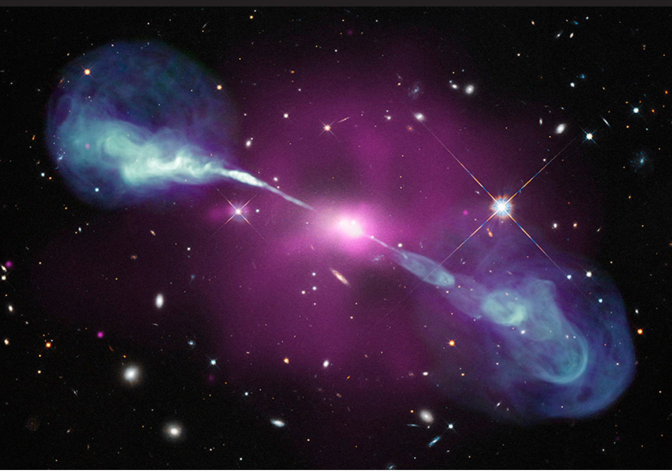
FACILITATOR'S EDITION

National Aeronautics and Space Administration

Exploring the Universe with AI

Space Detective: Can You Spot a Star or a Galaxy?



In this packet, you'll find simple paper and pen activities to help learners experience how AI is used in astronomy—no computers required.

NASA's Chandra X-ray Observatory has been exploring the high-energy universe since 1999, revealing phenomena such as exploding stars, black holes, and massive clusters of galaxies. Together with observatories like the Hubble Space Telescope and the James Webb Space Telescope, we can get a more complete picture of the cosmos across different types of light—from visible to infrared to X-rays.

These telescopes generate enormous amounts of data, more than scientists could ever analyze by hand. That's where **artificial intelligence (AI)** comes in. AI tools help astronomers quickly classify objects, detect unusual patterns, and make new discoveries hidden in vast datasets. By training AI, scientists can accelerate their research, uncover surprises, and share more of the universe's secrets with the world.

Learn more about NASA's Chandra X-ray Observatory's use of AI

Learning Objectives

Learners will be able to:

- Understand core concepts of artificial intelligence (AI), including classification, pattern recognition, training data, and anomaly detection.
- Recognize the role of AI in modern astronomy, particularly in handling large datasets and supporting scientific discovery.
- Apply scientific observation and classification skills to real-world-inspired astronomical problems.
- Evaluate the strengths and limitations of AI, fostering critical thinking and ethical reflection.
- Develop collaborative and communication skills through discussion, analysis, and debate.

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AI algorithms use similar processes to identify and classify celestial objects from vast amounts of observational data.

MATERIALS:

Images of different celestial objects, printed & cut out (one facilitator's version, and as many of the learners' version as needed).

GRADES: 5-8

ACTIVITY:

Learners will:

Classify the images into categories based on their features.

Discuss how they made their classification decisions, highlighting the visual cues and patterns they used.

Explain that AI algorithms, such as machine learning, use similar processes to identify and classify celestial objects.

INTRO ACTIVITY
How AI learns

Imagine you are looking through a pile of Halloween candy for Skittles. You rummage through the pile, looking for a glimpse or a feel of traits you associate with these candies. Use this analogy as an introduction to how AI works.

Give your learners this scenario: "Imagine you don't know what Skittles are. Your friend wants Skittles. You lift up pieces of candy one by one, and they tell you whether each one is Skittles or not. After going through a chunk of the pile, you start being able to tell when you're holding Skittles."

Have your learners discuss the particular traits they might look for as they search for Skittles. You can use the attached worksheet, or have them discuss verbally.

Possible question and responses:
What traits should you look for? (brightly colored, rectangular and flat, a packet —as opposed to a square of chocolate— can feel small round things inside, etc.)

Insight to share after this discussion:
"Even after getting trained, sometimes you still make mistakes. Sometimes you pick up a pack of M&Ms, and believe they're Skittles. This is how AI learns."

MAIN ACTIVITY
Classifying space images as stars or galaxies

Get materials ready

- Print the included set of real images from public archives (Chandra X-ray Observatory, Hubble Space Telescope, James Webb Space Telescope and others): This is a mix of stars and galaxies, some obvious, some that are harder to decipher. This set includes "tricky" cases that humans – and AI! – may find difficult.
- Print labeled images for your own use as an answer key.
- Print out copies of provided Observation Worksheet for learners.

