Lab 3: Landslide Indentification and Mapping

GEOG311 (Due 8 February, 2022)

Objectives

This lab introduces techniques of landslide identification from air photo interpretation and methods to analyze directional data. Both techniques are common procedures used in terrain analysis and surficial mapping. By the end of this lab you should be able to recognize landslides on air photos and unstable terrain on topographic maps, aerial photographs and satellite imagery.

Landslide Identification (50 points)

You will be working with the following air photo sets:

1.) **Photo Set C:** Houston Tommy Creek, south of Houston BC.

2.) **Photo Set J:** China Nose Mountain, south of Highway 16 between Burns lake and Houston, BC.

3.) **Photo Set Q:** Big Bend, Fraser River.

The photos are referenced by letters located in the upper right hand side of the photos. There is one original set of photos and four additional high quality photocopies. Please **DO NOT** mark on the original photos, but you are welcome to mark up the photocopied ones! Please work in groups of two people.

Also included with these photos are NTDB 1:50,000 map names that you can use to find the slide location on the BC Land Data BC website

Click on the button for 'BGCS 20K' to access the 1:20,000 scale mapping products (pdfs and tiff) of a given map sheet. The tiffs can be saved and loaded in GIS software (ArcMap or QGIS).

The map sheets you will be using include:

Set C Houston (93L/7)

Set J Forestdale (93L/8)

Set Q Big Bend (93G/8)

Using these data please complete the following:

a) [10 points] Determine the approximate scale of the photography using the BC mapping website. Identify landslide type for each photo set based on morphology. Classify whether the landslide is active or inactive. Provide details of any geomorphic features present in the air photos that may provide clues to terrain stability. Include your names on the back of the photos (the photocopies) or tracing paper so I can assign a grade to everyone. Make sure everyone gets a chance to do some of the air photo mapping. **Note: The Big Bend photo pairs represent the same failure in 1953 and 2005**.

b) [20 points] Map the extent of the landslides on the copies of the photos. Make sure to limit your mapping to the portion \textbf{in stereo only}. Since several photo sets have more than two photos, **limit mapping to the pair where landslides are most prevalent**. Be sure to write your name and photo numbers used at lower right of photos. Include any additional features which help to verify your choice for A. Also trace roads, river thalweg or lakes for reference. Use dashed lines to denote uncertain or vague boundaries, solid lines for well defined contacts. Do mapping in pencil or water soluble pens as you may need to erase your work. **DO NOT** mark original air photos or you will have to purchase ($10 per photo).

c) [10 points]Consider the prominent failure on the Big Bend Photo Pair (Quesnel). Determine the area of the failure using the BC mapping website tools (or use the nominal scale of the photos). Note that the ortho image displayed for this region is from 2005 and corresponds to the color photo pair that you have.

d) [10 points] What has been the rate ($m\ yr^{-1}$) of headward extension of the landslide near the Big Bend of Fraser River (i.e. how far has the landslide crown moved upslope over the period 1953-2005)?

Figure 1. Symbols commonly used for landslide mapping

Directional Data: 20 points

Analysis of directional data often reveals information about the type or nature of geomorphic processes. For example, large-scale lithologic structures (e.g. anticline) and bedding planes may explain the spatial distribution of rock avalanches. It is therefore important to investigate whether landslides show a preferred orientation. To work with directional data, however, one can not simply take the 'average' of circular data expressed in degrees (e.g. consider the average direction of the compass bearings 350 °, 355 °, and 23°). To determine statistical parameters such as central tendency and dispersion, we must convert the observations to vectors and plot them on a unit circle. A compass direction can be converted into polar coordinates by the following:

$$\begin{aligned} x_i &= cos(\theta_i) \\ y_i &= sin(\theta_i) \end{aligned} \tag{1}$$

Where x_i and y_i represent the X and Y coordinates of the unit vector and θ_i is the compass direction (in radians).

Mean direction ($\bar{\theta}$) for a set of 2-D vectors can be obtained by first computing the vector resultant:

$$\begin{aligned} X_r &= \sum_{i=1}^{n} cos(\theta_i) \\ Y_r &= \sum_{i=1}^{n} sin(\theta_i) \end{aligned} \tag{2}$$

Where X_r and Y_r are the X and Y coordinates of the resultant.

