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Obstacle Detection on Lunar Surface using U-Net

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A B S T R A C T

The lunar surface is a potential platform for a number of scientific investigations unrelated to the Moon itself. A Lunar rover is used for exploration of Moon surface. Rover can explore things without any human intervention. So to discover lunar surface, rovers play a major role by driving over the land on moon. But there are many challenges that rover has to face and one of them is obstacle detection. Lunar surface contains rocks which may damage rover. To overcome this problem a machine learning model with image segmentation can be implemented, which can help the rover to detect the obstacle easily. In this work, need of this technology is to find the obstacles (i.e. Rocks) on lunar surface. When the rover approaches on lunar surface, it travels, then it encounters many obstacles that may cause harm to it, to prevent this, a machine learning program using applications of deep learning could help to find out the obstacle easily, such that this system helps the rover to find out the clear path. In this system, images captured as an input is provided to model and model gives segmented image. The ML model labels rocks visible in a different class than lunar surface using Semantic Segmentation technique. This Technique classifies the pixels in an image into distinct classes with no information or context taken into consideration. A image of an airplane in the sky can be differentiated by semantic model into the "Aircraft" class and sky into different class.

Keywords:Machine Learning, Deep Learning, Semantic Segmentation.

1. INTRODUCTION

The lunar surface (Moon surface) is still unexplored by humans. Although the Moon has, almost certainly, never supported any life of its own, lunar exploration will nevertheless inform our searches for life elsewhere. A Lunar rover is used for exploration of Moon surface. Rovers have been partially or fully autonomous robots. So to discover lunar surface, rovers play a major role by driving over the land on moon. But there are many challenges that rover has to face and one of them is obstacle detection. Lunar surface contains rocks which may damage rover. To overcome this problem a machine learning model with image segmentation can be implemented which can help the rover to detect the obstacle easily.

2. MOTIVATION

The rocks on the lunar surface are so hard as compared to that on earth. While exploring the surface, rover faces such obstacles which can damage it. Vision plays an important role for exploration and in tackling of such obstacles. So, there is need of such system that can classify obstacles (i.e. rocks) and plain surface into different classes.

3. PROBLEM DEFINITION

To design and implement a machine learning model which creates a segmented image of rocks and plain land for the navigation of lunar rover.

4. LITERATURE SURVEY

Various methods have been implemented for obstacle detection. Various algorithms and hardware equipments were used for the same. This section provides a comprehensive information about such findings.

1. Fang Wu, AkashVibhute, Gim Song Soh, Kristin L. Wood and ShaohuiFoong[1] Spherical robot have an efficient travelling and tolerance towards dangerous territories. They are most useful in security purposes. This paper proposes a study on spherical robot named "Virgo". A magnetic proximity sensor based spherical robot uses pure – pursuit algorithm for trajectory tracking. It calculates the distance between current location and given waypoint. By calculating the distance wheel speed can be decided accordingly. This system mainly consists of sensor data acquisition, waypoint commander, trajectory controller and drivetrain controller. The system queries and store the readings then sets a waypoint calculates the trajectory and then drives accordingly with reference to obstacle detected.

2. BoyuKuang, Mariusz Wisniewski, Zeeshan A. Rana and YifanZhao[2] The challenging task in rover automation is rock segmentation. This paper proposes a framework and segmentation network for rock segmentation. The segmentation process consists of two stages: the pre-training process and the transfer-training process. The pre-training process applies the synthetic algorithm to generate the synthetic images; then, it uses the generated images to pre-train a rock segmentation network NI-U-Net++. It uses synthetic algorithm for creating valid data for system. Finally, system generates segmented image.

3. Kohtaro Matsumoto, Shuichi Sasa, Yasuhiro Katayama and TetsujiroNinomiy[3] Optical sensors play an important role in obstacle detection. This paper proposes method of integrating the optical sensors with three algorithms namely, stereo method, topography from brightness and shade method. Stereo method generally calculates the depth of land from landing vehicle from space. Topography from brightness generally consists of two methods namely, mean of brightness and brightness variance. The mean of brightness helps to guess too bright area and/or dark area as steep slope, that is the obstacle. By the variance of brightness, abrupt change of brightness in small area would mean rough terrain pattern. The brightness of variance could be said as an index of the roughness of that area.

4. Olaf Ronneberger, Philipp Fischer and Thomas Brox[4] Image is provided as an input to symmetrical U-Net architecture then spatial dimensions(pixels) of the image are reduced and more important features are extracted, this happens due to unpadded convolutions this is done by encoder part of U-Net. In decoder part, the number of filters in the convolutional layers are decreased with a gradual upsampling in the following layers all the way to the top. Skip connections connects the previous output to decoder blocks with each layer to provide comprehensive information in image. Thus segmented image is formed.

5. LiyongMa , Wei Xie and Haibin Huang[5] For operations like search, rescue, observing territories unmanned surface vehicles are used. This paper proposes the hybrid network architecture of ResNet and improved DesNet is combined to develop the feature pyramid method of bidirectional feature pyramid networks. Thus the proosed method based on CNN for autonomous navigation for the application of unmanned surface vehicle has performance for obstacle detection.

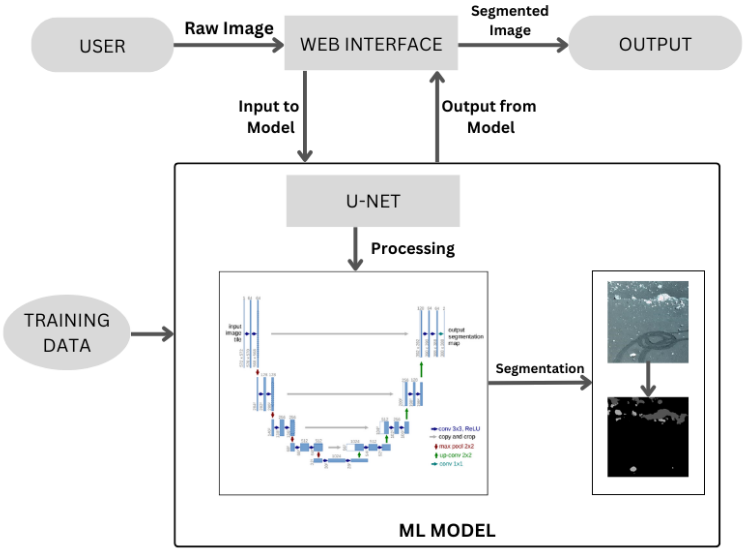
6. IwanUlrich ,IllahNourbakhsh[6] This obstacle detection system works on the appearance of each pixel. The difference in any pixel that is observed in appearance from the ground is classified as an obstacle. It filters color input image, transformations into HSI color space, histogramming of reference area and comparison with reference histograms.

5. PROPOSED SYSTEM

This section focuses on system design and its architecture. It also explains the concepts on which the model is implemented and the working of the model as well. The Proposed System is supervised machine learning model which is being trained on labeled data and based on training it produces outcomes.

- A dataset containing lunar surface images is used for training process.
- Proposed system is packed with U-Net architecture which is a symmetric architecture for semantic segmentation. The job of the U-Net is to capture important features from an image and also to perform localization.
- U-Net can be divided into an encoder-decoder path. Encoder is applied to reduce the spatial dimensions of image and the decoder network is used to take the abstract representation and generate a semantic segmentation mask. After successful training, input is provided to model by a web interface
- Web interface accepts input image from user and that input image will be provided to model.
- Then last result will be the model producing segmented image as an output.

6. SYSTEM ARCHITECTURE



7. ADVANTAGES

- Rocks Localization
- Safe lunar exploration
- Easy model implantation on rovers
- Qualitative segmentation results

8. LIMITATIONS

- Less efficient in darker areas
- Requires crystal clear vision for image processing

8. APPLICATIONS

- Mars exploration

The machine learning model can be implanted on rovers which can explore the martian surface. The martian surface contains obstacles like rocks and pits.

9.Conclusion

Semantic segmentation is computer vision task that involve grouping together similar parts of the image that belongs to same class. The implementation of this technique along with the use of U-Net supports the operation of lunar exploration by the rover safely.

Future Work

- Obstacle Avoidance
- Path Planning
- Implantation on rover

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