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SKI SLOPE SECURITY – A NEW METHOD TO HELP DEFINING THE LEVEL OF DIFFICULTY

Raul Eduardo Bobone Ressano Garcia

Escola Superior de Hotelaria e Turismo do Estoril, Portugal

Each ski slope has a color associated with it. These colors are used to inform the skiers about the difficulty level of the ski slope. The aim of this paper is to help improving the ski slope security by proposing a new method to define the color of a ski slope. Defining and informing the ski slope difficulty, is very important to advice skiers to do not go where they are not prepared to go, avoiding injuries and life lost. By proposing this new method we intent to reduce the subjectivity inherent to the classification of the ski slope. This way it is possible to achieve a bigger normalization on the classification and increase the security of the ski slopes.

Keywords: Ski, Slope, Security, Colors.

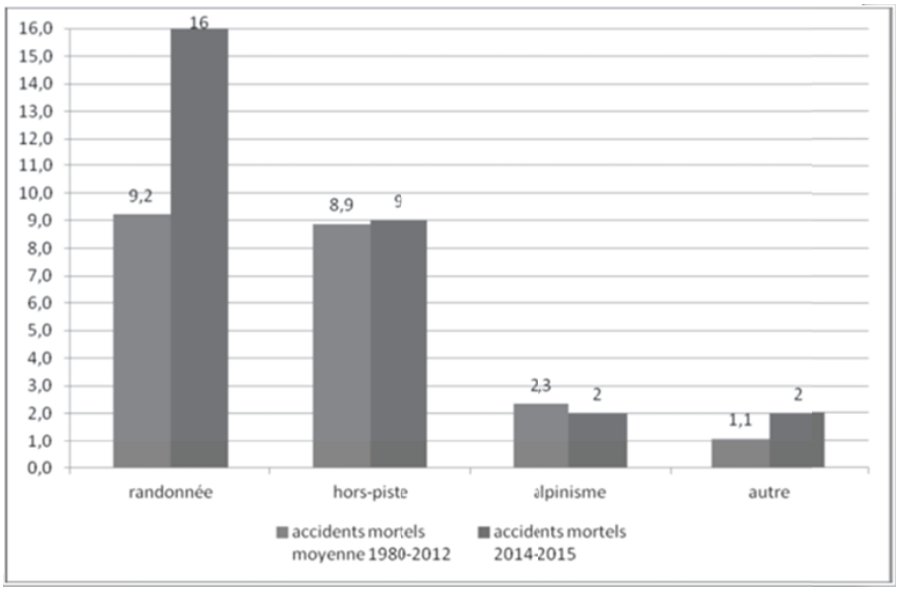
Introduction

Every year there are many accidents in ski resorts provoking many injuries and even several deaths among skiers. Nevertheless in this analysis it is important to separate the accidents by its type. The accidents that kill more people happen with the slide.

According to "Association Nationale pour l'Étude de la Neige et des Avalanches » in the « budget of accidents » for 2015, if we take a look at the picture 1 there are several conclusions that we can achieve.

Looking at the picture 1 we can see that most part of the accidents happen when people are hiking around the mountain or when they are skiing out of the ski slopes.

On the first column in grey we have the average number of deaths between 1980 and 2012. On the second column in dark grey we have the average number of deaths for the year 2014-2015.



Picture 1. Fatalities among skiers in France; Budget of Accidents

The "Bilan des accidents d'avalanche 2014-2015", proportionnâtes the figures for accidents in France.

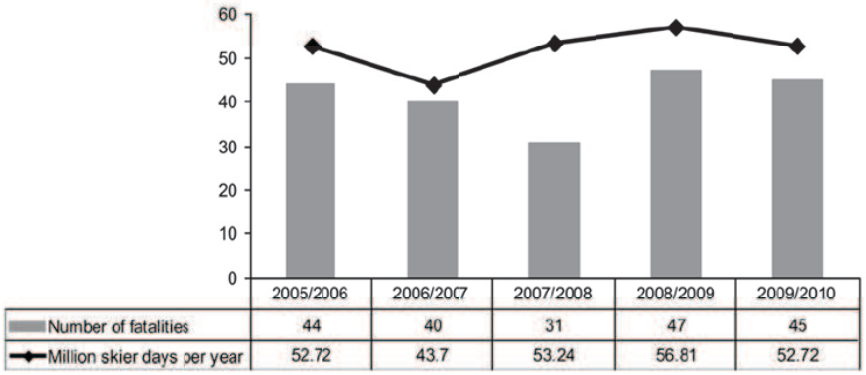
Activité	Nombre d'accidents	Nombre d'accidents mortels	Nombre de décédés
Randonnée	28	16	25
Hors-piste	23	9	10
Alpinisme	3	2	8
Autre récréatif	1	1	1
Autre non récréatif	4	1	1
TOTAL	**59**	**29**	**45**

