**PROJECT REPORT**

on

**NEAR EARTH OBJECT**

**(Project–1)**

**BACHELOR OF TECHNOLOGY**

(Computer Science and Engineering)

****

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**DECLARATION**

We, Vrnika Jain and Aman hereby declare that the report of the project entitled “Near Earth Object” has not presented as a part of any other academic work to get my degree or certificate except Chandigarh Engineering College Jhanjeri, Mohali, affiliated to I.K. Gujral Punjab Technical University, Jalandhar, for the fulfilment of the requirements for the degree of B. Tech in Computer Science & Engineering.

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**VRNIKA JAIN**

**AMAN**

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**CHAPTER - 1**

**INTRODUCTION**

**1.1. Overview**

The vast expanse of our solar system is home to an intriguing population of celestial bodies known as Near Earth Objects (NEOs). Comprising asteroids and comets whose orbits bring them into proximity with Earth, NEOs offer both scientific fascination and pose potential threats to our home planet. As we embark on the journey to analyze these NEOs, this research is fueled by the vast and invaluable dataset provided by NASA's Jet Propulsion Laboratory (JPL) - the JPL Asteroid Dataset.

**1.2. Significance of Near Earth Objects**

**1.2.1. Scientific Curiosities**

NEOs are remnants of the early solar system, providing astronomers with a unique opportunity to unravel the mysteries of our celestial neighborhood. These objects retain information about the formation and evolution of our solar system, offering glimpses into the conditions that prevailed during its nascent stages. The study of NEOs provides essential clues about the processes that led to the formation of planets, including Earth.

**1.2.2. Potential for Resource Utilization**

Beyond their scientific value, NEOs hold promise for future space exploration and resource utilization. The accessibility of these objects makes them potential targets for mining activities. The extraction of resources, such as metals and water, from NEOs could revolutionize space exploration by providing essential materials for sustained human presence beyond Earth.

**1.2.3. Planetary Defense Imperative**

While NEOs present scientific opportunities, they also represent a stark reality - the potential hazard they pose to Earth. The possibility of an asteroid or comet colliding with our planet raises concerns about the consequences of such an impact event. Understanding and mitigating this risk is not only a scientific endeavor but a planetary defense imperative.

**1.3. The Threat of Potentially Hazardous Asteroids**

**1.3.1. The Impact Hazard**

The concept of a celestial body colliding with Earth, while rare, has been etched into our collective consciousness by events like the Chicxulub impact, which is linked to the extinction of the dinosaurs. The scientific community acknowledges the potential severity of impact events and the need for vigilance in monitoring objects that traverse Earth's vicinity.

**1.3.2. Impact Risk Assessment**

Quantifying the risk posed by Near Earth Objects involves intricate calculations and simulations. Methods such as probabilistic impact models and trajectory simulations contribute to understanding the likelihood of an impact and the potential consequences. Impact risk assessment is a vital component of planetary defense efforts, guiding strategies for early detection and mitigation.

**1.4. NASA's JPL Asteroid Dataset**

**1.4.1. The Repository of NEO Knowledge**

At the forefront of NEO research is NASA's Jet Propulsion Laboratory, which maintains a comprehensive repository of data known as the JPL Asteroid Dataset. This dataset encompasses a wealth of information, including orbital parameters, physical characteristics, and spectral data, providing researchers with a powerful tool to investigate and analyze NEOs.

**1.4.2. The Role in Planetary Defense**

JPL's Asteroid Dataset plays a pivotal role in planetary defense initiatives. It is the bedrock upon which impact risk assessments are built. The dataset facilitates the identification, tracking, and characterization of NEOs, enabling scientists to predict their trajectories and assess potential hazard levels. This information is critical for developing strategies to mitigate the impact risk.

**1.5. Research Objective: Analyzing Potentially Hazardous Asteroids**

Against this backdrop of scientific intrigue and potential threat, the primary focus of this research is to analyze asteroids within NEOs that have the potential to be hazardous to Earth. Leveraging the wealth of data within the JPL Asteroid Dataset, the objective is to identify, characterize, and assess the risk associated with these potentially hazardous asteroids. The analysis encompasses considerations of their orbital dynamics, physical properties, and spectral characteristics.

**1.6. Methodology**

The methodology involves a multi-faceted approach, utilizing observational data, computational models, and advanced analyses. Ground-based telescopes, space-based observatories, and radar measurements contribute to the collection of observational data. Computational models, incorporating elements of celestial mechanics and impact dynamics, aid in trajectory predictions and impact risk assessments. The JPL Asteroid Dataset acts as the cornerstone, providing the necessary parameters for analysis.

**CHAPTER - 2**

**SYSTEM REQUIREMENTS**

**2.1. Hardware Requirements:**

**1. Computing Infrastructure:**

Utilize a High-Performance Computing (HPC) cluster with multiple nodes, each equipped with high-end processors (e.g., multi-core CPUs or GPUs).

A minimum of 64GB RAM per node is recommended to handle large datasets and simulations efficiently.

**2. Storage Solutions:**

Employ a storage system with a large capacity to accommodate the extensive dataset. Utilize a combination of high-speed Solid State Drives (SSDs) for fast access and traditional Hard Disk Drives (HDDs) for cost-effective storage.

**3. Network Infrastructure:**

Implement a high-speed and low-latency network to facilitate seamless communication between nodes in the cluster, crucial for distributed computing tasks.

**4. Security Measures:**

Ensure robust data security measures, including encryption protocols and access controls, especially when dealing with potentially sensitive information.

**5. Backup and Recovery Systems:**

Establish regular backup procedures to prevent data loss due to system failures, and implement recovery systems for quick restoration.

**2.2. Software Requirements:**

**1. Data Analysis Software:**

Leverage data analysis tools such as Python with scientific libraries (NumPy, SciPy) and data manipulation platforms like Pandas for efficient processing of the JPL Asteroid Dataset.

**2. Simulation Software:**

Utilize specialized software for celestial mechanics and impact dynamics simulations. Consider integrating SPICE (Spacecraft, Planet, Instrument, Camera-matrix, Event) for NASA-standardized simulations.

**3. Database Management System (DBMS):**

Employ a robust DBMS like PostgreSQL, MySQL or MongoDB for efficient management and querying of large datasets.

**4. Visualization Tools:**

Use visualization tools such as Matplotlib for Python or specialized 3D visualization tools to interpret and present analysis results effectively.

**5. Collaboration Software:**

Utilize collaboration tools like project management software, version control systems (e.g., Git), and communication platforms (e.g., Slack, Microsoft Teams) for seamless team coordination.

**6. Educational and Outreach Resources:**

Utilize resources for creating educational materials and websites if there is an outreach or public engagement component.

**7. Security Software:**

Install security software to monitor and protect the system against cyber threats and vulnerabilities.

**8. Documentation and Training:**

Develop comprehensive documentation for software, methodologies, and data sources to ensure reproducibility. Provide training programs for effective utilization of tools and methodologies.

**9. Legal and Ethical Compliance Software:**

Implement compliance management software to ensure adherence to legal and ethical standards, especially concerning sensitive data.

**CHAPTER - 3**

**SOFTWARE SYSTEM ANALYSIS**

**3.1. Data Analysis Software:**

**1. Python and Scientific Libraries:**

Python serves as the primary language for data analysis due to its versatility and extensive libraries. Scientific libraries like NumPy and SciPy provide essential tools for numerical operations, statistical analysis, and scientific computing.

**2. Pandas for Data Manipulation:**

The Pandas library is crucial for handling and manipulating structured data. It facilitates tasks such as filtering, cleaning, and organizing the JPL Asteroid Dataset for efficient analysis.

**3.2. Simulation Software:**

**1. Celestial Mechanics Simulations:**

Specialized simulation software is essential for modeling celestial mechanics. Integration of tools like SPICE (Spacecraft, Planet, Instrument, Camera-matrix, Event) ensures standardized simulations aligned with NASA's practices.

**2. Impact Dynamics Simulations:**

Dedicated software for impact dynamics simulations is necessary to model potential asteroid impacts on Earth accurately. These simulations contribute to impact risk assessments.

**3.3. Database Management System (DBMS):**

**1. PostgreSQL or MongoDB:**

A robust DBMS is critical for efficient data management. PostgreSQL or MongoDB can handle large datasets, providing reliable storage and retrieval mechanisms for the JPL Asteroid Dataset.

**3.4. Visualization Tools:**

**1. Matplotlib for Python:**

Matplotlib is a powerful visualization library for Python, enabling the creation of various plots and graphs. It aids in visually interpreting analysis results, such as orbital trajectories and impact scenarios.

**2. Specialized 3D Visualization Tools:**

For in-depth analysis and interpretation, specialized 3D visualization tools can be employed. These tools allow researchers to explore complex spatial relationships within the NEO dataset.

**3.5. Collaboration Software:**

**1. Project Management Software:**

Tools like Jira or Trello facilitate project management by organizing tasks, tracking progress, and promoting collaboration among team members.

**2. Version Control Systems (VCS):**

Git, as a widely used VCS, ensures version control and collaboration on code repositories. It enhances collaboration and maintains a record of changes made during the project.

**3.6. Mission Planning Tools:**

**1. Space Agencies' Mission Planning Software:**

Integration with mission planning software used by space agencies, such as NASA's GMAT (General Mission Analysis Tool), assists in designing potential NEO exploration missions.

**3.7. Security Software:**

**1. Cybersecurity Tools:**

Implementation of cybersecurity tools is crucial to safeguard the software system against potential threats. Antivirus softwares, firewalls, and intrusion detection systems enhance the overall security posture.

**3.8. Documentation and Training:**

**1. Documentation Tools:**

Platforms like Confluence or Sphinx aid in creating comprehensive documentation. Clear documentation ensures the reproducibility of analyses and provides valuable insights for future researchers.

**2. Training Programs:**

Design training programs to familiarize researchers with the software tools and methodologies used in the project. This promotes effective utilization and knowledge transfer within the team.

**CHAPTER - 4**

**SOFTWARE DESIGN**

**4.1. Modular Architecture:**

The software design adopts a modular architecture for flexibility and maintainability. Key functionalities are encapsulated within independent modules:

* **Data Acquisition Module:** Retrieves and updates data from NASA's JPL Asteroid Dataset.
* **Data Processing Module:** Cleans and preprocesses raw data using Pandas and NumPy.
* **Simulation Module:** Integrates celestial mechanics and impact dynamics simulations.
* **Database Interaction Module:** Manages interactions with the chosen DBMS for storage and retrieval.
* **Visualization Module:** Generates visuals using Matplotlib and 3D tools for interpretation.
* **Collaboration Module:** Integrates project management and version control for team coordination.

**4.2. Workflow:**

**1. Data Retrieval and Preprocessing:**

* Acquire the latest data from NASA's JPL Asteroid Dataset.
* Preprocess raw data to ensure consistency and quality.

**2. Simulation and Analysis:**

* Employ celestial mechanics and impact dynamics simulations for hazard assessment.
* Store and analyze simulated data within the Database Interaction Module.

**3. Visualization and Interpretation:**

* Transform complex data into graphical representations for easy interpretation.

**4. Collaboration and Documentation:**

* Facilitate team coordination through project management and version control.
* Document methodologies, parameters, and results for reproducibility.

**4.3. Integration Points:**

Well-defined integration points ensure a smooth exchange of data between modules. For example, the Simulation Module communicates with both the Data Processing Module and the Database Interaction Module to ensure accurate simulations and storage of results.

**4.4. Technology Stack:**

The technology stack includes Python, NumPy, Pandas, Matplotlib, SPICE for simulations, and Git for version control. Collaboration tools enhance team coordination.

**CHAPTER - 5**

**IMPLEMENTATION**

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