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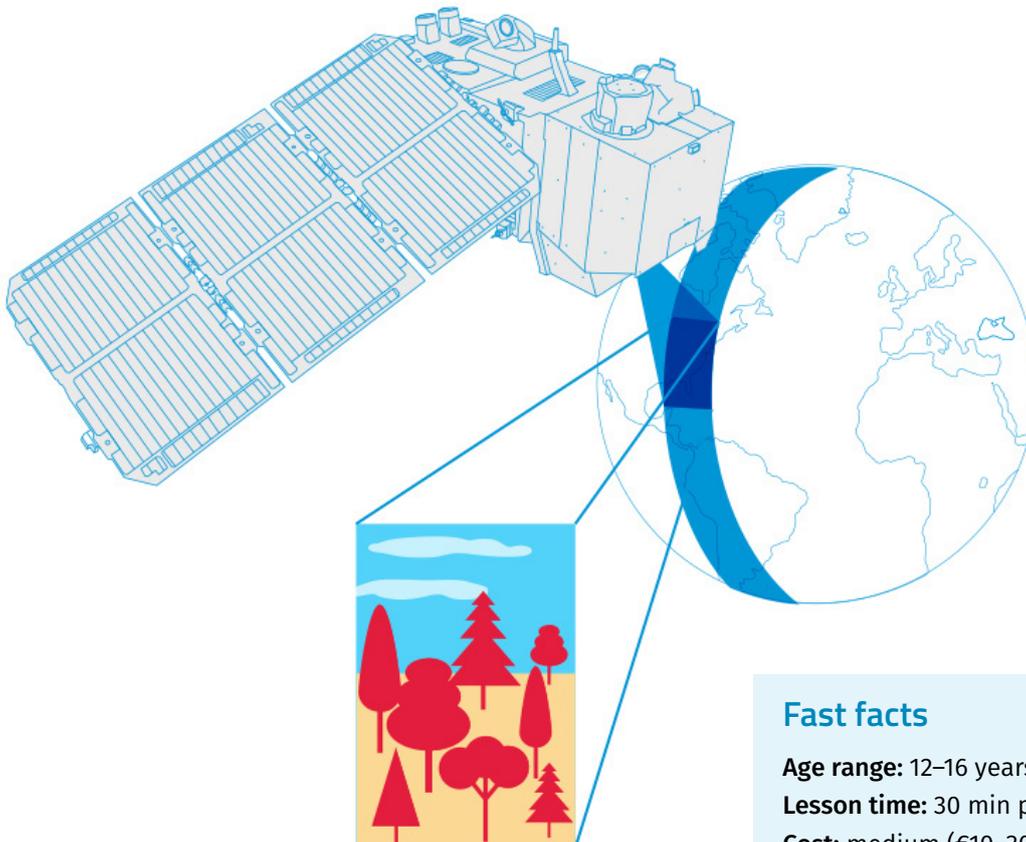
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Infrared webcam hack – using infrared light to observe the world in a new way

ESA Education

What would the world look like if we could see infrared light? With some simple modifications, you can turn a cheap webcam into an infrared camera and find out!



Fast facts

Age range: 12–16 years old

Lesson time: 30 min per activity

Cost: medium (€10–30 per group)

Location: any indoor space with daylight

Requires: webcam and computer

Brief description

This set of three activities will enable students to understand the electromagnetic spectrum and observe infrared radiation through the modification of a cheap webcam.^[1] It provides a basis for discussion of how infrared radiation can be used to obtain information that is not available using visible light. Students will also analyze satellite images, providing them with a context to understand why it is useful to ‘see’ in infrared.

Learning objectives

- Identify the different types of electromagnetic radiation.
- Describe different applications of infrared light.
- Use tools available on the internet to collect and analyze satellite data.
- Understand how infrared light can be used to monitor the health of vegetation.
- Identify false-colour and true-colour satellite images.

Activity 1 – Hacking the web cam

The human eye can only see a very limited range of the electromagnetic spectrum: visible light. However, we can use different instruments to see what is invisible to us. Earth observation satellites, for example, carry scientific instruments that can see in the visible and infrared ranges, as well as other ranges of the electromagnetic spectrum. See [Worksheet 1](#) for details on infrared radiation and why detecting it can be useful. In this activity, students will modify a webcam, so that it sees in near-infrared light rather than in visible light. Alternatively, the webcams can be modified in advance, and students can run Activities 2 and 3.

Materials

- [Worksheet 1](#)
- One webcam with a manual focus ring on the front
- One drawing pin or a similar pin
- Two pieces of exposed photographic film or polarizing filters large enough to cover the lens
- Clear tape
- Scissors
- Computer

Procedure

1. Hand out Worksheet 1 and read through the information on infrared light.
2. **Disassemble the camera**
Unscrew the focus ring in an anticlockwise direction until the whole lens can be pulled out.



Image courtesy of ESA

3. Remove the infrared filter

On the inside of the lens, there is a small piece of plastic with a red/green tint (see the left lens below). This is the infrared filter. Using a pin or a scalpel, remove the filter. Be careful: this should be done very gently, as the filter can break if too much pressure is used.



Image courtesy of ESA

4. Assemble the camera

Screw the lens back onto the webcam and plug the webcam into a computer. It may be necessary to open video software to view an image through the webcam. Use the focus ring to adjust the focus until you have a clear image of the object that you wish to look at.

5. Add visible-light filters if necessary

If the image appears very bright on the screen, it may be necessary to add a visible-light filter. Two polarized filters are required to block visible light. This is because the wave may be moving up and down or side to side. Two filters fixed perpendicularly ensure that all the visible radiation is blocked.

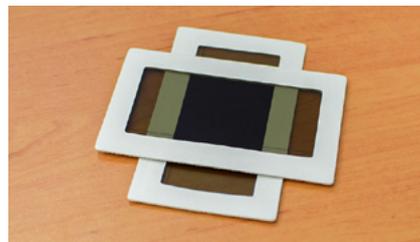


Image courtesy of ESA

Notes

Cheap webcams are usually easier to disassemble than more expensive models. The example shown is a Trust Primo 17405 webcam.

Discussion

Teachers should make sure that students understand that the hacked camera is a near-infrared camera, not a thermal-imaging camera!

The sensors used in digital cameras are sensitive to light with wavelengths up to around 1 micron (near-infrared). Thermal-imaging cameras use infrared radiation at longer wavelengths. All objects with a temperature above absolute zero emit radiation, and the higher the temperature, the shorter the wavelength of the emitted radiation. When the temperature of an object is high enough, the radiation emitted can even be detected by eye. We can see this in our kitchen: when a toaster reaches very high temperatures, it turns red!

Activity 2 – Looking at objects with an infrared camera

Now we use the modified webcam constructed in Activity 1 to examine everyday objects. Daylight is necessary for the experiment with the plants. The experiment should be tested in the classroom before doing it with the students. Depending on the light conditions, it may be necessary to block visible light by putting a polarizing filter/exposed film in front of the lens.

Materials

- [Worksheet 2](#) – results table
- Infrared camera (from Activity 1)
- Remote control
- LED light
- Candle
- Healthy plant and fake plastic plant

Procedure

Look at the different objects firstly with your eyes (visible light) and then through the webcam (infrared light).

1. Fill in the results table in Worksheet 2 with your observations.

Notes

A simpler infrared experiment can also be done using smartphones and red, green, and blue (RGB) filters. Watch the ESA video [seeing the invisible](#) to learn how.



A fake and a real plant are imaged using the modified webcam under natural light.

Image courtesy of ESA (https://www.esa.int/Education/Teachers_Corner/Infra-red_Webcam_Hack_-_Using_infrared_light_to_observe_the_world_in_a_new_way)

Discussion

The remote control, the candle, and the LED light emit infrared radiation. With the help of the hacked webcam, students can ‘see’ this infrared light. By looking at light sources from daily life, like the LED light and the candle, the infrared camera allows us to investigate which one emits less infrared light and is therefore more energy efficient.

Looking at the plants with the hacked webcam, what we see is reflected daylight. Plants have a particular way of reflecting electromagnetic radiation. Chlorophyll in plants absorbs visible light to get energy for photosynthesis. Near-infrared light is not needed for photosynthesis; therefore, most of this light is reflected. When a plant becomes less healthy, for example, due to water scarcity, it reflects more of the visible light and less of the near-infrared light. We can thus use infrared images to judge how healthy a plant is.

Activity 3 – Looking at Earth in infrared light

In this activity, students will analyze satellite images.[2] The activity introduces true-colour images and compares them to false-colour images that visualize near-infrared radiation. This provides students with a context, so that they understand why it is useful to detect near-infrared radiation.

Materials

- [EO browser online application](#)
- [Worksheet 3](#)

How to use the EO Browser application

1. Open [EO Browser](#) application and on the top right corner of your EO Browser screen, click on this symbol:



2. Choose the Education mode. This mode gives the option to access specific satellite data tailored to a selected theme. Themes cover different topics, from agriculture to the atmosphere and water bodies. Select the theme 'Monitoring Earth from Space'.

