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Detecting Asteroids and Comets using Machine Learning and Deep Learning

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Abstract

Asteroids and comets are potentially hazardous objects that may make close approaches and enter into Earth's orbit. Detecting and tracking asteroids and comets is a global challenge. Machine learning and deep learning are powerful tools that can be used to observe such hazardous objects early to protect our planet from any future impact. In this paper, we attempt to present a concise review on using machine learning and deep learning in tracking asteroids and comets.

Keywords: Asteroids – Comets – Machine Learning – Deep learning

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1. Introduction

Comets and asteroids are celestial dangerous moving objects with high speed. Such objects may make close approaches and enter into Earth's orbit. If an asteroid or a comet hits the Earth, it would be a catastrophic global crisis [1-4]. On the other hand, some of such potential objects can finish the life on Earth by a deep impact which can release energy more powerful than nuclear weapons. The impact of a 10km comet or asteroid, was responsible for the extinction of dinosaurs. Several Satellites are tracking asteroids and comets in the space to sound the alarm if an asteroid or a comet comes close to the Earth [5,6]. Researchers are developing new methods to give detect any future hazardous object that may come close to Earth with sufficient warning time (figure 2). On the other hand, scientists and engineers devise new strategies to search for the best way to deflect an incoming asteroid/comet. NASA's DART Mission was the first ever planetary defense test to redirection the double asteroid Dimorphos [6]. Machine learning and deep learning are types of AI. Machine learning and Deep learning are powerful tools used to track asteroids and comets. Also such tools are used to discover new asteroids and comets. Machine learning and deep learning are both types of AI. They can help in asteroid and comets tracking and classification. Machine learning studies computer algorithms which can learn from the gathered big data while Deep learning is subset of machine learning that uses artificial neural networks to mimic the learning process of the human brain. In this paper, a short review about the importance of using machine learning and deep learning in detecting asteroids and comets is conducted. The rest of the paper is organized as follows. In section two, a discussion about using machine learning and deep learning in tracking asteroids and comets are presented while section three is devoted for a discussion on using deep learning for searching for long period comets. In section four and five respectively, we discuss using machine learning in Near Earth objects detection and classification.

2. Machine Learning and Deep Learning for detecting asteroids and comets

Searching for dangerous asteroids and comets isn't an easy process. Earth is surrounded by thousands of such potentially hazardous objects, known as Near Earth Objects (NEOs). Several satellites and probes in space use image processing techniques to detect asteroid in space [7]. A lot of such objects are floating in the darkness of the space and difficult to detect (Figur1). In the last few decades, the process of asteroids/comets tracking was performed by the old-fashioned telescopes on clear nights. Scientists and engineers are now developing advanced technology techniques to find and track asteroids and comets. Hundreds of hidden

asteroids detected by machine learning and deep learning algorithms by studying old telescope big data.

Machine learning approaches used in tracking asteroids and comets are divided into two major categories; supervised learning and, unsupervised learning. Recognizing or tracking asteroids or comets with human eye is not easy, but machine learning and deep learning techniques are more efficient in the detection process. Machine learning and deep learning can be implemented with different popular software like Python. Such algorithms consider the data with same flux as points which form linear equation where the data are named as asteroid/comet.

