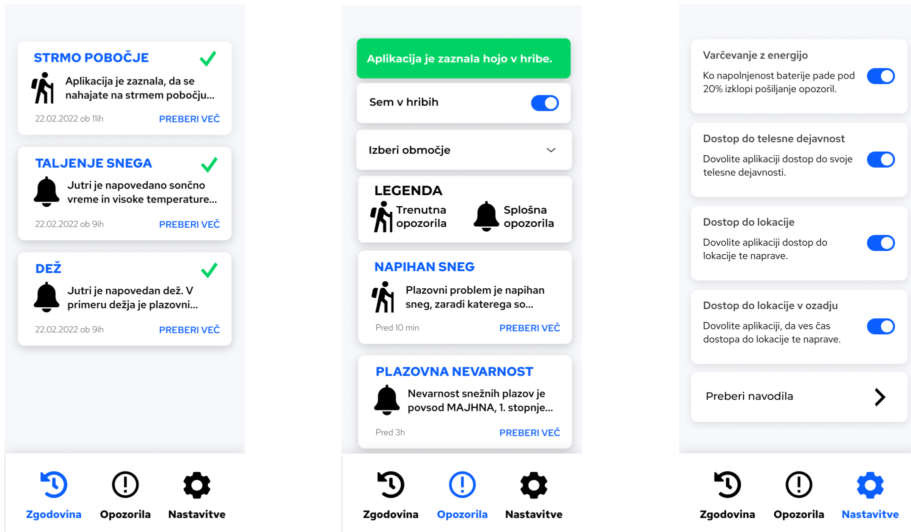
4.5 Battery Efficiency

Recognizing the importance of battery conservation in outdoor settings, GoraNiNora is designed to be able to take advantage of context-aware and approximate computing techniques to optimize energy consumption [17]. The application intelligently adjusts its data collection and processing activities based on the current battery level and the availability of critical information, thereby extending the device's battery life without compromising the delivery of essential safety information.

5 Usability evaluation

The testing took place with ten volunteers (7 male and 3 female) aged between 15 and 65 years. The purpose of testing was to determine if GoraNiNora is sufficiently simple and understandable to use. User experience and interface testing was done using interactive mockups in Figma [5].

Participants were asked to use GoraNiNora during a mountaineering activity designed to simulate typical usage scenarios. The System Usability Scale (SUS) [13, 12] was employed to quantitatively measure the application's usability. Post-activity interviews were conducted to gather qualitative feedback on the user



(a) History tab to display historical alerts.

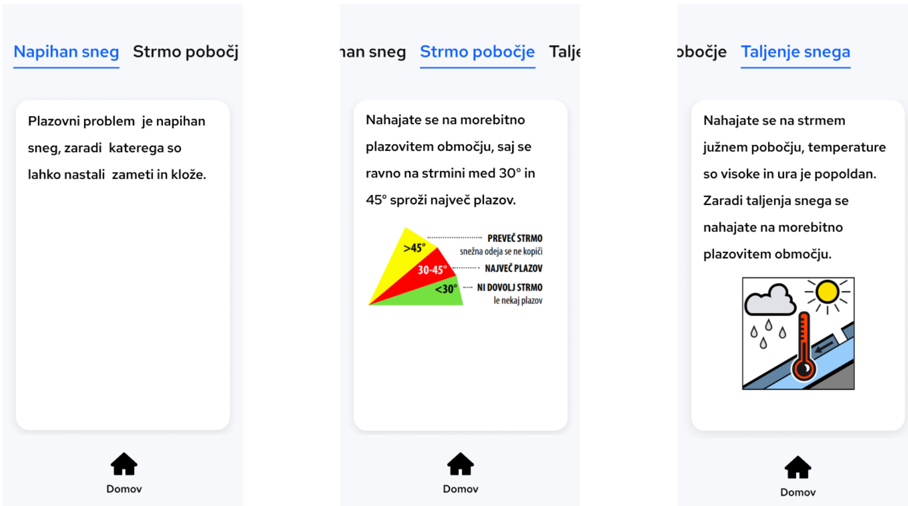
(b) Alert tab to display contextually-relevant and general alerts.

(c) Settings tab to edit app permissions, display instructions, and turn on power saving.

Fig. 1: Three main tabs of GoraNiNora.

experience, the perceived relevance of the educational content, and suggestions for improvements.

