Artificial Intelligence and Astronomy

Lab Manual

Introduction

Artificial intelligence (AI) has greatly impacted astronomy and space exploration in several ways:

Data Processing and Image Enhancement:
AI algorithms enhance raw images from telescopes like Hubble or James Webb, removing errors and noise to improve clarity for scientific studies. For instance, a machine learning technique clarified an image of the supermassive black hole in the galaxy Messier 87, revealing detailed features of its structure.

Pattern Recognition and Classification:
AI is used to classify galaxies, stars, and other celestial bodies by learning from sample data and applying that knowledge to new datasets. This increases both the accuracy and speed of classifications. AI also detects patterns in large amounts of data, discovering new phenomena or links between data points.

Spacecraft Autonomy and Risk Prediction:
AI improves spacecraft independence by processing extensive data about celestial bodies and predicting risks like solar storms and space debris. This enhances mission planning and safety, reducing the need for human intervention and making space missions more efficient.

Cosmological Phenomena Prediction:
Using historical data, AI models predict events like gravitational waves or supernovae, allowing astronomers to allocate their observation efforts and resources better.

Collaboration and Efficiency:
AI automates routine tasks, which frees scientists to concentrate on more complex analysis and discoveries. This reduces costs and speeds up research, facilitating deeper exploration into the universe's mysteries.

Overall, AI is transforming astrophysics and space exploration by improving data analysis, recognizing patterns, and streamlining data processing. As AI technology evolves, we can anticipate even more groundbreaking discoveries in the future.

In this lab, students will explore how artificial intelligence (AI) can be utilized to deepen their understanding of astronomy, cosmology, astrophysics, astrobiology, and space exploration. The integration of AI tools in these fields represents a significant advancement in how we process complex data, simulate cosmic phenomena, and even predict future events in the universe.

Goals of the Lab:

Understanding AI Capabilities: Students will gain firsthand experience with various AI platforms, learning how these tools interpret and respond to complex astronomical queries.

Critical Analysis: By comparing responses from different AI systems, students will develop critical thinking skills as they assess the accuracy and reliability of AI-generated information.

Enhancing Engagement: Through interactive and practical engagement with AI technologies, the lab aims to enhance student interest and participation in astronomical studies.

Technological Proficiency: Students will acquire essential skills in navigating and utilizing advanced digital tools that are increasingly relevant in scientific research and academia.

Expectations:

Active Participation: Students are expected to actively engage with all the platforms and complete each task with diligence and curiosity.

Critical Engagement: Students are expected to approach each exercise with a critical mind—question the AI, explore its strengths and limitations, and reflect on the implications of using AI in scientific contexts.

Collaborative Learning: While the lab focuses on individual interactions with AI, students are encouraged to share insights and findings with peers, fostering a collaborative learning environment.

Innovative Thinking: This Lab encourages creativity in formulating questions and interpreting AI responses. Exploring complex and tricky questions will challenge the AI and deepen students' understanding of both the technology and the astronomical concepts.

By the end of this lab, students will not only have a better understanding of how AI can be applied in the field of astronomy but also appreciate the complexities and nuances of using AI in scientific inquiry. This lab is a step towards becoming not just consumers of AI technology but also thoughtful and critical users who can leverage these tools in their future careers and studies.

Materials Needed:

Computers with Internet access

1. AI Chat Platforms

Objective:

Students will evaluate the accuracy and reliability of AI responses by devising and inputting astronomy-related questions into various AI chat platforms and then comparing the platforms based on the correctness of answers.

Expected Learning Outcomes:

1. Develop the ability to formulate clear, concise questions covering a broad range of astronomy topics.
2. Enhance critical thinking skills by analyzing and comparing the accuracy of answers from multiple AI platforms.
3. Gain familiarity with different AI tools and their applications in answering astronomical queries.

Materials

Computers with Internet access

AI Chat Platforms:

ChatGPT https://chat.openai.com/

Gemini https://gemini.google.com/app
Claude https://claude.ai/chats
Microsoft Copilot in Bing https://www.bing.com/chat

Procedure:

Devise ten questions covering topics in Astronomy, Cosmology, Astrophysics, Astrobiology, and Space Exploration, ensuring that you know the correct answers. You may source these questions from your textbook or Blackboard exams.