Facilitate the Classification Challenge

- Spread out the printed images (or provide a digital grid).
- Ask learners to sort the images into two piles: Stars vs Galaxies.
- Encourage users to write or talk through their reasoning: What made them choose one category over the other? Have them think one step further – if they were designing an AI model, what attributes of stars/galaxies would they provide as rules?
- Possible traits used for classification: "roundness", point-like vs extended, diffraction spikes, color, visible structure.
- Some images might contain both galaxies and stars of course, but the object is to identify the primary case.

AI CONCEPTS VOCABULARY

CLASSIFICATION ALGORITHM

Definition: A set of rules an AI uses to sort things into groups based on their characteristics.

Astronomy Example: Sorting galaxy photos into "spiral" or "elliptical."

Analogy: Like sorting laundry into whites, colors, and darks.

DECISION TREE

Definition: A diagram that uses yes/no questions to reach an answer.

Astronomy Example: Asking "Is the star blue?" and "Is it bright?" to figure out if it's a giant star.

Analogy: Like a "choose your own adventure" story — each choice leads you closer to a different ending.

FALSE POSITIVE

Definition: When an AI says something is true, but it's actually wrong.

Astronomy Example: AI sees a dip in the brightness of a star, claims it is caused by a planet moving in front of the star, but it's actually just a starspot dimming the light.

Analogy: Like thinking you saw your friend across the street, but it's just someone with similar hair.

LABELS

Definition: The correct answers given to training examples.

Astronomy Example: Marking which stellar datasets have planets in them before an AI designed to find planets learns from them.

Analogy: Like flashcards with the answers written on the backs.

MODEL

Definition: The "brain" an AI builds from training data that it uses to make predictions or decisions.

Astronomy Example: An AI model trained to deduce whether a galaxy is spiral or elliptical.

Analogy: Like a mental picture in your head of what a "dog" is, so you can recognize one in real life.

NOISE

Definition: Unwanted or random information that makes it harder to see the real signal.

Astronomy Example: Static or interference in telescope data that hides a faint planet transit.

Analogy: Like trying to hear your friend's voice in a crowded cafeteria.

OUTLIER

Definition: A piece of data that's very different from all the others.

Astronomy Example: a galaxy that's so bright it has diffraction spikes

Analogy: Like a single snowball in a pile of oranges — it just doesn't fit and can throw off your idea of oranges.

PATTERN RECOGNITION

Definition: The ability to find repeated shapes, sequences, or signals in data.

Astronomy Example: Spotting a repeating radio signal that might come from space.

Analogy: Like hearing your favorite song's melody and knowing it instantly, even if the instrument changes.

RULES (ALGORITHM STEPS)

Definition: Instructions that AI follows to solve a problem or make a decision.

Astronomy Example: "If galaxy has spiral arms, classify as spiral."

Analogy: Like following a recipe step-by-step to bake a cake.

TRAINING DATA

Definition: Examples given to an AI so it can learn patterns and make predictions.

Astronomy Example: Giving AI thousands of datasets showing the brightnesses of individual stars over time, some with planets briefly dimming the star's light, some without, and with all datasets labeled with whether or not they include a planet.

Analogy: Like studying many practice problems before a test so you know what to expect.

Scan this QR code to learn more about exoplanets.

Scan this QR code to play NASA's Space Jam to learn about coding and sound.

Image examples and links

EASY

Stars

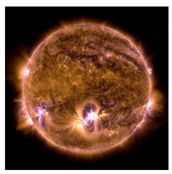
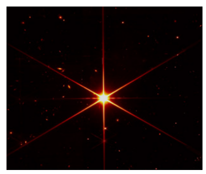
https://cdn.esahubble.org/archives/images/screen/opo0742c.jpg

https://chandra.harvard.edu/photo/2020/terzan5/terzan5_xray_optical.jpg

https://tinyurl.com/2m5shsk8

https://www.nasa.gov/wp-content/uploads/2022/03/telescope_alignment_evaluation_image_labeled.jpg



