Detecting Volcanoes on Venus via Classification (Where are the Volcanoes?!!)

STAT 432 Final Project

Team Mamamia!
Di Ye (diye2), Hao Wang (haow2),Hannah Pu (chpu2)

November 17, 2018

INTRODUCTION

Data Source Information

The data was downloaded from Kaggle, which is originally from NASA's Magellan spacecraft database. (https://www.kaggle.com/amantheroot/finding-volcanoes-on-venus/data)

Data Description

9734 images were captured by the spacecraft and converted to pixels (110 x 110, from 0 to 255), where every image is one row of 12100 columns (all the 110 rows of 110 columns). Images can contain more than one volcanoes or maybe none. The 9000+ images are separated to four datasets (file names : *train_images*, *train_labels*, *test_images*, and *test_labels*):

Image Dataset (*train_images* and *test_images*)

Train_images : 7000 images as train data with 12100 variables;
Test_images : 2734 images as test data with 12100 variables; All the variables (V1 to V12100) correspond to the pixel image, 110 pixels * 110 pixels = 12100 pixels.

Label Dataset (*train_labels* and *test_labels*)

A summary of the variables in both *train_labels* and *test_label* datasets is listed down below:
1. *Volcano?* : If in the image there exists at least one volcano, the label is 1 (Yes). Otherwise, the label is 0 (No). (If Volcano? equals 0, the following three categories would be "NaN"). 2. *Type* : 1 = definitely a volcano,2 = probably, 3 = possibly, 4 = only a pit is visible
3. *Radius* : Is the radius of the volcano in the center of the image, in pixels?
4. *Number Volcanoes* : The number of volcanoes in the image.

Literature Review

In the Kaggle, the data analysis of the project is done in Python. People have already had vivid data visualization and exploratory data. Different methods have been used, such as Convolutional Neural Network (CNN) and VGG Neural Network for deep learning. People have reached the 95% accuracy.

Scientific Goal

For this project, we will focus mainly on predicting whether each image has a volcano or not. In addition, if the classification prediction goes well, we will also construct models to predict the number of volcanoes in the images. We aim in constructing different classification models and choosing the best model to predict whether there exists a valcano in each image. Identifying valcano through IT technology would increase the efficency of space exploration and safty of the crews.

EXPLORATORY DATA

The first 6 observations of *train_labels*

```
##   Volcano. Type Radius Number.Volcanoes
## 1        1    3  17.46                1
## 2        0  NaN    NaN              NaN
## 3        0  NaN    NaN              NaN
## 4        0  NaN    NaN              NaN
## 5        0  NaN    NaN              NaN
## 6        0  NaN    NaN              NaN
```

The first 6 observations of *test_labels*

```
##   Volcano. Type Radius Number.Volcanoes
## 1        0  NaN    NaN              NaN
## 2        0  NaN    NaN              NaN
## 3        1    1  17.00                1
## 4        0  NaN    NaN              NaN
## 5        1    3  15.13                1
## 6        0  NaN    NaN              NaN
```

After exploring the datasets, we found only labels have NaNs. We have set the those values to 0, an insignicant value in our dataset.

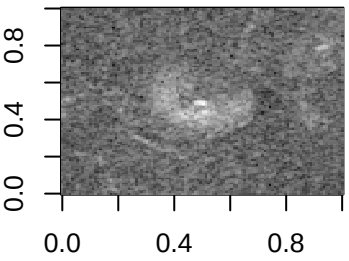


Figure 1: Obs 10 Type: 1 Radius: 22.02 Number Volcanoes: 1

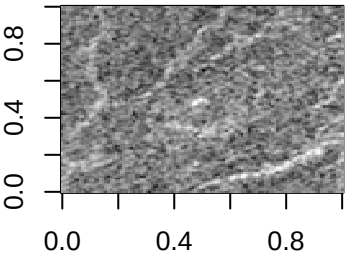


Figure 2: Obs 39 Type: 2 Radius: 19.31 Number Volcanoes: 1

Data Visualization

6 observations are picked to demonstrate how the images got labeled. Figure 1 - 4 show how well the volcanoes can be seen from the images ($Type$: 1 = definitely a volcano,2 = probably, 3 = possibly, 4 = only a pit is visible). Figure 5 contains 2 volcanoes, and Figure 6 contains no volcano at all. We can tell from the images that a bright white dot indicates a potential volcano, while the white dot might not be clear enough to see in the image, which means that it is hard to identify whether there is a volcano or not.