Picture 2. Number of accidents in France; Bilan des accidents d'avalanche

The lack of security can be caused by several aspects. Avalanches are very danger but usually ski slopes are treated properly to avoid avalanches. But "Personne ne sait où et à quelle heure se déclenchera une avalanche" (FFME, 2003), meaning that nobody knows when or where will be the next avalanche. Anyway if we take a good look at the figures, it is easy to conclude that on the year 2014-2015 there aren´t any deaths caused by avalanches in the ski slopes.

According to Gerhard Ruedl et all (2011) the ski fatalities on Austrian slopes are every year somewhere between 30 and 50. In total, 52.7% were non-traumatic deaths, with the majority (73%) attributed to cardiac arrest. Regarding traumatic deaths, 41.2% died after a fall, 18.6% after collision with another skier, and 35.1% after an impact with a solid object. Head injury was the primary cause of death in 46.4% of traumatic deaths. In 207 fatalities only 4 were caused because of Avalanche on slope.

Ski Fatalities on Austrian Slopes



	2005/2006	2006/2007	2007/2008	2008/2009	2009/2010
Number of fatalities	44	40	31	47	45
Million skier days per year	52.72	43.7	53.24	56.81	52.72

Figure. Number of fatalities and million skier days per year from winter season 2005–2006 to 2009–2010.

Picture 3. Number of fatalities in Austria; Gerhard Ruedl et all (2011)

Statistically the most dangerous place in a ski slope is when two ski slopes cross each other.

The cause of accident leading to the highest number of legal actions was collision between skiers (35.85%); this was followed by lone skier falls (24.52%) and crashes into objects (22.64%), and by a lower frequency of lawsuits arising from accidents involving access to or use of ski lifts (16.99%). Ribalaygua (2009)

In winter sports, the risk of having an accident is significantly higher on beginners. "Le risque est significativement plus élevé chez les débutants dans tous les sports alpins". Jean-Dominique Laporte, Dominique Constans, Virginie Pidou (2004)

The risk of accident is also bigger in beginners among the youngsters. In an article about Risk Factors Associated with Alpine Skiing - Injuries in Children (1999), Goulet et all refers that "The injured skiers seemed more likely to be low skilled".

The probability of accident increase when beginners decide to try a ski slope that is above their skills. It is essential that skiers don´t take a chance on a ski slope beyond their capacity.

There are several aspects that can increase the difficulty of a ski slope:

- Ice can make skiers slide and lose control
- Pumps can make skiers loose balance
- If the ski slope is narrow it makes the turn harder
- Obstacles like rocks can be difficult to avoid
- When the ski slope is crowed other skier can be a moving obstacle difficult to transpose.

The problem when we need to attribute a classification of the difficulty level of a ski slope, is that we cannot considerer all the variables. Most of the variables cannot be analyzed objectively, meaning that there is always a big percentage of subjectivity in all this aspects. However, the most important variable that can be objectively analyzed is the inclination.

The inclination of the ski slopes is probably the most important way to define the level of difficulty, but what define the level of a ski slope is not the average level of the ski slope between the starting point and the finishing point. The difficulty must be measured in every point by measuring the inclination in every point of the ski slope.

In Spain Atudem - "Associación Turistica de Estaciones de Esqui e Montaña" define the rules to attribute the color difficulty level, based on the inclination.

The color green to very easy ski slopes with inclination below 15%
The color blue to easy and intermediate ski slopes with inclination below 25%
The color red to difficult ski slopes with inclination below 45%
The color black to very difficult ski slopes with inclination higher than 45%

Atudem advise that weather conditions and the snow characteristics might increase the difficulty level.

According to the Club Alpin Français Reignier-Esery (2016) the inclination is not the unique criteria to determinate the level of difficulty of a ski slope, nevertheless it is probably the most important. The club defines five levels of difficulty based on the inclination.

Ski 1 – Initiation level. The slopes inclination don´t exceed 30°. The ski slope is neve narrow. The height difference is smaller than 800 m.

Ski 2 – A few technical difficulties. The slopes inclination does not exceed 35°.