$\bar{\theta}$ is then obtained from:

$$\bar{\theta} = tan^{-1}(\frac{Y_r}{X_r}) \tag{3}$$

The length (R) of the resultant (a measure of vector dispersion) can be found by:

$$R = \sqrt{X_r^2 + Y_r^2} = \sqrt{(\sum_{i=1}^{n} cos\theta_i)^2 + (\sum_{i=1}^{n} sin\theta_i)^2} \tag{4}$$

In order to compare resultants from different sample sizes the standardized resultant ($\bar{R}$) is usually calculated:

$$\bar{R} = \frac{R}{n} \tag{5}$$

where n is the number of observations. Finally the circular variance (s_o^2) can be obtained from:

$$s_o^2 = 1 - \bar{R} \tag{6}$$

For each group (2-3 students) determine the direction of shallow landslides that have occurred on the outer coast of Haida Gwaii near 53.071 N, -132.390 W. Use QGIS to collect slide direction. After you've started QGIS, right click on the icon that says 'xyz tiles' and add 'new connection' and then add this website:

http://ecn.t3.tiles.virtualearth.net/tiles/a%7Bq%7D.jpeg?g=1%0A

and call it 'Bing Aerial imagery'. Zoom to coordinate listed above. We can now collect orientation data by using the 'bearing measuring tool' located in the upper right of the QGIS menu.

Preferably, I would like each of you to map directions in a different study area (make sure you discuss with each other to avoid overlap). I want you to then plot the data as rose diagrams (see below) to assess whether the mapped landslides have a preferred direction. If they do, what factors might account for a preferred direction?

Provide me with the data for each of you so that I can put them on my GitHub site. We will use combined data to construct a rose diagram (a graph used to plot directional data) and calculate out the mean slide direction, slide dispersion (variance), and vector resultant.

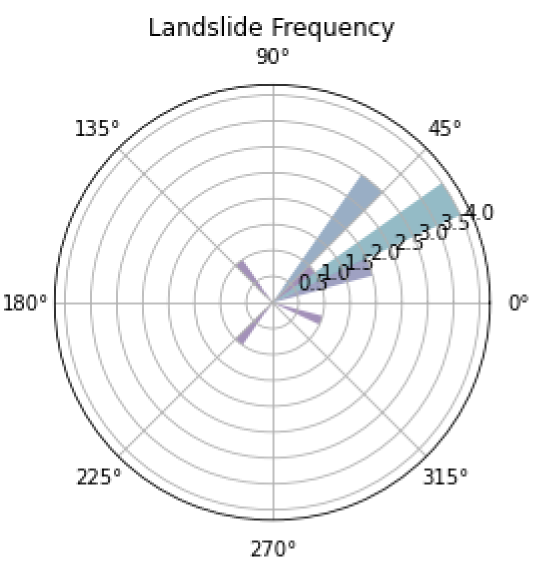
See code block below for directions and ways to do this in Python.

Also remember that computers deal with radians rather than degrees so you will need to convert degrees to radians to do the calculations. Remember to report the final directions as degrees in your lab write up.

Remember to use the function arctan2 in Python numpy to take the arctangent of x and y components of the unit vector. Otherwise you will need to worry about which quadrant x and y are in.

In [2]:

```
"""
Demo of bar plot on a polar axis (rose diagram) and instructions
for calcuating  statistics from circular data

"""
import numpy as np
import matplotlib.pyplot as plt


## I've used random data here but make an array of numbers
## for your own work
## e.g. dirs = np.array([obs1, obs2, obs3, ...])
dirs = np.array([23,45, 46, 47, 12, 23, 34, 12, 23, 23, 129, 330, 220])


## calculate polar coordinates for mean direction

## express x component of directions in radians
r_x = np.cos(dirs * np.pi/180)

## calculate out polar coordinates for:
## r_y and mean direction
## Resultant and circular variance
## direction based on equations above this code block
## remember to pay attention to how you use arctan2



#################################
### Construct rose diagram below
#################################

## make equal angle bins centered on 10 degrees
bins = np.arange(0, 360., 10)
n_obs, bins = np.histogram(dirs, bins=bins)

## there will be n + 1 bins since the histogram function returns
## the edges of the bins. We need to make n bins (mid point)
bins = ((5 + bins[:-1]) + (5 + bins[1:]))/2.0


#print(n_obs)
#print(sum(n_obs))

N = len(n_obs)

theta = np.pi/180. * bins
radii = n_obs
width = (2.0 *np.pi) / N


ax = plt.subplot(111, projection='polar')
bars = ax.bar(theta, radii, width=width, bottom=0.0)

# Use custom colors and opacity
for r, bar in zip(radii, bars):
    bar.set_facecolor(plt.cm.viridis(r / 10.))
    bar.set_alpha(0.5)

plt.title('Landslide Frequency')
plt.savefig('Rose_diag.pdf', dpi=600)
plt.show()

print('All done!')
```




```
All done!
```

In [ ]: