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| **Deep Learning for Image Classification of Volcanoes on Venus** |

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**Abstract**

The aim of this project is to build a trainable deep learning model that helps in locating the volcanoes on the surface of planet Venus. This project will be helpful in classifying and locating volcanoes on the surface of Venus by using the images that were returned from the Magellan spacecraft. By creating a trainable deep learning model, the surface structure of Venus will be more clearly explained, and the model can be used in future space projects.

1. **Introduction**

Venus is the second planet of our solar system. Despite being the second planet in the solar system, it is the hottest planet and the strangest planet. To study the planet, a space mission was initiated named as Magellan Mission. On the day, May 4th, 1989, the Magellan spacecraft was launched to orbit around Venus and study the topographical structure of the planet. The spacecraft returned the radar images of the planet which provides the topography and electrical characteristics of Venus. There are numerous large shield volcanoes on Venus whose flows cover an area more than 500 km in diameter. Venusian volcanoes of this size are generally accepted as forming from hot spots that are or were located over mantle upwellings. In the images that spacecraft has returned gives the idea that Venus has many unstable volcanoes[3]. With this finding, the study of the planet will become clearer.

In this project, we are using various deep learning techniques that will provide better understanding of the spacecraft images. The model that will be created will help in getting a clearer view of other space expenditures. We are going to use image data obtained from the spacecraft to do classification using convolution neural networks and many more deep learning techniques[4].

**2. Problem Statement**

As the planet Venus is very unstable, it is difficult to classify the images and the volcanoes on the surface. So, to solve this problem, radar images are taken[1], and we will be using these images to create the deep learning model.

**3**. **Data Description**

Data Source Link: <https://archive.ics.uci.edu/ml/datasets/Volcanoes+on+Venus+-+JARtool+experiment>

Data Format: **Images**

The data was collected by the Magellan spacecraft over an approximately four-year period from 1990--1994. The objective of the mission was to obtain global mapping of the surface of Venus using synthetic aperture radar (SAR). There are some spatial dependencies. For example, background patches from within a single image are likely to be more similar than background patches taken across different images. The image quality is not that clear that it provides complete view of the volcanoes. There are labels that provide some measure of subjective uncertainty

1 = a volcano,

2 = probably,

3 = possibly,

4 = only a pit is visible.

There are also files that specify the exact set of experiments using in the published evaluations of the JAR tool system. The image files are in a format called VIEW. This format consists of two files, a binary file with extension.sdt (the image data) and an ascii file with extension.spr (header information). There is a MATLAB utility function included in the data package that can be used to read the data. The labeling files are provided in two forms. The .lxyr files are simple space-separated ascii containing label, x-location of center, y-location of center, and radius.

**4. Image Information**

The images are 1024X1024 pixels. The pixel values are in the range [0,255]. The pixel value is related to the amount of energy backscattered to the radar from a given spatial location. Higher pixel values indicate greater backscatter. Lower pixel values indicate lesser backscatter. Both topography and surface roughness relative to the radar wavelength affect the amount of backscatter.

**5. Algorithm that are to be explored**

* Convolution Neural Network: **Convolutional Neural Network** (**CNN**, or **ConvNet**) is a class of deep, [feed-forward](https://en.wikipedia.org/wiki/Feedforward_neural_network) [artificial neural networks](https://en.wikipedia.org/wiki/Artificial_neural_network) that has successfully been applied to analyzing visual imagery.
* Support Vector Machines: **Support Vector Machines (SVM)** are supervised learning models with associated learning algorithms that analyze data used for classification and regression analysis.
* Deep Residual Network: **Deep Residual Network** is a residual learning framework designed by Microsoft research for image classification[2].
* An approach to find a new algorithm for image classification.

**6. Execution Timeline**

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| **Task** | **Time** |
| 1. Collecting image data and Feature Extraction | 2/9 – 2/28 |
| 2. Implementing/Experimenting Algorithms | 3/1 – 3/20 |
| 3. Evaluating and comparing algorithms | 3/21 – 4/5 |
| 4. Slides, demo and Presentation | 4/6 – 4/14 |
| 5. Writing report | 4/15 – 4/26 |

**7. References**

[1] G.H. Pettengill, P.G. Ford, W.T.K. Johnson, R.K. Raney, L.A. Soderblom, "Magellan: Radar Performance and Data Products", Science, 252:260-265 (1991).

[2] Kaiming He, Xiangyu Zhang, Shaoqing Ren, Jian Sun, “Deep Residual Learning for Image Recognition”.

[3] Charles R. Wiles, M.R.B. Forshaw, “Recognition of Volcanoes on Venus using Correlation Methods”.

[4] Robert R. Herrick, Josef Dufek, Patrick J. McGovern, “Evolution of large shield volcanoes on Venus”.