Ski 3 - Presence of technical passages. Long slopes inclination up to 35°, some very short passages up to 40-45°.

Ski 4 - Corridor skiing or steep slope: Slopes inclination at 40º or 45° during more than 200 m.

Ski 5 - Slope inclination at 45°/50° for more than 300 m or more than 50° for more than 100 m.

The State of Art

When we go to mountains and talk to specialists we realize that there is not a real scientific method to attribute the level of difficulty to a ski slope. We can refer to it as a method, but maybe it is more like a practice established and accepted more than a scientific method.

As far as we know, by talking to specialist, the procedure used nowadays is something like this:

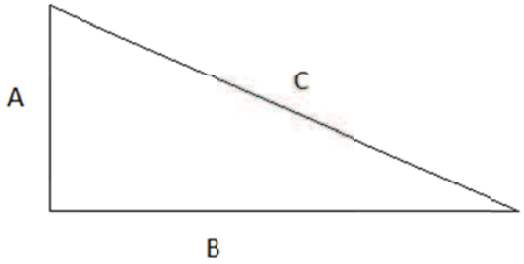
1) Several expert skiers, went down the ski slope
2) The experts have a meeting to discuss about the level of difficulty of the ski slope
3) The experts decided, what should be the color of the ski slope based on its difficulty level.

By putting it this way we are over simplifying the analyses that is not that simple. When specialists go down a ski slope they have to pay attention to all the details of the ski slope. Details like inclination, ice, pumps, narrowness, and obstacles like rocks or trees are some of the aspects that specialists should be aware. When the specialists take the meeting they must talk about all this issues before taking their decision.

Proposing a New Method

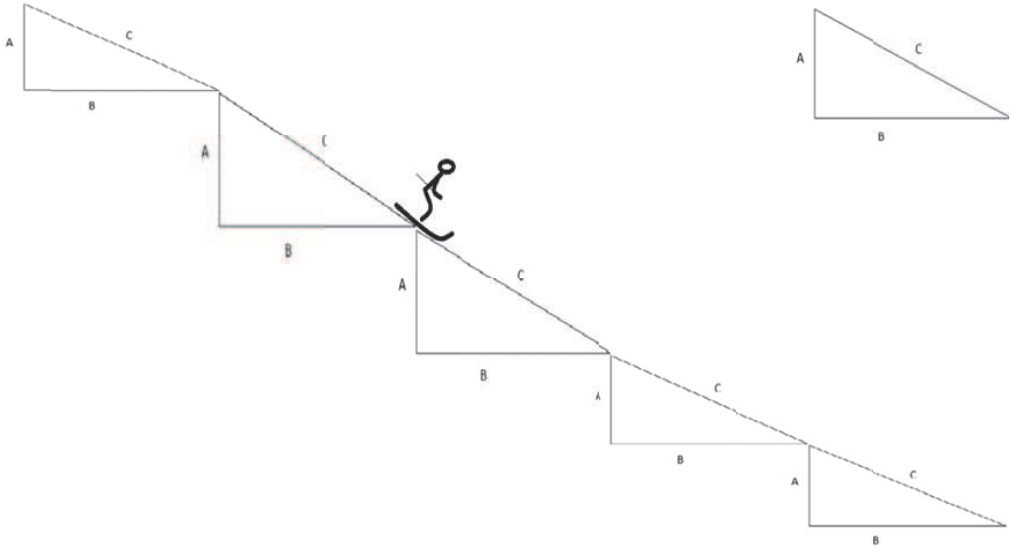
We propose a new method, that has some semblances and some differences from the one used nowadays. The method that we propose has nine steps.

1) Several expert skiers, went down the ski slope, and mark a GPS line automatically. The GPS line marked has the coordinates and its altitude.
2) The length of the ski slope is obtained by measuring the distance between the starting point and the finishing point.
3) In the computer the marked line of the GPS is followed and a new point is marked every time that the GPS coordinates change.
4) The length of the ski slope is divided by the number of points less one. By doing this we obtain the distance between each two points in the ski slope.
5) The inclination is obtained dividing the difference of altitude between two points (A) by the distance between this two points (B). Inclination = A/B



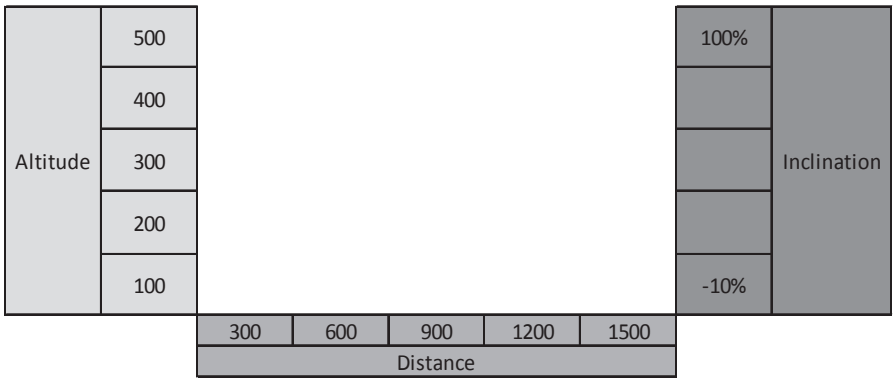
Picture 4. Inclination (own source)

6) Once it is obtained the inclination between every two points of the ski slope, it is made a chart with two different lines.
   a. The first line gives information about the altitude of the ski slope during its entire trajectory.
   b. The second line gives information about the inclination of the ski slope during its entire trajectory.



Picture 5. Inclination during its entire trajectory (own source)

   c. First and second lines are inserted in a chart designed with three variables, Altitude, Inclination and distance, as we can see in the next picture.



Picture 6. Chart with three variables (own source)

This way it is possible to easily achieve graphically the critical points where the ski slope presents a more difficult level according to its inclination.

All the points inserted in the chart are identified with the GPS coordinates, this way it is easy to find the hardest points of the ski slope on the terrain.

The last decision of the attribution of a color to a ski slope, must be allays based on the observation of the terrain. What this method permit is to identify the critical points that should be observed in the terrain.

7) Several expert skiers go down the ski slope, to analyze the GPS critical points of the ski slope.
8) The experts have a meeting to discuss about the level of difficulty of the ski slope
9) The experts decided what should be the color of the ski slope.

The Limitations of the Method

- GPS measure mistakes in coordinates and altitude are despised.
- The changing of GPS coordinate in the computer line followed, does not guarantee that the GPS points are all at the some distance one from the others.
- This little GPS mistakes in the field and their distance in the computer, can have a small influence on the calculation of the inclination of the ski slope.
- This method gives a strong importance to inclination, nevertheless the experts in the field analyze the others constraints.

The big question about this method is if it is a new method or just a new tool that is provided to the experts. For me it is acceptable this discussion. I consider that it is a new tool, but this new tool is sufficiently powered to slightly change the old method.

One thing has no discussion; this new tool/method can be very useful to help on deciding the level of difficulty of a ski slope and what color it should have.

Results

By going to the field, it permits us to obtain information about the GPS coordinates of each point on the ski slope, and also about the altitude of each point. Based on the points altitude and the distance between them it is calculated the inclination between each two points.

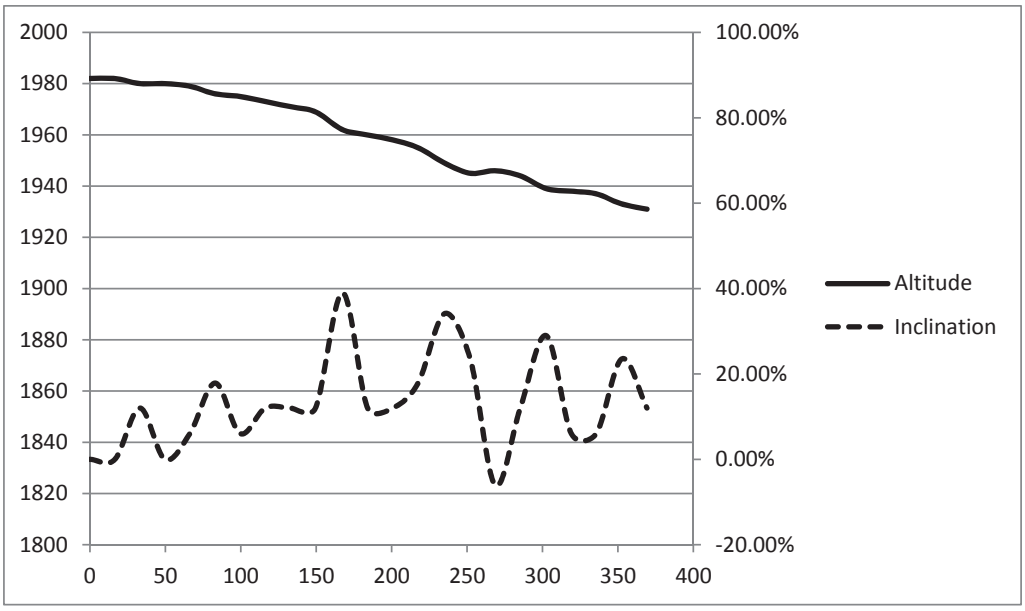
As we can see in the table, first we have the GPS coordinates for north and west. Than we have the altitude than B, A and C. Based on the difference of altitudes (A) and the distance between them (B) we calculate the inclination. Inclination = A/B.

