CHAPTER I
INTRODUCTION

A. Background

Studying asteroids is crucial in enhancing our comprehension of the solar system's history. Asteroids are like planets. They orbit the sun but with a smaller size (Wang et al., 2014). The asteroid belt, which located between Mars' and Jupiter's orbit, is a region of asteroids including small asteroids, young asteroids, and pairs of asteroids on very similar orbits. The asteroid pairs usually involve different mechanisms such as larger parent bodies collisional disruption, gravitational bound binary systems separation, and bodies on planet crossing orbits disruption (Moskovitz, et al., 2019).

There are over 1,8 million asteroids in the solar system and 25,000 of them are identified as Near Earth Asteroids (NEAs) because their orbit is close to Earth (Harris & Chodas, 2021). NEA can be observed using extensive space survey technology and grouping into four orbital clusters: Atens, Apollos, Attiras, and Amors. Atens' and Atiras' orbits are close to the Earth; meanwhile, Atiras' are inside the Earth's orbits, and Amors' are outside the Earth's orbits (Perna et al., 2013).

4.700±1.500 NEAs are Potentially Hazardous Asteroids (PHAs) that can collide with the Earth. The PHA have a diameter of over 140 meters or about 390 feet. PHAs' size is large enough to pass through Earth's atmosphere, causing massive damage and endangering life on Earth (Perna et al., 2013). Once PHA collides with the Earth, it will cause a big hole in the surface, similar to the moon's craters. The craters appear because asteroids hit the moon's surface often. Fortunately, the Earth has an atmosphere that shields it from collision with other objects like asteroids. Therefore, the object will erode before it touches the Earth's surface. Meanwhile, asteroids that successfully crash the Earth's surface will form some holes. After a time, the holes will disappear from the Earth's surface because of the erosion processes. Sometimes, the PHA that reaches the Earth's surface is a result from the collision asteroids pairs. The collision separates some parts of the asteroid, entering the Earth's orbit and falling into the Earth's surface as a meteorite (Sagan, 2016).

The collision between the PHA and the Earth has happened in the past and will occur again in the future (Li et al., 2019). For example, a meteor crashed into Earth's surface in Russia in June 1908. The crash caused an explosion that destroyed over 2.000 square kilo meters of Taiga forest (Artemieva & Shuvalov, 2016). Furthermore, another 30-meter diameter meteor crashed near the Sikhote-Alin Mountains in the same country in February 1947. The crash caused over 100.000 mountain fragments erosion, creating a large hole in the mountain. Another example is the fall of the 20-meter diameter Chelyabinsk meteor in Russia in February 2013, which harmed more than 1.500 people and ruined a lot of material. It shows that the collision can cause massive destruction (Perna et al., 2013).

To minimize the risk of asteroid collision, the United States (US) Congress and the National Aeronautics and Space Administration (NASA) developed an international project, the Spaceguard Survey, in the early 1990s. The project has identified over 32,000 of the largest Near-Earth Objects (NEOs). It confirmed that those asteroids will not collide with the Earth (Baum, 2019). The number of NEOs is increasing every year. Therefore, predicting the possibility of PHAs' collisions with the earth is essential. The prediction can be provided by a suitable computer program (Bhavsar et al., 2023). The study applies machine learning algorithm to classify the asteroids.

Machine Learning algorithm enables automation, reduce human error, analyse complex data and identify patterns in the asteroid dataset to provide more accurate and faster classification. These algorithms can adapt and improve over time, enhancing their accuracy and reliability to categorize PHA and non-PHA (Metzger, 2016). Several machine learning algorithms such as K-Nearest Neighbor (KNN), Random Forest, and Naïve Bayes are generally applied to make classification. However, the performance of each algorithm depends on the data type and the tasks required.

By applying the asteroid dataset, there will be two classes of the classification program: PHA and non-PHA, referred as Binary class (Bahel et al, 2020). The

KNN, Random Forest, and Naïve Bayes performance in classifying asteroid will be evaluated by the standard classification metrics such as accuracy, precision, recall, and F1-score. The classification metrics provide a comprehensive assessment of each algorithm's strength and weaknesses. The study aims to identify the most effective method to develop asteroid classification program (Idrees & Alsheref, 2020).

Based on the explanation, developing an asteroid classification program by applying machine learning algorithm becomes a critical step to address significant challenges in astronomy and the security of The Earth. However, to maximize the performance of the asteroid classification program, there must be further analysis of the machine learning algorithms, KNN, Random Forest, and Naïve Bayes. Each algorithm will be evaluated by the classification metrics to obtain the most appropriate method for the asteroid classification task. The asteroid classification program is expected to protect Earth and improve human comprehension of the universe.

B. Research Problem

The problems of this study are as follows:

1. How can machine learning algorithm develop an asteroid classification program?
2. What is the most appropriate machine learning algorithm to develop an asteroid classification program?

C. Research Objective

The objectives of this study are as follows:

1. Classify asteroid based on the orbital motion.
2. Develop an asteroids classification program with machine learning algorithm.
3. Determine the most appropriate machine learning algorithm to develop an asteroid classification program.

D. Research Benefits

The benefits of this study are as follows:

1. To facilitate more efficient identification and monitoring of asteroids that are crucial for space exploration and mitigating potential collision risk.
2. Promote scientific comprehension of asteroids, their variations, and their roles in the solar system's evolution.
3. The research can be a reference for further study on asteroid classification program.