CELESTIAL CODERS

SpaceCode

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Problem 01: Analysis of Exoplanets Based on Orbital Time Period

To solve this problem, We followed a systematic approach to obtain the relevant dataset and filter the data based on specific criteria. First, we accessed the provided URL, which contains information about exoplanet discoveries. Then we focused on exoplanets that have been confirmed through observations by selecting the Confirmed option from the "Status" drop-down menu. This ensured the data only contained verified exoplanets.

After which,we selected the Radial Velocity detection method from the "Detection" drop-down menu to narrow down the dataset to exoplanets discovered using this technique. Subsequently, we filtered the data of exoplanets having their orbital period from 0 to 400 Earth days, as this range focuses on planets with observable orbital periods relevant to the Radial Velocity method.

Once the dataset was filtered, We generated a histogram plot to visualize the distribution of the orbital periods of exoplanets discovered via the Radial Velocity method. This plot provided insights into the characteristics of the detected exoplanets and helped answer the key questions.

Problem 02: Radial Velocity Method for Finding Exoplanets

To approach this problem, we first visualized the radial velocity data using a scatter plot, estimating the orbital period based on observed periodicity. Then, we performed a Lomb-Scargle periodogram analysis to precisely calculate the orbital period. Finally, we folded the data to create a radial velocity curve, analyzing the periodic motion and identifying trends.

Problem 03: Pulsars in Deep Space

We developed two classification pipelines for pulsar detection: one for numerical features and another for image data, ensuring robust evaluation for both approaches.

1. **Numerical Model:**

   - *Preprocessing:* Standardized features using StandardScaler for optimal performance with distance-based classifiers.
   - *Models*: Tested SVM, Random Forest, Neural Network, and a Voting Classifier combining SVM and Random Forest.
   - *Data Imbalance:* Addressed using class weights inversely proportional to class frequencies.
   - *Optimization:* Performed hyperparameter tuning via RandomizedSearchCV.
   - *Best Result:* Voting Classifier achieved 98.16% accuracy with balanced precision and recall.

2. **Image Model (CNN):**

   - *Preprocessing:* Processed 32x32 RGB images (or resized where necessary) with Weighted Random Sampling to address class imbalance. Applied augmentations including flipping, rotation, color jittering, and random cropping.

- *Architecture:* Developed a custom CNN with four convolutional layers (each followed by ReLU and max-pooling), fully connected layers, and optional dropout for feature extraction and classification.
- *Optimization:* Employed Adam optimizer, a learning rate scheduler (ReduceLROnPlateau), and weighted cross-entropy loss to handle class imbalance.
- *Best Result:* CNN achieved 98.65% accuracy, excelling in recall, showcasing the power of spatial pattern recognition for rare pulsar detection.

Problem 04: Orbital Resonances

We approached this question by using Kepler's third law and the given values of the semi major axis and solar mass to find the orbital time period of the inner planet.

Now, the orbital period for inner planet can be used to find orbital time period of the outer planet as we know the relation between the orbital time period of both is 3:2, and using this newfound orbital time period of the outer planet, we can find the semi major axis of outer planet.

Problem 05: Escape Velocity from a White Dwarf

We approached this problem using the basics of physics we learned in high school. We used conservation of energy, gravitational potential energy and kinetic energy formulas and logic. By doing so, we got the formula of escape velocity.

Now, as we have got the formula for escape velocity, we put in the values as given for the dwarf star and then also represent it as a fraction of speed of light.

Github Repository : https://github.com/Dev31415926535/Space-Code-Challenge (will be made public after contest ends)