IGNITE MY FUTURE

Recognizing an Invader

Guiding Question: How could we improve the world?

Ignite Curiosity

- How do image searches work?
- Can computers "see"?
- How can you tell the difference between animals that look alike?
- How do you know if something is an invasive species?

In this lesson, students will discover how computers are designed to recognize patterns during image searches, by applying this approach to a real-world STEM problem. In **THINK**, students act as conservation biologists challenged by the misidentification of look-alike species that negatively impact their data collection. In **SOLVE**, students explore solutions to help the public identify invasive species from native ones by creating an electronic field guide, or reverse image search, that can recognize distinctive patterns and features. In **CREATE**, students sketch out how humans can teach a computer to see and recognize patterns using plant or animal species as models. In **CONNECT**, students identify how facial recognition and image recognition connect to careers and to problems of tomorrow.

Students will be able to:

- decompose complex problems into manageable sub problems.
- recognize patterns and common features to create solutions.
- plan and create brainstorming documents.

SUBJECTS

Science
Technology
Engineering
Math
Graphic Arts
Computer Science

COMPUTATIONAL THINKING PRACTICE

Recognizing and Defining Computational Problems

MATERIALS

Invasive Species Student Handout

Image Search Solutions Student Handout

Access to Computers with Internet Access (optional)

Students act as conservation biologists challenged by the misidentification of look-alike species that negatively impact their data collection.

1 **Read** the following scenario to students:
Imagine you are a wildlife conservation biologist who studies the behavior of animals in their natural habitats. Your focus is to help scientists understand how to conserve threatened and endangered species and how to control invasive species. Patience in the field is key to an effective observation as well as a quick eye. The accuracy of your work relies on you being able to identify species accurately. Let's see how well you do!

Ask students if they know the difference between a sea lion and a seal? Show the images and ask students to identify which is which. Ask students if they can tell the difference between a Burmese Python and a Ball Python. Show the images and ask students to identify which is which. Share correct answers, and ask students to share out how well they did. Was it easier or harder than they expected?

2 **Lead** students to consider the importance of accurate species identification using the following guiding questions:

- What could happen if you chose incorrectly during your field research? (the wrong species could be captured, research and data collection wouldn't accurately reflect the species intended)
- What other variables could influence an incorrect identification? (undiscovered species, incorrect tagging of species, human error)
- What resources are available to help scientists and average citizens identify species of plants and animals? (field guide books, smart device applications)
- Why is it important to be able to tell look- alike species apart? (some species may be venomous, may be confused with native species)

3 **Distribute** the Invasive Species Part I Student Handout to see how much students already know about invasive species. Guide students to review each statement and check if they agree or put an x mark if they disagree with the statement. Direct students to partner with someone in the room to share and record their responses in the second column. Review correct responses.

Clarify that invasive species are any species not native to a particular area. They compete with native species which can negatively impact ecosystems. Invasive species are a leading threat to native wildlife and many of our commercial, agricultural, and recreational activities depend on healthy native ecosystems.

4 **Highlight** the final statement from the Invasive Species Part I Student Handout: "It is easy to tell a native species apart from an invasive species." Review with students that not all invasive species are easily identifiable. They can be confused with native plants and animals. Invasive species can lead to widespread loss of habitat, kill large numbers of native species (often times leading to extinction), and impact human health. All of these threaten our ability to use and enjoy natural resources and invite a need to protect native species for future generations.

5 **Challenge** students to identify and summarize the problem that needs to be solved. Consider providing students with a splash of words to guide their thinking: native species, invasive species, ecosystem, identify, improve. Students should be able to explain that invasive species disrupt ecosystems by competing with native species. Sometimes it is very challenging to identify species from one another. Being able to identify species with accuracy can help improve cataloging biodiversity.

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Students will explore solutions to help the public identify invasive species from native ones by creating an electronic field guide, or reverse image search, that can recognize distinctive patterns and features.

1 **Ask** students to consider how computers and smart device applications use image searches. An image search uses a picture, instead of text, as your search. It uses this picture to find related images and information on the Internet. Students may identify social media tagging, facial recognition, search engine image searches, and image recognition apps. Invite students to brainstorm with a partner responses to the following guiding questions:

- How do you think computers recognize objects in images? (they look for patterns)
- How have humans helped computers enhance their searches? (helping to tag images, confirming if the search is accurate)

2 **Guide** students to read Part II of the ***Invasive Species Student Handout*** and invite students to complete the summarizer after reading. Ask students to turn to a neighbor and discuss their possible solution to identify an invasive species. Clarify with students that computers search through data to look for patterns. Together with humans, computers can learn to recognize specific features and help make predictions.