In the last three columns we putted together the information needed to build the chart, distance, altitude and inclination.

N	N'	N''		W	w'	w''		Altitude	B	A	C	Inclination		Distance	Altitude	Inclination
40	19	15		7	36	47		1982						0	1982	0
40	19	15		7	36	46		1982	16,5	0	17	0		16,5217	1982	0
40	19	15		7	36	45		1980	16,5	2	17	0,1201753		33,1641	1980	0,1201753
40	19	15		7	36	44		1980	16,5	0	17	0		49,6858	1980	0
40	19	15		7	36	43		1979	16,5	1	17	0,0604158		66,2378	1979	0,0604158
40	19	15		7	36	42		1976	16,5	3	17	0,1786576		83,0297	1976	0,1786576
40	19	14		7	36	41		1975	16,5	1	17	0,0604158		99,5817	1975	0,0604158
40	19	14		7	36	40		1973	16,5	2	17	0,1201753		116,224	1973	0,1201753
40	19	14		7	36	39		1971	16,5	2	17	0,1201753		132,866	1971	0,1201753
40	19	14		7	36	38		1969	16,5	2	17	0,1201753		149,509	1969	0,1201753
40	19	14		7	36	37		1962	16,5	7	18	0,3901142		167,452	1962	0,3901142
40	19	13		7	36	37		1960	16,5	2	17	0,1201753		184,095	1960	0,1201753
40	19	14		7	36	36		1958	16,5	2	17	0,1201753		200,737	1958	0,1201753
40	19	14		7	36	35		1955	16,5	3	17	0,1786576		217,529	1955	0,1786576
40	19	14		7	36	34		1949	16,5	6	18	0,3413458		235,106	1949	0,3413458
40	19	14		7	36	33		1945	16,5	4	17	0,2353072		252,105	1945	0,2353072
40	19	14		7	36	32		1946	16,5	-1	17	-0,060416		268,657	1946	-0,060416
40	19	14		7	36	31		1944	16,5	2	17	0,1201753		285,3	1944	0,1201753
40	19	14		7	36	30		1939	16,5	5	17	0,2896578		302,561	1939	0,2896578
40	19	13		7	36	31		1938	16,5	1	17	0,0604158		319,113	1938	0,0604158
40	19	13		7	36	30		1937	16,5	1	17	0,0604158		335,665	1937	0,0604158
40	19	13		7	36	29		1933	16,5	4	17	0,2353072		352,664	1933	0,2353072
40	19	14		7	36	28		1931	16,5	2	17	0,1201753		369,307	1931	0,1201753

Picture 7. Information to build the chart (own source)

Based in this information it is possible to build the chart with the two lines. The first line gives the information of the altitude of the ski slope during all its length. The second line gives the information of the inclination during its length.



Picture 8. Chart with the two lines (own source)

In the left side of the chart we can see the altitude of the ski slope. In the right side we can see the inclination of the ski slope. On the bottom of the chart we have the distance measured from the beginning of the ski slope.

As we can see looking to the chart it is easy to find the GPS critical points where the inclination is bigger and consequently the ski slope is more difficult.

Conclusion

This proposed method measures the inclination of the ski slopes in an objective way, permitting to reduce the level of subjectivity.

This proposed method allows the specialist on ski slope evaluation to focus on critical points and observe them more consistently, instead of losing energy observing the entire ski slope to evaluate its difficulty level.

This method permit specialist to analyze and compare the inclinations on charts, reducing the level of subjectivity.

By reducing the level of subjectivity and focusing on critical points, it is easier to standardize the classification of the ski slope.

As we have seen before, defining and informing the ski slope difficulty, is very important to advice skiers to do not go where they are not prepared to go, avoiding injuries and life lost.

Doe to that situation we can affirm that this method help increasing the security of the ski slopes.

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