Pimpri Chinchwad Education Trust's

Pimpri Chinchwad College of Engineering

Sector No. 26, Pradhikaran, Nigdi, Pune 411044
An Autonomous Institute Approved By AICTE and Affiliated To SPPU, Pune

DEPARTMENT OF INFORMATION TECHNOLOGY

Fundamentals Of Digital Image Processing (FDIP)

Report of

T. Y. B. Tech

Academic Year: 2025-26
Semester - I

on

Improving Exoplanet Detection with Image Processing in Angular Differential Imaging

By

PRN	Name of the Student
123B1F033	Jay Sudam Jadhav

Problem Statement :

Detecting exoplanets, which are planets that orbit stars outside our solar system, is both interesting and difficult in modern astronomy. The detection process often involves analyzing telescope images where exoplanets appear very faint compared to their host stars. These images suffer from atmospheric distortion, noise, and equipment limitations.

The main challenge is creating a system that can effectively process telescope images, separate the star's light, and spot slight variations or faint circular patterns that might indicate exoplanets. Traditional methods, like setting thresholds or manual observation, are slow and prone to mistakes when handling large amounts of data. This highlights the need for AI-based automated image analysis techniques.

Aim:

The goal of this project is to create a smart system that can accurately detect exoplanets from telescope images using image processing and convolutional neural network (CNN) techniques.

Motivation :

- Discovering exoplanets gives important insights into how planets form and evolve, as well as the possibility of extraterrestrial life.
- Manually checking telescope data takes a lot of time and can be affected by human error, especially since exoplanets are thousands of times dimmer than their host stars.
- AI and deep learning can automatically identify patterns of exoplanets by analyzing image structures and brightness changes, which improves detection reliability.
- Better exoplanet detection helps advance research in astrophysics and supports the worldwide search for habitable worlds.

Objectives :

- To preprocess telescope images by removing background noise, normalizing lighting, and enhancing fine circular features to improve visibility of exoplanets.
- To build and train a deep learning model (CNN) that can distinguish between “star-only” images and “star-with-exoplanet” images.
- To check the performance of the trained model using multiple validation folds for reliability and generalization.
- To visualize exoplanet detection through image segmentation and highlight possible planetary regions for better understanding.

Literature Survey :

Author & Year	Features / Dataset	Methodology Used	Limitations
Seager & Deming (2023)	Light curve data and telescope imaging datasets	Transit and direct imaging analysis using AI filters	Noise sensitivity, requires high SNR images
Brogi et al. (2024)	High-resolution spectra and star imaging	Cross-correlation with CNN feature extraction	Limited by atmospheric distortion
Zhou et al. (2024)	Deep sky telescope datasets	Hybrid CNN–Transformer model for exoplanet detection	Requires extensive GPU resources
Singh & Patel (2025)	Synthetic telescope images with labeled exoplanets	CNN with adaptive thresholding for faint planet detection	Dataset imbalance; small exoplanets missed
Reddy et al. (2023)	Space telescope (Kepler/TESS) image sets	Autoencoder for feature enhancement and anomaly detection	Model interpretability and false positives
Proposed System (This Work)	Star-only and star-with-exoplanet images from Google Drive dataset	Preprocessing ; CNN model ; K-Fold cross-validation; Exoplanet visualization using adaptive thresholding detection	Small exoplanets may still be difficult to detect; Limited dataset size; Relies on 128×128 image resolution

Methodology :

- **Data Preprocessing**
  - ➢ Telescope images were collected from two groups: Star-Only and Star-with-Exoplanet.
  - ➢ Images were resized to a standard resolution of 128×128 pixels and normalized to the range [0,1].
  - ➢ Techniques like Gaussian Blur, CLAHE (Contrast Limited Adaptive Histogram Equalization), and Histogram Equalization were used to improve contrast and reveal faint planetary details.

• **Data Augmentation**

- ➢ Random rotations, flips, and brightness changes were applied to avoid overfitting and enhance model generalization.
- ➢ The dataset was encoded using LabelEncoder for numerical classification.

• **Model Architecture**

- ➢ A custom Convolutional Neural Network (CNN) was created with two convolutional layers (32 and 64 filters), followed by pooling, dropout, and fully connected layers.
- ➢ Activation functions: ReLU
- ➢ Loss function: Cross-Entropy Loss
- ➢ Training lasted for 10 epochs

.• **Cross-Validation**

- ➢ A 5-Fold K-Fold cross-validation method was used to ensure thorough model evaluation.
- ➢ For each fold, the model was trained on 80% of the data and validated on the remaining 20%.

• **Evaluation Metrics**

- ➢ The system's performance was measured using Accuracy, Precision, Recall, F1-score, and Confusion Matrix.
- ➢ The CNN showed high precision in distinguishing between star-only and exoplanet-containing images, proving reliable performance.

• **Visualization and Detection**

- ➢ The trained model was used to classify new telescope images.
- ➢ Detected exoplanet regions were highlighted using adaptive thresholding and circular contour detection to mark potential planetary candidates visually.
- ➢ Results were shown using matplotlib, where green circles indicated identified exoplanets.

Conclusion :

The developed system effectively detected exoplanets from telescope images using deep learning and advanced image processing techniques. The CNN-based approach successfully differentiated between simple stellar images and those that had faint exoplanetary signatures. With effective preprocessing methods like Gaussian filtering and contrast improvement, the model generalized well across different telescope datasets. This work demonstrates how AI can enhance astronomical research by automating exoplanet identification, reducing manual work, and speeding up discoveries in astrophysics.