3 **Share** with students one way they could help conservation biologists by simulating how computers can be designed to conduct image searches using native and invasive leaf species as models. Helping conservation biologists and local communities identify differences in similar-looking species could help against misidentification. Distribute the Image Search Solutions Student Handout for students to investigate this solution by following the steps humans take to teach a computer how to recognize an image. Ask students to read through the descriptions of two types of image searches – reverse image search and photo search – and complete the graphic organizer. Review key differences between the two searches. Note: Photo searches typically look for outlines while reverse image searches typically look for geometric shapes.

4 **Direct** students to break down how each type of image search approach would "see" their leaves. Anticipated responses include:

Photo Search: Uses edge detection to break down the image into an outline. Students will trace several leaves of their native species in different sizes and combine the outlines into one leaf-shaped outline that represents that native species. Students will repeat this process with the invasive leaf species.

Reverse Image Search: Decomposes each leaf species to triangles that build the image. By guessing the basic geometric shapes of the leaf, they will mimic how computer vision algorithms work.

5 **Guide** students to write on sticky notes how they think these solutions could solve the problem they outlined earlier. Summarize that a photo search usually takes years of collecting and photographing a species to develop the recognition technology that identifies it from another species. Photo searches typically look for patterns in outlines and areas of contrast. Reverse image searches break down images by defining the image into geometric shapes. A reverse image search will look for this collection of unique geometric shapes. Both methods could help conservation biologists simply take a picture of a species to identify it. But first, humans will need to teach the computer what patterns to look for.

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Students will sketch out how humans can teach a computer to see and recognize patterns using plant or animal species as models.

Teacher note: Computers see shapes, but they are represented by mathematics. When an image search is conducted, the data representation of the shapes and colors in an image are then compared to other images. With more data, computers become better and better at identifying the parameters to make a decision. This is called machine learning. Machine learning helps humans by making the best guess for a match. This part of the lesson guides students through a very simplified model to understand how a computer decomposes an image to identify patterns.

1 **Lead** student partners to choose an image search approach (photo search or reverse image) and select two species to compare. Students should create their search by carrying out the steps they identified in the Solve section. This will enable students to model how a computer decomposes an image to identify patterns by using outlines or shapes. They can use paper and pencil or a CAD platform, such as Google Sketch-Up, to create their outline or shapes.

Photo Search: Students will trace several leaves (8-10) of their native species in different sizes to identify patterns. They can use real leaves or images. They will combine the outlines into one leaf-shaped outline that represents that native species. Students will repeat this process with the invasive leaf species.

Reverse Image Search: Students will decompose each leaf species to triangles to draw each species of leaf. Students can use real leaves or images. Students should test their image by using several leaves (8-10) as models to identify patterns.
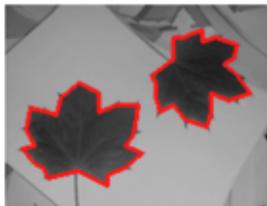

Photo Search   *Reverse Image Search*

Suggested species to compare:
Japanese Angelica Tree vs. Devil's Walkingstick
Wineberry vs. Native Blackberries and Raspberries
Japanese Honeysuckle vs. Native Twining Honeysuckles

Multiflora vs. Native Roses
Porcelain-berry vs. Native Grapes

Or, invite students to select their own using the suggested link:
https://www.invasivespeciesinfo.gov/index.shtml

2 **Summarize** by inviting students to share out how using visual recognition software and image searches to identify species can help protect our native species to help sustain healthy ecosystems.

- How did you solve this problem before using a computer?
- How could a computer help you with next steps?
- How did identifying and recognizing patterns help you think like a computer?

Select one of the strategies listed below to help students answer these questions:

- How does this problem and solution connect to me?
- How does this problem and solution connect to real-world careers?
- How does this problem and solution connect to our world?

1 **Write** the three questions on PPT or flip chart slides and invite students to share out responses. Display chart paper around the room, each with one question written on it. Ask students to write down their ideas on each sheet.

2 **Assign** one of the questions to three different student groups to brainstorm or research, and then share out responses.

3 **Direct** students to write down responses to each question on a sticky note, and collect them to create an affinity diagram of ideas.

How does this connect to students?

Students likely use image searches every day and more than likely use them several times in a day. Search engines, gaming, social media tagging, and facial recognition apps all look for patterns in images to make a match. Humans and computers are still learning how to make this process more accurate and efficient.

One way scientists are using image recognition tools is to identify invasive species that disrupt ecosystems. Many of the foods we eat and pets we own are actually invasive species. In some cases, invasive species can be beneficial, such as the honey bee.

How does this connect to careers?

