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Prediction of an Asteroid Diameter Using Machine Learning Algorithms

Miss.Mansi Subhash Bachal
Information Technology VPKBIET,Baramati INDIA

Miss.Namrata Sangram Mare
Information Technology VPKBIET,Baramati INDIA

Miss.Nilam Tatyaba Kamble
Information Technology VPKBIET,Baramati INDIA

Miss.Sonali Bhagvan Kolape
Information Technology VPKBIET,Baramati INDIA

Abstract: *Asteroid are small, rocky object that orbit the sun. Asteroids are rocky worlds revolving around the sun that are too small to be called planets. They are also known as planetoids or minor planets. There are millions of asteroids ranging in size from hundreds of miles to several feet across. In these paper we are going to measure the diameter of an asteroids. The diameter of an asteroid is one of the most important physical parameter of asteroid. There are many method used to estimate the diameter or size of asteroid. The latest technique that is used by space scientist to estimate the size of asteroid is through absolute magnitude (H) and Geometric albedo (a),where diameter is considered as function of H and a. For estimation of diameter of an asteroid we have used machine learning algorithm. The impact machine learning can make is truly boundless and this paper is confirmation of the utility machine learning have in predicting asteroid diameter. The overall paper can be viewed as success as it was able to predict accurate and powerful results using machine learning technology.*

Index Terms: *Detection, Machine Learning, Asteroids, Multilayer Perceptron Regressor.*

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I. Introduction

In this research paper, we are going to discuss how the concept of artificial neural network could be utilized to estimate the diameter of asteroid .For estimating the diameter of an asteroid the multilayer perceptron algorithm are used. A multi-layer perceptron is feed forward artificial neural network that maps a set of input data into set of appropriate data.The diameter of an asteroid is one the most important physical parameter of an asteroid, it is used to calculate many other physical and basic parameters of the asteroids like calculating the rotation period of asteroid, and also used to detect if an asteroid is potentially hazardous or not if it is found to be a Near Earth Object.The diameter is also used in many other researches about the asteroid.

We have used the dataset from Kaggle .Kaggle is the world largest data science community with powerful tools and research resources to help you achieve your data science goals. We have used the python as programming language to implement the model .The libraries which we have used in python are numpy and pandas for data analyzing .sklearn for preprocessing, importing regressor algorithm and model evaluation. Seaborn and matplotlib are used for data visualization.

II. Literature Survey

In this paper they study concept of artificial neural network could be utilized to estimate the diameter of an asteroid. In research paper used the Multilayer Perceptron algorithm as the base algorithm to predict the diameter. This paper considered all types of asteroids such as asteroids which are grouped as Near Earth Objects (NEO), Potentially Hazardous Objects(PHA). The diameter is also used in many other researches about the asteroid.

There are many methods used to estimate the diameter or size of the asteroids, the latest technique that is used by space scientists to estimate the size of the asteroid is through absolute magnitude(H) and geometric albedo(a) where diameter(d) is considered as a function of (H) and (a).

Denisa Copandean, Ovidiu Vaduvescu,Dorian Gorgan worked an automated pipeline prototype for asteroids detection, written in Python under Linux, which calls some 3rd party astrophysics libraries.European Near Earth Asteroids Research (EURONEAR) project has been contributing to this research since 2006 .

”Comparison of generalized regression neural network and MLP performances on hydrologic data forecasting”.

In this paper they study about comparison of neural network and MLP method for hydrologic data forcasting EURONEAR includes only a small number of professional astronomers, involving more amateurs and students who promptly reduce the data, report discoveries and perform NEA recoveries. For the image reduction, THELI software is used (under Linux).The Near-Earth Asteroid Tracking (NEAT) programmade the first fully automated system for controlling a remote telescope, acquiring wide-field images.

M.L. Vaughn; J.G. Franks.2003.”Explaining how a multilayer perceptron predicts helicopter airframe load spectra from continuously valued light parameter data”. Proceedings of the International Joint Confer- ence on Neural Networks,2003

In this study they showing result for helicopter airframedenisa Copandean, Constantin Nandra, Dorian Gorgan worked an automated ”blink” technique for asteroids detection. Asteroids detection is a very important research field that received increased attention in the last couple of decades.

Recently, ESA (European Space Agency) has begun to contract some European services to contribute to SSA (Space Situational Awareness) program. NEODyS at the University of Pisa ,KLENOT at the Klet Observatory, some national space agencies and other space industry entities are involved.

Over the past few years, the SSA program used the one-meter telescope ESA-OGS in Tenerife for some NEO studies and further analysis .By manually ”blinking” a set of consecutive images of the same field, they made 9 important discoveries and multiple of asteroids recoveries. Having this manual ow in mind, they propose an automated pipeline prototype for moving object detection.