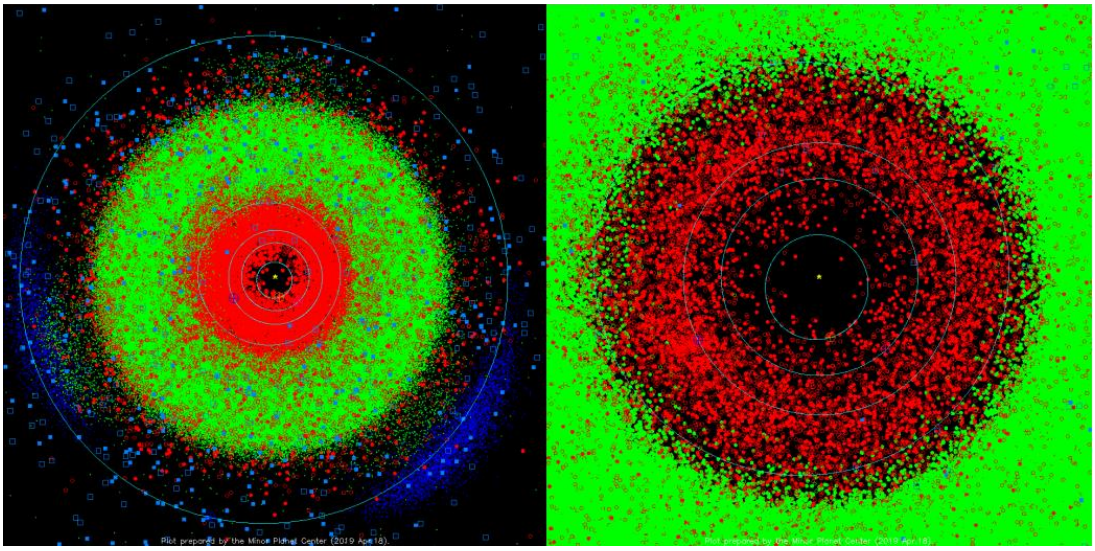

Figure 1: known asteroids and comets distribution in the solar system [7]. Main Belt asteroids (green circles), near earth asteroids (red circles), Jupiter Trojans (blue circles), comets (blue squares) and the Sun (yellow circle in the center).

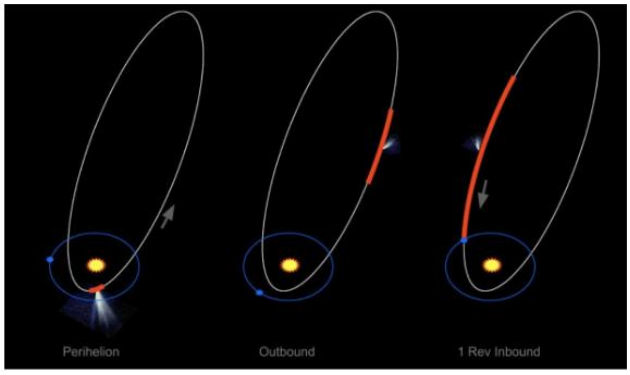

Figure 2: A Long Period Comet travels to the inner Solar System (the blue point is the Earth) [8].

3. Searching for long-period comets with deep learning tools

Deep Learning tools can help to search for potentially large, long-period comets size with fast impact speeds of up to 72km/s to process the collected data from low light video observations, and makes results available to the observers. In [9], detections are classified by using a convolutional neural network (CNN), and a long short term memory network (LSTM). The performance of both CNN and LSTM are approximately the same [9].

4. Near-Earth Asteroid Detection by Preprocessing of Astronomical Images by Machine learning

In [11], the authors used machine learning to create an efficient method of near-Earth asteroids big data classification. They used the data gathered by NEOWISE telescope. Several machine learning classifying models, like logistic regression, a support vector machine (SVM), and a random forest to classify a source as an asteroid or not.

5. Machine learning for Asteroids classifications

Astronomical big data requires using efficient machine learning techniques to classify asteroids. Several studies have been presented to perform the big data analysis [11]. For example, Sykes et al. (2000) presented a study about the distribution of color indices of asteroids and comets and proposed a map of the asteroid belt. The authors' goal in [12], was to figure out the performance of different asteroid spectral features in predicting the asteroid type using machine learning. They declared that machine learning techniques such as naïve Bayes, support vector machine (SVM), gradient boosting, and multilayer networks can reproduce that taxonomic classification at a high rate of balanced accuracy. Also, the authors in [14] created a taxonomic classification and studied the distribution of different asteroid types.

6. Conclusion

In this work, we present a short review on using machine learning and deep learning in tracking asteroids and comets. We attempt to highlight the importance of using such tools to accurately detect and track hazardous near-Earth objects. On the other hand, machine learning and deep leaning can help to search for unknown asteroids and comets to sound the alarm with a sufficient time before any future impact.

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