The SUS scores (average 89.75, standard deviation 5.83) indicated a high level of usability [7]. The usability evaluation also revealed areas for improvement. Testers tried to interact with the legend differentiating contextually-relevant from general alerts, mistaking it for a filter function, indicating a desire for alert filtering capabilities. Users expressed interest in seeing only contextually-relevant alerts during hiking and general alerts otherwise. However, to simplify interaction, especially with gloves, and prioritize the display of contextually-relevant alerts, a decision was made against implementing a filtering feature. Additionally, the notification indicating the app had detected hiking activity was not sufficiently noticeable in its original blue color, leading to oversights by some testers. This feedback led to the adoption of a more visible green color for this alert. Finally, one tester suggested that trust in the alerts could be enhanced by clarifying who is responsible for setting and managing the content of these alerts, proposing that this information be included in the app's instructions or settings.



(a) Blown snow (b) Steep slope (c) Melting of snow

Fig. 2: Examples of context-relevant alerts in GoraNiNora.

6 Discussion

In this study we analysed the potential for mobile technologies to enhance mountain safety. We discovered that while mobile devices may not currently serve as the best tool for accident detection, they hold significant promise for educational purposes. With the advancement of sensor technology in wearable devices, such as smartwatches, and the increasing prevalence of these devices, we anticipate a future where applications could accurately detect imminent dangers in real-time. The integration of augmented reality and on-device machine learning could enable users to identify hazardous slopes directly, thereby avoiding potential dangers.

Our application GoraNiNora represents a stride towards this future by offering context-dependent notifications to users based on data sensed on a smartphone and matched against predefined rules. This approach not only addresses the immediate need for educational content tailored to the mountaineer's current situation, but also opens up possibilities for predictive models that could identify new hazards based on the collected field data. However, it's crucial to acknowledge that the current set of rules within our system is not exhaustive. The expertise of professionals in the field will be invaluable in expanding these rules to cover a broader range of scenarios.

7 Conclusion

In this paper we designed and implemented GoraNiNora to demonstrate the significant potential of mobile apps to enhance the safety and knowledge of outdoor enthusiasts. By leveraging sensor data to deliver context-sensitive information, such as location and physical activities, and querying a number of external APIs, GoraNiNora acquires both general and contextually-relevant information and issues alerts to a mobile user. As we move towards a future where mobile and wearable technologies become increasingly sophisticated, the possibility of creating an ecosystem of applications that can accurately predict, warn, and, most importantly, educate users of potential hazards in real-time becomes more tangible.

Acknowledgement The authors thank the survey respondents, the interviewees, and the usability testers. This work was supported by the Slovenian Research Agency (grant P2-0098 and project J2-3047).

References

1. Activity recognition api, https://developers.google.com/location-context/activity-recognition
2. Arcgis summarize elevation, https://developers.arcgis.com/rest/elevation/api-reference/summarize-elevation.htm
3. Arso plazovi, https://vreme.arso.gov.si/plazovi
4. Arso weather forecast, https://meteo.arso.gov.si/met/sl/service/
5. Figma, https://figma.com
6. Location services, https://developers.google.com/android/reference/com/google/android/gms/location/LocationServices
7. Measuring usability with the system usability scale (sus), https://measuringu.com/sus/
8. Project crossrisk, https://crossrisk.zrc-sazu.si/
9. Snowsafe blog, https://www.snowsafe.co.uk/avalanche-transceiver-app/
10. There's not an app for that: Cac issues warning about avalanche apps (2013), https://newatlas.com/cac-warning-avalanche-search-apps/29575/
11. Accident statistics GRZS (2022), https://www.grzs.si/resevanje/statistika-nesrec/
12. Blažica, B., Lewis, J.R.: A slovene translation of the system usability scale: The sus-si. International Journal of Human-Computer Interaction **31**(2), 112–117 (2015)
13. Brooke, J., et al.: Sus-a quick and dirty usability scale. Usability evaluation in industry **189**(194), 4–7 (1996)
14. Chen, G., Kotz, D.: A survey of context-aware mobile computing research (2000)
15. Eidenbenz, D., Techel, F., Kottmann, A., Rousson, V., Carron, P.N., Albrecht, R., Pasquier, M.: Survival probability in avalanche victims with long burial (60 min): A retrospective study. Resuscitation **166**, 93–100 (2021)
16. Inukollu, V.N., Keshamoni, D.D., Kang, T., Inukollu, M.: Factors influencing quality of mobile apps: Role of mobile app development life cycle. International Journal of Software Engineering Applications (IJSEA), Vol.5, No.5, September 2014 (2014)
17. Pejović, V.: Towards approximate mobile computing. GetMobile: Mobile Computing and Communications **22**(4), 9–12 (2019)
18. Yamabe, T., Takahashi, K.: Experiments in mobile user interface adaptation for walking users. In: The 2007 International Conference on Intelligent Pervasive Computing (IPC 2007). pp. 280–284. IEEE (2007)