Albino Carbognani and Alberto Buzzoni”Spinning and color properties of the active asteroid(6478)”Accepted 2020 january 21 in original form 2019 july 18. In this paper they study about color properties of the active asteroid(6478) In 1984, the Spacewatch group at the University of Arizona’s Lunar and Planetary Laboratory has used this approach to *implement the first* computer detection system based on CCD (change coupled device).

Their automated ”Moving Object Detection Program” (MODP) searched for objects showing consistent motion in three successive scans over the same region. Having a modular structure, the prototype can be easily improved from the performance point of view. It will also bring a great value to any user that will want to use this prototype. Mehrshad Salmasi,H. Mahdavi-Nasab, H. Pourghassem performance of multilayer perceptron (MLP) and generalized regression neural networks (GRNN) is evaluated in active cancellation of sound Noise .

Denusa(Balazs) copandean ,Doreian Gorgan”A Visual Solution in Asteroid detection”2019. In this paper they implemented system to detect asteroid.Some of the applications of active noise control are engine noise cancellation, compressors and pumps noise reduction, reduction of air-conditioning ducts noise, acoustic noise cancellation in MR imaging, reduction of car interior noise and control of aircraft cabin noise.

There are two types of ANC systems. The first one is feedforward control and the second one is feedback control. In feedforward control systems, a reference noise signal is sensed.In feedback ANC systems the reference signal is unknown and the main idea is to regenerate the reference signal .In this paper, two kinds of feedforward neural network are used. Multilayer perceptron (MLP) and generalized regression neural networks (GRNN) are designed and trained for active cancellation

“Hazardous Asteroid Classification through Various Machine Learning Techniques”

- In this paper, I tried to find a new model to identify the hazardous asteroids. As far as, asteroids are concerned, there are many asteroids called near-earth asteroids, but all are not hazardous. So, our target in this paper is to identify those hazardous asteroids and classify them with non-hazardous types.

For this, I choose many machine learning models. I trained those various model with the data features and later I compare those results to find the most accurate model which gives the most accurate classification. In my prediction random forest and xgb classifier give most accurate prediction.

“Identifying Earth-impacting asteroids using an artificial neural network”

In this paper, By means of a fully connected artificial neural network, we identified asteroids with the potential to impact Earth. The resulting instrument, named the Hazardous Object Identifier (HOI), was trained on the basis of an artificial set of known impactors which were generated by launching objects from Earth’s surface and integrating them backward in time. HOI was able to identify 95.25% of the known impactors simulated that were present in the test set as potential impactors. In addition, HOI was able to identify 90.99% of the potentially hazardous objects identified by NASA, without being trained on them directly.

"The Deflector Selector: A Machine Learning Framework for Prioritizing Hazardous Object Deflection Technology Development"

Several technologies have been proposed for deflecting a hazardous Solar System object on a trajectory that would otherwise impact the Earth. The effectiveness of each technology depends on several characteristics of the given object, including its orbit and size. The distribution of these parameters in the likely population of Earth-impacting objects can thus determine which of the technologies are most likely to be useful in preventing a collision with the Earth. None of the proposed deflection technologies has been developed and fully tested in space. Developing every proposed technology is currently prohibitively expensive, so determining now which technologies are most likely to be effective would allow us to prioritize a subset of proposed deflection technologies for funding and development.

We present a new model, the Deflector Selector, that takes as its input the characteristics of a hazardous object or population of such objects and predicts which technology would be able to perform a successful deflection. The model consists of a machine-learning algorithm trained on data produced by N-body integrations simulating the deflections. We describe the model and present the results of tests of the effectiveness of nuclear explosives, kinetic impactors, and gravity tractors on three simulated populations of hazardous objects

"The machine-learning methods in the asteroids dynamics"

In asteroid dynamics, many problems require numerical integration of asteroids orbits. This approach consumes enough computer resources, especially when we try to analyses the dynamics of hundreds of thousands of asteroids. Any improvement in the orbit of the asteroid requires additional computer resources to be applied. Therefore, within the context of the increasing volume of new information, fast new methods should be applied to work with big data.

Artificial intelligence and machine-learning (ML) methods have become popular in recent years. In this study, we apply the modern ML methods to the classical problems of the dynamics of the asteroid: the identification of the resonances, families, non-regular objects. It is shown, that such methods provide acceptable accuracy and requires much less computational resources.

"Predicting Asteroid's Diameter Using Machine Learning"

The unique approach of predicting asteroid's diameter via machine learning was posed by Victor Basu of the CSE Jalpaiguri Government Engineering College West Bengal, India. He created the Kaggle post I mentioned earlier and directed me to the NASA/JPL Solar System Dynamics website to find some useable data on asteroids (surprisingly hard to find). The NASA/JPL SSD query helped me generate my dataset for this project.

The final goal of this project is to create a powerful machine learning model that accurately predicts the asteroids diameter based on orbital and observation features. That model will be used in order to deploy an Plotly Dash App. The app will allow users to visually compare and contrast the model's predictions against the true diameters of specific asteroids. Several of the features used in data are not intuitive to the average joe (units on variables range from astronomical units [au], degrees/day [deg/d], degrees [°], etc.) so one key attribute to the app will be a slider input form. This will add a boost to the UX by eliminating the guessing associated with these foreign characteristics, while not compromising the predicative model. The link to the app can be found here. The app allows users to mess around with some aspects of the asteroid and see how it impacts the asteroid's diameter!

"A Methodology For Sequential Low Thrust Trajectory Optimization Using Prediction Models Derived From Machine Learning Techniques"

In this work, a methodology is developed for integration of these machine learning techniques into a trajectory sequence optimization technique. First a set of training data composed of low thrust trajectories is produced using a Sims-Flanagan solver. Next, this data is used to train regression and classification models that respectively predict the final mass of a spacecraft after a low thrust transfer and predict the feasibility of a transfer.

Two machine learning techniques were used: Gradient boosting and artificial neural networks. These predictors are then integrated into a sequence evaluation evaluation scheme that scores a sequence of targets to visit according to the prediction models. This serves as the objective function of the global optimizer. Finally, this objective function is integrated into a Genetic Algorithm that optimizes sequences of targets to visit

"Machine Learning Regression For Estimating Characteristics Of Low-Thrust Transfers"

Trajectory planning is a time-consuming and difficult part of spacecraft mission design. There are often requirements for a spacecraft to visit specific points in space, with tight fuel margins. Therein lies the difficulty, as it is trivial to create an infeasible trajectory, but difficult to create an optimal one.

Additionally, the ability for a spacecraft to visit multiple destinations is often desired by mission planners; however, this comes at a cost of making the trajectory planning problem much harder. This is because there is additional complexity in choosing not only the destinations the spacecraft would visit, but also the order in which the spacecraft visits them. At the same time, trajectories must be found between candidate destinations.

Since the number of destinations can easily reach the tens of thousands and even climb, as with the number of known asteroids near the Earth

"Applying Machine Learning To Asteroid Classification Utilizing Spectroscopically Derived Spectrophotometry"

Taxonomic studies of asteroids have been ongoing for more than fifty years without a clear understanding of the class parameters. The current method of Principal Component Analysis is computationally expensive and leaves ambiguous results. In this study, I selected the machine learning algorithm, k-Nearest Neighbor in combination with the current BusDeMeo (DeMeo, et al. 2009) taxonomic classification schema to test if machine learning can take the place of Principal Component Analysis.

Using a dataset of spectrophotometric color indices derived from combined visible and near-infrared (NIR) observations and paired with Bus-DeMeo taxonomic class, I created a training dataset for the model to learn. The results support the visible wavelength region as more diagnostic of spectral slope and the NIR wavelength region as more diagnostic for surface mineralogy. The overall accuracy scores (>80%) of the machine learning test dataset validate the methodology, but fall short of the threshold necessary to replace current methods of classification (>95%).

"Prediction of Orbital Parameters for Undiscovered Potentially Hazardous Asteroids Using Machine Learning"

The purpose of this study is to make a prediction of combinations of orbital parameters for yet undiscovered potentially hazardous asteroids (PHAs) with the use of machine learning algorithms. The proposed approach aims at outlining subgroups of all major groups of near-Earth asteroids (NEAs) with high concentration of PHAs in them. The approach is designed to obtain meaningful results and easy-understandable boundaries of the PHA subgroups in 2- and 3- dimensional subspaces of orbital parameters. Boundaries of these PHA subgroups were found mainly by the use of Support Vector Machines algorithm with RBF kernel.

Additional datasets of virtual asteroids were generated to handle sufficient amount of training and test data, as well as to emulate undiscovered asteroids. This synthetic data helped in revealing 'XX'-shaped region with high concentration of PHAs in the (ω, q) plane. Boundaries of this region were used to split all NEAs into several domains. For each domain the subgroups of PHAs were outlined in different subspaces of orbital parameters. Extracted subgroups have high PHA purity (~90%) and contain ~90 % of all real and virtual PHAs. Obtained results can be useful for planning future PHA discovery surveys or asteroid-hunting space missions.

III. Conclusions

Space researches could proceed further with the help of machine learning algorithms. The overall paper can be viewed as success as it was able to predict accurate and powerful results using machine learning technology. The impact machine learning can make is truly boundless and this paper is conformation of the utility machine learning have in predicting asteroid diameter

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