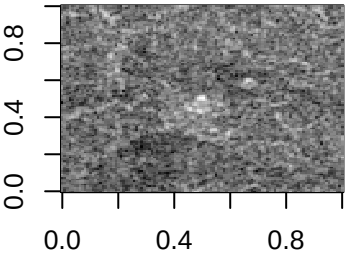


Figure 3: Obs 1 Type: 3 Radius: 17.46 Number of Volcanoes: 1

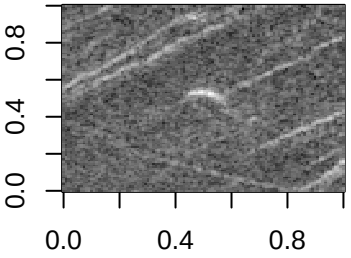


Figure 4: Obs 30 Type: 4 Radius: 6.40 Number Volcanoes: 1

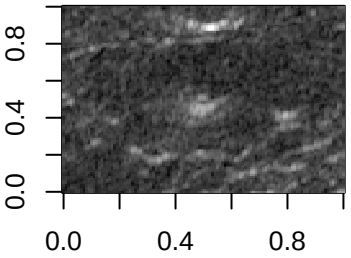


Figure 5: Obs 289 Type: 1 Radius: 11.05 Number Volcanoes: 2

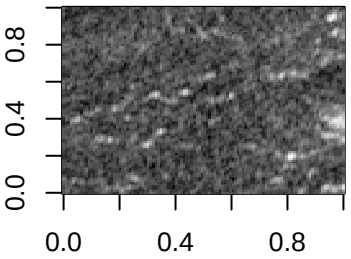
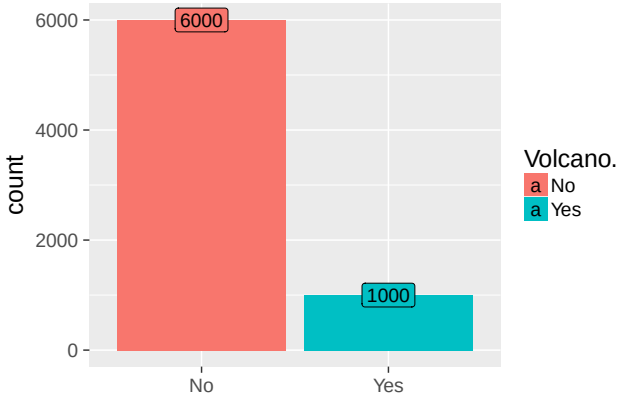


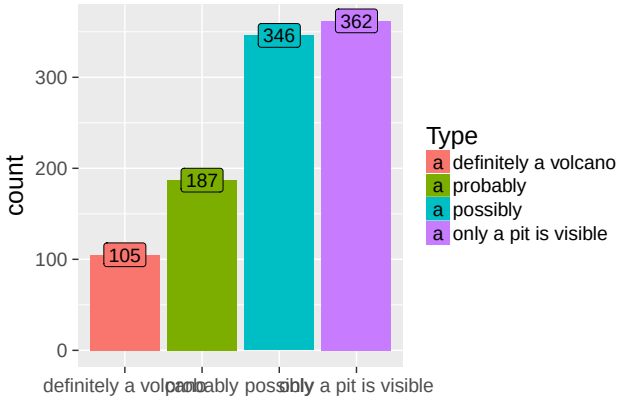
Figure 6: Obs 2 No Volcano

Data Summary

To facilitate the analysis process and explore the data, we have summarized the data. The `ggplot` has been used to visualize the training set labels. The first figure shows that only 1000 images in the training dataset have volcanoes. The second figure shows that within 1000 images that have volcanoes, how clearly we can identify the volcanoes.



How many images have volcanoes?



How clearly can we identify the volcanoes?

METHODOLOGY

Models we used:

Lasso Regression

ElasticNet

Neural Network

Neural Network was used in the project for seeking better classfication results. The raw data *train_images* and *test_images* was converted into numeric variables and reshaped into 3D array with dimension 7000 × 110 × 110 and 2734 × 110 × 110 respectively. The pixels were shrinked from 0-255 to 0-1 by dividing each pixel by 255. The target label (Volcano?) was converted into categorical variable for classification. The neural network used several convolutional dense layers for classification. The neural network model yielded a satisfying classification result.

	No	**Yes**
No	2270	88
Yes	30	346

RESULTS & DISCUSSION