Software engineers use programming languages to design and develop software solutions to solve problems.

Project Managers/ Botanists provide environmental impact analysis and technical reports to clients.

Invasive Species Technicians conduct sampling, surveys, and outreach related to early detection and management.

How does this connect to our world?

Facial recognition and feature recognition are used in spy agencies, the military, augmented reality, and gaming. The possibilities are endless as image and face recognition becomes a familiar feature. It's not perfect, and there are ways we can improve and extend the reach of the technology.

One application being explored is how this can help identify invasive species. They are a leading threat to native wildlife, and many of our commercial, agricultural, and recreational activities depend on healthy native ecosystems.

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National Standards

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Analyzing and Interpreting Data ▪ Analyze and interpret data to provide evidence for phenomena.	**LS2.C: Ecosystem Dynamics, Functioning, and Resilience** ▪ Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)	**Stability and Change** ▪ Small changes in one part of a system might cause large changes in another part.

COMMON CORE STATE STANDARDS CONNECTIONS

Mathematics MP.4 Model with mathematics. (MS-LS-5)

K-12 COMPUTER SCIENCE FRAMEWORK

Practice 3. Recognizing and Defining Computational Problems

The ability to recognize appropriate and worthwhile opportunities to apply computation is a skill that develops over time and is central to computing. Solving a problem with a computational approach requires defining the problem, breaking it down into parts, and evaluating each part to determine whether a computational solution is appropriate.

Invasive Species Part I

Do you agree or disagree with these statements?

*Mark the boxes with a **check mark** for agree, and **x** for disagree, then find out what your partner thinks.*

Statement	Me	My Partner
An invasive species is an organism that is not native to a particular area.		
Invasive species do not cause economic harm.		
Not all non-native species are invasive.		
Invasive species cannot disrupt food webs.		
Invasive species are always introduced into a new region accidentally.		
Invasive species can outcompete native species for food and habitat.		
Many invasive species arrive on large cargo ships that travel the ocean.		
It is easy to tell a native species apart from an invasive species.		

Invasive Species Part II

Invasive species are threatening the biodiversity in ecosystems. They may come accidentally with cargo ships traveling across the ocean or could even be pets that were released into the wild. Not everyone knows what invasive species look like. Confusing a native species and an invasive species can result in adverse ecological consequences. It may lead to the accidental decline of native plants and have negative impacts to the local community or ecosystem. But there are 50,000 non-native species in the U.S. today, with approximately 4,3000 being identified as invasive. How can an average citizen identify them all?

Field guide books and field guides available on smart device apps are tools that can help people identify species, but they take time to open and search. Computers can do all that work for us. Computers use methods and different tools to "see" images and help tell us what is in that image. Scientists, computer engineers, and photographers are working together to make it as easy as taking a picture to identify a species. Some applications are even trying to use facial recognition systems to identify animals from one species apart from each other. This can help anyone from a landscaper to an average citizen understand and identify species around them.

Four important ideas:

1.

2.

3.

4.

Three things I need to learn more about:

1.

2.

3.

**Two people that could benefit from being able to identify an invasive species:**

1.

2.

One possible solution to identify an invasive species:

1.

Image Search Solutions

There are different tools and methods for computers to "see" an image. Some electronic field guides exist that use visual recognition software to help identify plant species by analyzing an image of their leaves. They are often limited to a select species from a specific region while there are 391,000 species of vascular plants in the world! Computer software tries to identify objects in images by going through previously labeled images to find combinations of visual features.

Below are two different approaches to teach a computer how to recognize an object.
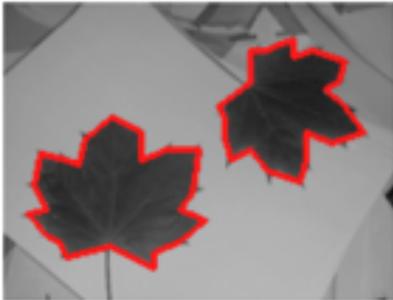
PHOTO MATCH

A photo search is initiated by an image and results are ordered by the best likely match. A unique outline shape will identify quickly. When the outline shape is not as common, images are laid on top for clues. Large libraries of high resolution images are created by taking several images of leaves from the same species. Images can also have a geotag associated with them.

MATHEMATICAL MODEL

Reverse image searches create a mathematical model based on shapes, lines, proportions, colors, and other elements of an image. When an image search is conducted, the data representation of the shapes and colors in an image are then compared to other images. With more data, computers become better and better at identifying the parameters to find the best likely match. Images can also have a geotag associated with them.

Compare and Contrast Graphic Organizer

Item #1   ## Item #2

How are they alike?

How are they different?