3. Search for images:

- On the top right corner of your EO Browser screen, in the search bar, type in the name of your area of interest/place. You can zoom in/out to get a good view of your area of interest.
- To find the ideal satellite image that will show a cloudless and clear image, on the main navigation panel, select advanced search → L2A (atmospherically corrected) → max. cloud coverage (10%).

- The last step is to set the time range. The satellite images above are from 28 November 2016.

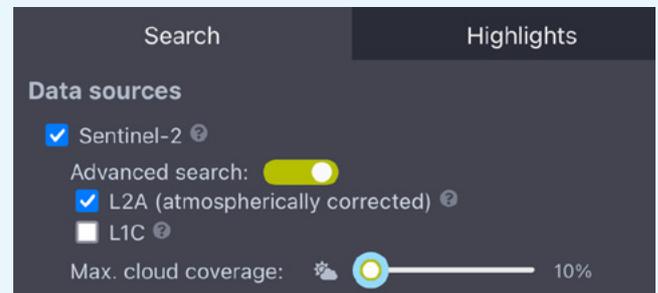
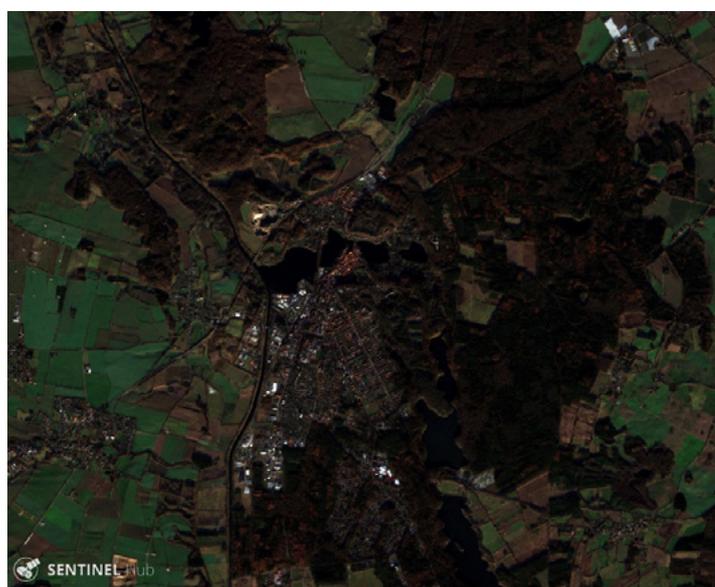


Image from [EO Browser](#)

4. Click search and select the satellite image with the least cloud coverage. Click visualize and wait a few moments, as this may take some time to load. After a few moments, you should be able to see a high-resolution true-colour image. You can then select from different visualization options, including false colour.

Procedure

1. Start by showing the students their hometown in summer and winter with true- and false-colour images. The pictures below are of the town Molln, in Northern Germany.
2. Let the students explore and find their own examples.
3. Have the students fill out Worksheet 3 and then discuss the results.



True-colour (left) and false-colour (right) images taken by the Sentinel-2 satellite Modified Copernicus Sentinel data [2017] processed by Sentinel Hub

Discussion

These practical activities can be used to discuss the electromagnetic spectrum, Earth observation applications, and the monitoring of vegetation on our planet. The activities also provide a setting for discussing the impact of space technology on our future and on our everyday lives.

Acknowledgements

This article has been adapted from one originally published as the ESA teaching module [Infrared Webcam Hack – using infrared light to observe the world in a new way](#). <<

References

- [1] The original article from the ESA website: https://www.esa.int/Education/Teachers_Corner/Infrared_Webcam_Hack_-_Using_infrared_light_to_observe_the_world_in_a_new_way
- [2] The EO Browser online platform to access satellite imagery: <https://apps.sentinel-hub.com/eo-browser>

Resources

- Watch the [accompanying video](#) from ESA, which demonstrates the activities in this article.
- Discover how to use RGB filters and a smartphone to [see the invisible](#).
- Explore additional ‘[Teach with Space](#)’ classroom resources from ESA.
- Discover ESA’s ‘[Teach with Earth](#)’ resources.
- Learn about how [ESA’s Earth observation missions](#) contribute to society.

AUTHOR BIOGRAPHY

The ESA Education team is composed of a group of STEM didactics experts that develop space-related educational materials for teachers and students. The ESA Education Office is based at the European Space Research and Technology Centre (ESTEC) in Noordwijk, the Netherlands.

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