Galaxies

https://cdn.eso.org/images/screen/eso1042d.jpg

https://chandra.si.edu/photo/2022/chandrawebb/chandrawebb_cartwheel_comp.jpg

https://cdn.esahubble.org/archives/images/screen/heic0311a.jpg

https://chandra.si.edu/photo/2014/m106/m106.jpg




MEDIUM

Stars

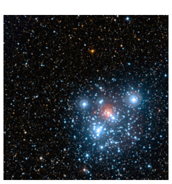
https://cdn.esahubble.org/archives/images/screen/heic0913c.jpg

https://chandra.si.edu/photo/2024

https://chandra.si.edu/photo/2024/25th/25th_ngc1850.jpg

https://chandra.si.edu/photo/2025/cosmic/cosmic_n79.jpg

Galaxies



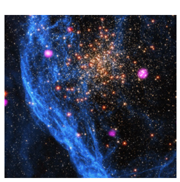



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Image examples and links

https://chandra.si.edu/photo/2022/chandrawebb/chandrawebb_stephansquintet_comp.jpg

https://chandra.si.edu/photo/2024/25th/25th_ngc7469.jpg

https://chandra.si.edu/photo/2024/25th/25th_arp220.jpg

https://chandra.si.edu/photo/2024/25th/25th_cena.jpg




HARD

Stars

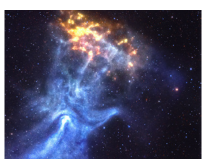
https://chandra.si.edu/photo/2025/cosmic/cosmic_ic348.jpg

https://chandra.si.edu/photo/2024/25th/25th_wr124.jpg

https://assets.science.nasa.gov/dynamicimage/assets/science/missions/webb/science/2024/07/STScI-01J0BY6PAJXJ34084103H43036.png?w=2160&h=1719&fit=crop&crop=faces%2Cfocalpoint

https://chandra.si.edu/photo/2024/25th/25th_msh1552.jpg



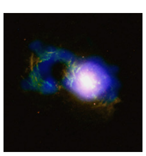



Galaxies

https://chandra.si.edu/photo/2019/teacup/teacup.jpg

https://chandra.si.edu/photo/2014/archives/archives_herca.jpg

https://chandra.si.edu/photo/2022/chandrawebb/chandrawebb_smacs0723_comp.jpg




Notes:

Stars often show up as compact dots in X-ray images, while galaxies, nebulas and supernova remnants appear more extended or diffuse.

Composite views introduce complexity: Many astronomical images are multiwavelength composites—combining data from Chandra, Hubble, Webb, Spitzer, or MeerKAT, for example, in X-ray, optical, ultraviolet, infrared and/or radio light. This helps learners understand that telescopes “see” different features of the same object in different parts of the spectrum.

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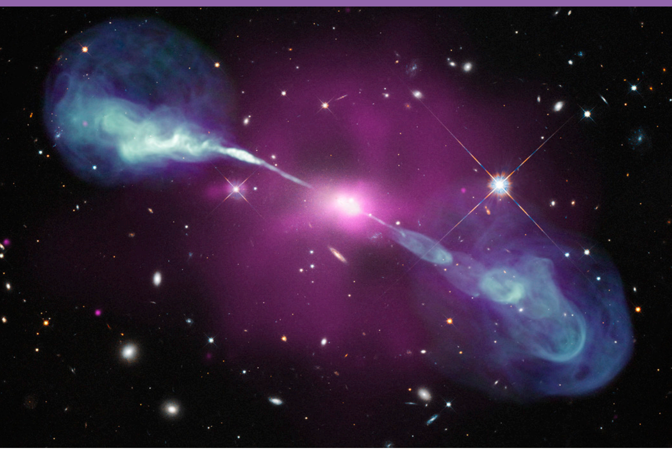

Discover how artificial intelligence helps us explore the universe! You'll learn how AI works in astronomy by practicing one of its key techniques: the classification algorithm. Here, we will learn to sort and classify celestial objects.

AI algorithms use similar processes to identify and classify celestial objects from vast amounts of observational data. Let's imagine you're a space detective, and the universe has sent you a mystery file full of unknown objects. Some are stars, some are galaxies, but they all look pretty similar from here on Earth. Could you figure out which is which? And could you teach a computer to do it for you?

Why do we care?

We study stars and galaxies because they are the building blocks of the universe. Stars forge nearly all the elements that make up planets and (our) life itself, while galaxies show us how the universe is organized on the largest scales. By understanding how stars form, evolve and die—and how galaxies grow and interact—we can trace the history of the cosmos and our place within it.

Modern telescopes collect staggering amounts of data about stars and galaxies, far more than humans can examine alone. AI tools allow us to sift through this flood of information, spot patterns we might miss and make new discoveries faster. By combining human insight with AI's speed, we can unlock hidden stories of the cosmos and deepen our connection to the universe we all live in.

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YOUR OBSERVATIONS

1. When searching for Skittles, what textures should you look for?

2. When searching for Skittles, What colors and shapes should you look for?

3. When searching for Skittles, What kind of package should you look for?

Even after getting trained, sometimes you still make mistakes. Sometimes you pick up a pack of M&Ms, and believe they're Skittles. **This is how AI learns.**

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The Science of Stars & Galaxies

The Science of Stars

Our Milky Way galaxy contains several hundred billion stars of various ages, sizes and masses. A star forms when a dense cloud of gas collapses due to gravity until nuclear reactions begin deep in the interior of the cloud and provide enough energy to stop the collapse.

Many factors influence a star's life and final form, but the most important is its initial mass. A star with a mass similar to the Sun's will become a white dwarf. A more massive star may explode as a supernova, leaving a neutron star or black hole.

The Science of Galaxies

Galaxies are gravitationally-bound systems of stars, gas, dust and dark matter. A typical large **spiral galaxy** such as our home galaxy, the Milky Way, consists of hundreds of billions of stars, enough gas, and dust to make billions more stars and at least ten times as much dark matter as all the stars, gas and dust put together. This type of galaxy is identified by its distinctive spiral shape, with visible "arms" of dust and gas orbiting around the center.

An **elliptical galaxy** has stars distributed in an elliptical shape, ranging from elongated to nearly circular in appearance. The light is smooth, with the apparent brightness decreasing as you go farther out from the center.

An **irregular galaxy** is a strangely shaped galaxy, often rich in interstellar matter, but not a member of either of the major classes of spiral or elliptical galaxies.

Glossary

star: a luminous ball of gas, mostly hydrogen and helium, held together by its own gravity.

supernova: the explosive death of a massive star. It is one of the most energetic events in the universe.

supernova remnant: the structure resulting from the explosion of a star in a supernova.

black hole: a place in space where gravity pulls so much that even light cannot get out.

pulsar: a rapidly rotating neutron star that emits pulses of radio waves and other electromagnetic radiation at rates of up to one thousand pulses per second.

neutron star: an extremely compact star – about the size of a city! –produced by the collapse of the core of a massive star in the supernova process.

white dwarf: end phase of a Sun-like star where its remaining material, minus the amount blown off in the red giant phase, is packed into a volume one millionth the size of the original star – about the size of the Earth.

dark matter: A term used to describe the mass in galaxies and clusters of galaxies that can be inferred to exist from its gravitational effects, but has not been directly detected by light.

galaxy: A system of stars, gas, dust and dark matter held together by gravity.

galaxy cluster: Galaxies swarm together to form groups and clusters, held together by their mutual gravity.

Milky Way galaxy: The specific galaxy to which the Sun belongs. On clear nights, most of its visible stars appear as a milky band of light across the sky.

quasar: a galaxy with a highly active central supermassive black hole, which causes the center of the galaxy to glow brightly, and sometimes results in jets shooting out from the center.

spiral arms: the visible arcs of a spiral galaxy, consisting of dust, gas, and stars.

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Observation Worksheet

Instructions:
Look closely at each image. Use the checkboxes to note what you see, and write down any extra details.

1. Brightness
❏ Very bright
❏ Medium
❏ Faint

2. Diffuseness
❏ Puffy or cloudy
❏ Well defined structure
❏ Patchy or mottled

3. Shape
❏ Tiny sharp point
❏ Slightly fuzzy
❏ Spikes (diffraction spikes)
❏ Spiral (like a pinwheel)
❏ Elliptical (round/oval, smooth)
❏ Irregular (messy, odd shape)

4. Features
❏ Bright center/core
❏ Spiral arms
❏ Bar across the middle
❏ Clumpy star-forming regions
❏ Smooth, even light

5. Signs of Activity
❏ Tidal tails (wispy streaks)
❏ Double/multiple cores (possible collision)
❏ Surrounded by many neighbors (cluster)

4. Additional Observations: