A localized avalanche risk assessment strategy assisted by on-site user-generated data

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Extended Abstract

Avalanche accident prevention and risk reduction consists of the following three main factors (Harvey et al. 2012):

(a) Equipment including: maps, orientation devices and emergency equipment

(b) Knowledge and experience in alpine surroundings

(c) Information about various environmental factors including: terrain, weather, the avalanche bulletin and human interactions

Some parts of these factors need to be learned, some experienced or bought while others need to be made available by experts. Combining as many of these elements would greatly improve the daily routine of winter sports enthusiasts who plan to go outside of patrolled areas.

Since the beginning of avalanche bulletins (ca. 1945 in Switzerland), the accuracy and up-to-dateness has increased from weekly to semi-daily updates and from general warnings to internationally recognized warning levels (1-5). Avalanche risk maps published by avalanche bulletin providers combine large, homogenous areas (usually mountain ranges) with related weather patterns. These providers issue avalanche bulletins generated by experienced forecasters with specific knowledge for evaluating the situation (Schweitzer et al. 2005).

There are two ways to evaluate avalanche risk: (a) by assessing known avalanche triggering factors (Mair 2012) and (b) through the rules of physics – meaning shear, drag, friction and other forces. Bulletin providers and experienced snow sports enthusiasts rely on the first option as there is no way of measuring all forces for any slope (Schweitzer at al. 2005).

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Bulletins usually consist of a map with a classification depending on risk level (1 to 5), exposition (8 directions – each 45 degree) and diurnal variation of the hazard (morning vs. afternoon), as well as a written report. Bulletins in most countries are available through websites or read out loud on hotlines. Written reports contain more information and valuable insights into a specific situation while maps display information in a spatial context (LWD Steiermark 2014).

An application already available in this sector is called “White Risk” by SLF (WSL Institute for Snow and Avalanche Research at Davos), providing a daily avalanche bulletin as a static map along with a written report. It also includes a parameterizable simulator for risk assessment. The bulletin is available only in Switzerland while the simulator may be used anywhere.

In addition to the bulletin, a skilled winter sports enthusiast needs to be informed about past weather events or reports by other sportsmen. This information is available in online forums (Styria’s avalanche warning service “Lawinenwarndienst Steiermark” operates „Touren Forum“). To gather all information, a user has to access various sources offering information for different topics (past weather events and forecasts, terrain analysis, et cetera).

The complexity of assessing all possible input parameters resulted in a variety of risk-reducing strategies, e.g. „at danger level 3 do not go any steeper than 30°.“ (Munter 2013, Larcher 2012). Attempts have been made to transfer these rules into smartphone applications for sportsmen. Modification (e.g. decreasing the slope by 5° for example) might lead to a reduced risk, but users may ignore threats resulting from other factors than slope and danger level. There is no model available yet to automatically take into account all relevant information to reflect the real world situation. Avalanche prediction still doesn’t have any scientific way to create forecasts (Harvey et al. 2012). Additionally, after talking to „Lawinenwarndienst Steiermark“, a conclusion was drawn: a singular number or word describing the situation or danger-level at a specific situation would be unwise.

Users outside of permanently controlled skiing areas either need to know how to judge the report depending on situation they are in, or be overchallenged, so they don’t make a lightheaded decision. To enhance the avalanche bulletin, all information needs to be available and tailored to a skilled and well-informed user (Schweitzer et al. 2005). Within this system, the user should be able to find all information needed easily and on-location. Furthermore, a user should have the opportunity to upload and share experiences and sightings, therefore turning into a “prosumer” (providing and consuming information).

The system focuses on time- and position-relevant information, made available by a location based service on a mobile device. In return, users should be motivated to upload their experiences in order to create information valuable for other users and avalanche service providers. With all necessary information provided, further assessment is left to the user.

The presented system is a prototype currently under development, to test and evaluate its strengths and weaknesses. It is designed as a web-application to allow access by different mobile devices with various operating systems.

Mobile component

The mobile part consists of two main features: the first provides viable information to the user, while the other allows users to upload specific „events“, separated by categories. Displaying information is realized with a combination of jQuery mobile for usability on mobile devices (pinch zoom, swipe and other specific commands), OpenLayers 3, and HTML 5 APIs. Displayed information consists of the following layers:

- basemaps
- user position and attitude
- pre-calculated avalanche bulletin map
- weather stations
- user-generated data („event“ layers)

Displaying the current position is essential for user orientation and information immediately relevant to the location. In addition, exposition and slope are important factors for avalanche assessment retrieved from the mobile device’s GPS and inertial sensors by the HTML 5 Geolocation and Device Orientation API. A pre-calculated avalanche bulletin map provided by a WMS will show a general warning level for the selected area.

Weather stations and user-generated events are shown as different symbols on the map: current meteorological information is selectable on click and queryable for past meteorological events (e.g. snowfall from three days ago). User generated events are shown depending on their age in respect to their category.

Events do not only include visible phenomena such as avalanches and incidents, but also those that can only be sensed (e.g. sounds that happen when snow cover settles under its own weight, causing a structural weakening). Another example is surface hoar (LWD Tirol 2014) which occurs only during specific weather conditions and when snowed onto becomes invisible or hard to find even if looking at a snowprofile. Events are registered with their respective location, attitude and timestamp. Along with a personal assessment of the risk level given by the user, the official avalanche risk level issued by the avalanche bulletin provider is recorded. Depending on the type of event, users have to fill in a dynamically modified HTML form. Then the data is processed and sent to a database.

Server component

Data is stored in a PostgreSQL/PostGIS databases with a distinction between raster data (used to create the avalanche risk map) and vector data including user-generated events as well as weather information. Published avalanche risk maps are aggregated on a large-scale basis, therefore not being qualified as a basemap. Creating a useful basemap is currently under research. Experts of the avalanche service providers should enter daily risk assessments into an online-form. Upon upload, a function will be triggered to analyze the given information and render a new basemap, available via WMS.

Meteorological data and user-generated events are stored in the database, published by a GeoServer WFS instance in GeoJSON-format and implemented in an OpenLayers map. Attribute information is included and can be used for further information and rule-based styling.

Future approaches and benefits

Currently, no avalanche bulletin provider offers the chance for public users to upload their localized sightings and experiences yet (Entweder Currently oder yet!?). Putting effort in the upload-part and raising its usability could increase the systems acceptance. In the future avalanche service providers such as the „Lawinenwarndienst Steiermark“ could profit from additional information. At present they have to go outside and check the situation during questionable conditions. Since staff is limited and the area covered by each service provider in Austria is large, they could plan outdoor inspections accordingly and use information created by users.

Including additional data layers such as CORINE landcover, high quality ALS digital elevation models or vector layers for crests, spines and other terrain features, might help to further distinguish the risk map.

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