**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**

**IV B. Tech Major Project Phase I / II, A.Y:2025-26**

**Abstract Submission Form**

|  |  |  |
| --- | --- | --- |
| **Team Number:** 25MP\_TB10 | | |
| **Title of the Project:** CraterMorph :Automated Luner Crater Detection | | |
| **Name of the Guide:** Mrs.A.Swathi | | |
| **Sl. No.** | **Roll Number** | **Name of the Student** |
| 1 | 22R21A05C0 | RITESH BIRADAR |
| 2 | 23R25A0571 | BADDA VARSHA |
| 3 | 22R21A0574 | BODDU VENKATA GANESH |
| 4 | 22R21A0594 | KAKI AKSHAYA |

|  |  |
| --- | --- |
| **Area/Domain of Project** | Machine Learning, Deep Learning in Space Science. |
| **PROBLEM STATEMENT** | |
| Manual and traditional methods for detecting lunar craters from vast high-resolution image data are time-consuming, labor-intensive, and lack the scalability and robustness needed for varying lunar surface conditions (lighting, shadows, crater sizes). This inefficiency and inconsistency hinder scientific research and future lunar missions. The challenge is to develop an automated, accurate, and scalable deep learning system to efficiently detect and characterize lunar craters. | |
| **ABSTRACT** | |
| The accurate identification and detailed characterization of lunar craters are paramount for a multitude of scientific and exploratory endeavors. These include deciphering the Moon's intricate geological history, precisely pinpointing safe and scientifically valuable landing sites for future missions, and providing essential foundational data to support ongoing and upcoming space exploration initiatives. Historically, the process of detecting and analyzing lunar craters has predominantly relied on laborious manual annotation by human experts and the application of classical image processing techniques. While these methods have provided valuable insights, they are inherently time-consuming, demand significant human resources, and are frequently susceptible to errors and inconsistencies, particularly when confronted with the immense volume of high-resolution image data now available from advanced missions such as Chandrayaan-2.  Furthermore, traditional image processing approaches often lack the necessary scalability and robustness to effectively manage the diverse and complex conditions encountered in lunar surface imagery. These challenges include significant variations in lighting, the presence of deep and extensive shadows, and the wide spectrum of crater sizes, from minuscule impact features to vast basins. Such limitations lead to considerable inefficiencies and potential inaccuracies in crater detection and subsequent analysis, thereby impeding the progress of critical scientific research and the strategic planning of future lunar missions. The overarching challenge, therefore, is to innovate and develop an automated, highly accurate, and scalable system capable of overcoming these existing constraints by harnessing the power of advanced deep learning methodologies to efficiently detect, delineate, and characterize lunar craters with unprecedented precision and speed.  This project, aptly named CraterMorph, proposes a comprehensive and automated lunar crater detection system that leverages cutting-edge deep learning and computer vision techniques to address the aforementioned challenges. Our primary objective is to fundamentally transform lunar surface analysis by significantly improving both its speed and precision, moving decisively beyond the inherent limitations of manual methods and conventional image processing. To achieve this, we implement a novel and robust hybrid architecture that strategically combines the strengths of YOLOv5 for efficient and rapid object detection with a sophisticated U-Net model, enhanced by a ResNet18 backbone, for precise pixel-level segmentation of craters. This integrated approach allows our system to not only identify the presence of craters but also accurately delineate their boundaries from high-resolution images acquired by the TMC-2 instrument aboard Chandrayaan-2.  The methodology employed in CraterMorph incorporates several advanced techniques to ensure optimal performance, accuracy, and generalization capability. We extensively utilize transfer learning, leveraging pre-trained models to accelerate the training process and enhance feature extraction from complex lunar imagery. To bolster the model's robustness and its ability to generalize across diverse terrains and varying imaging conditions, we apply comprehensive data augmentation strategies, artificially expanding the training dataset by introducing variations in rotation, scaling, brightness, and contrast. Furthermore, k-fold cross-validation is meticulously employed during the training pipeline to rigorously evaluate the model's performance and ensure its reliability across different subsets of the data. This meticulous training approach, which is designed to incorporate both annotated and unannotated datasets, is critical for creating a model that can perform consistently and accurately in real-world lunar environments.  Experimental results derived from rigorous testing demonstrate the efficacy of the proposed CraterMorph system, achieving a notable detection accuracy of 86.91%. This performance underscores the model's capability to effectively identify craters of various sizes, including the particularly challenging scenarios involving overlapping and nested crater formations, which often confound traditional methods. The successful implementation of CraterMorph represents a significant advancement, as it substantially reduces the manual effort previously required for lunar crater analysis, thereby dramatically improving the efficiency and throughput of scientific investigations into lunar surfaces. Beyond its immediate application to the Moon, the robust and adaptable nature of this deep learning model suggests its considerable potential for extension and application to other planetary bodies within our solar system. This broad applicability positions CraterMorph as a valuable tool that can provide reliable, automated insights into planetary geomorphology, thereby supporting future space research, mission planning, and our broader understanding of planetary evolution. | |
| **OBJECTIVES** | |
| * To create a system for the detection and analysis of lunar craters that is both reliable and operates without manual intervention. * To significantly improve the speed and precision of lunar surface analysis, moving beyond the limitations of manual methods and traditional image processing. * To utilize advanced deep learning methodologies, specifically a custom YOLOv5 model with a ResNet18 backbone, for crater detection. * To create a model that can generalize well across diverse terrains and imaging conditions by incorporating both annotated and unannotated datasets into the training pipeline. | |

**Project Guide Project In-charge Project Coordinator**