Refer to the sample questions below for inspiration, but formulate your own questions for this exercise.
Input your questions into ChatGPT and tally how many it answers accurately.
Conduct the same process with other AI platforms: Gemini, Claude, and Microsoft Copilot in Bing.
If you are familiar with additional AI platforms, include them in this exercise as well.

Try to make the questions more difficult and find such astronomy questions where some AI chat platforms give correct answers and other chat platforms give wrong answers.
Determine which platform makes the fewest errors.
Evaluate which platform's responses you prefer the most.

Write everything down in your report with your questions and AI answers.

Examples of Questions (Don't use example questions; use your questions)

1. What is the closest planet to the Sun? Mercury.
2. How many planets are there in our solar system? 8.
3. What is the largest planet in our solar system? Jupiter.
4. What is the name of our galaxy? Milky Way.
5. How many moons does Mars have? 2.
6. What is the last name of the first human to walk on the Moon? Armstrong.
7. What was the last name of the first person to fly around the Earth in outer space? Gagarin.
8. What is the name of the first artificial satellite launched by humans? Sputnik.
9. What is the closest star to the Earth? Sun.
10. What is the brightest object (excluding the Sun) visible from Earth at night? Moon
11. What is the term for a massive collapsed star with a strong gravitational pull that not even light can escape? Black Hole.
12. What is the gaseous giant planet with beautiful rings? Saturn.
13. What is the name of the hottest planet in our solar system (despite being closer to the Sun than Mercury)? Venus.
14. What planet is known as the Red Planet? Mars.
15. Which star is at the center of our Solar System? Sun.
16. What is the largest planet in our Solar System? Jupiter.
17. What is the term for a system of millions or billions of stars, together with gas and dust, held together by gravitational attraction? Galaxy.
18. What term describes the path of a celestial body in space? Orbit.
19. What is the brightest planet in the night sky? Venus.
20. What is the darkest phase of the month, when the moon is between the Earth and the Sun? New moon.

Examples of questions to which AI chats usually give incorrect answers:

1. What is the brightest star visible in the sky? Sun
   (The question doesn't say "night sky", but people and AI chats usually don't notice that)

Compare your answer and the answers of AI chats to the following question:
How many full minutes does it take for the Earth to make one full revolution around its axis?

Examples of questions that AI chats answer differently:

1. Who was the first to correctly predict the route of the spacecraft that took people to the Moon?

Template for report:
https://docs.google.com/document/d/1plFWkrrvOQwInuqv2zcVHAC--RL8LJ1k_geglk3W-vU/edit?usp=sharing

2. AI Image Platforms

Objective:

Students will generate images of cosmic objects and phenomena using various AI image generation platforms and then analyze and compare the accuracy and creativity of the images produced.

Expected Learning Outcomes:

1. Learn to create detailed and scientifically accurate descriptions of astronomical phenomena as prompts for AI image generators.
2. Develop skills in evaluating AI-generated images against standard astronomical imagery.
3. Understand the capabilities and limitations of AI image generation in representing complex astronomical concepts.

Materials

Computers with Internet access.
AI Image Platforms:
https://creator.nightcafe.studio/
https://www.bing.com/images/create?FORM=GENILP
https://aitestkitchen.withgoogle.com/tools/image-fx

https://www.craiyon.com/

When you see the words "Artist's concept" under images of space objects, it means that the image is an artistic interpretation rather than a direct photograph. These images are created to help visualize scenarios, phenomena, or objects in space that cannot be directly photographed due to limitations in current technology or because they depict events, structures, or concepts that are abstract or theoretical.

For example, we can't currently take direct photos of planets around distant stars, black holes, or detailed surface features of far-off planets and moons. Artists work with scientists to create these images based on scientific data, theories, and understanding of the universe to give a plausible visual representation of these objects or phenomena. This helps the public and the scientific community to conceptualize what these distant and often invisible parts of the universe might look like.

Now, under the images of space objects, you can see the words “Artificial Intelligence Concept”. Now you will practice creating such images using AI graphics platforms.

Soon, you will see the words “Artificial Intelligence Concept” under images of space objects. Now you will practice creating images of space objects and phenomena using artificial intelligence graphics platforms. To begin, find an image of a space object with a description of the image in a textbook or in your favorite other source. Use this description as a prompt for the AI graphics platform. Evaluate how similar the AI-generated image is to the original image. Check how the generated image with the same hint depends on different parameters of the AI graphics platform. For example, try different styles on the Night Cafe platform: NightCafe, Artistic Portrait, Epic, Bon Voyage, Cosmic, and Surreal.
Make up a few more descriptions of space objects and phenomena without focusing on whether you saw an image of those objects before. Use these descriptions as prompts to input into the graphics platform and to generate an “Artificial Intelligence Concept” of space objects. Compare artificial intelligence concepts with your own.

Create a description of a cosmic object or phenomenon to use as a prompt.
Input this prompt into an AI image generator and evaluate the resulting image.
Note any errors and any additional elements the generator introduced independently.
Repeat this process with a different generator and compare the images to determine which generator produced the more interesting results.
Continue this exercise with three more distinct prompts.
Include the generated images and prompts in your report.
Summarize your observations about the performance of the AI generators.
Were the AI-generated images similar to what you expected, similar to images you might see in astronomy publications, or were the AI-generated images surprising to you?

Describe each Image (have to be 5 images):

1. Title
2. Description
3. model:
4. advanced mode:
5. style:
6. AI Image platform:
7. Prompt
8. Weblink to your picture on a platform

Copy and paste your image

3. Visualizing Dynamical Astronomical Phenomena with AI

Objective:

Students will use AI video-generation platforms to create short videos that illustrate dynamic astronomical phenomena, enhancing their understanding of these phenomena through visual representation.

Expected Learning Outcomes:

1. Acquire the ability to research, script, and storyboard an astronomical phenomenon accurately.
2. Develop proficiency in using AI video-generation platforms to create educational and scientifically accurate videos.
3. Enhance communication skills by translating complex scientific information into engaging visual narratives.

Materials:
Computers with Internet access
Access to an AI video generation platform:

1. https://invideo.io/make/ai-video-generator/
2. https://www.kapwing.com/ai-video-generator
3. https://www.synthesia.io/

List of astronomical phenomena (e.g., lunar phases, solar eclipse, star life cycle, collision of black holes, big bang, asteroid falling on the earth, meeting with extraterrestrial intelligence, start of cosmic vehicle)

Procedure:

Research and Script Writing:

AI Video Generators transform your ideas into engaging videos effortlessly.
Select astronomical phenomena from the given list or any that you want.
Conduct brief online research to gather accurate scientific information about the phenomenon.
Write a short script or storyboard that outlines the key stages or elements of the phenomenon to be visualized in the video.

Using the AI Video Platform:

Introduction to the AI video generation platform: an overview of features and guidelines for use.
Log in to the platform and familiarize yourself with the interface.
Using your script/storyboard as a guide, select appropriate visuals, effects, and transitions to depict the phenomenon.
Experiment with different settings and options to best illustrate the scientific concepts.

Video Creation:

Use the platform to create your video.
This involves selecting templates, inputting text, and arranging visuals according to their storyboard.
Apply edits and enhancements to accurately represent the astronomical phenomenon, ensuring the visual content aligns with scientific facts.
Finalize the video by adding captions, voice-overs (if applicable), and background music that complements the educational content of the video.
Save your video and submit your video or web link to your video using Blackboard. Add to the report a short description of your video and how you created it.

Notes:

Try to explore and apply different artistic styles and narratives to make their videos engaging and educational.

This lab teaches students about specific astronomical phenomena and introduces them to modern digital tools that can be used in scientific education and communication.

Describe your Video

1. Title:
2. Description:
3. AI Video Platform:
4. Prompt:
5. Weblink to your video: