LE/ESSE 2220 Algorithmic and Computational Methods

Lab 7: Detecting Features in Space, SIFT and ORB in Action
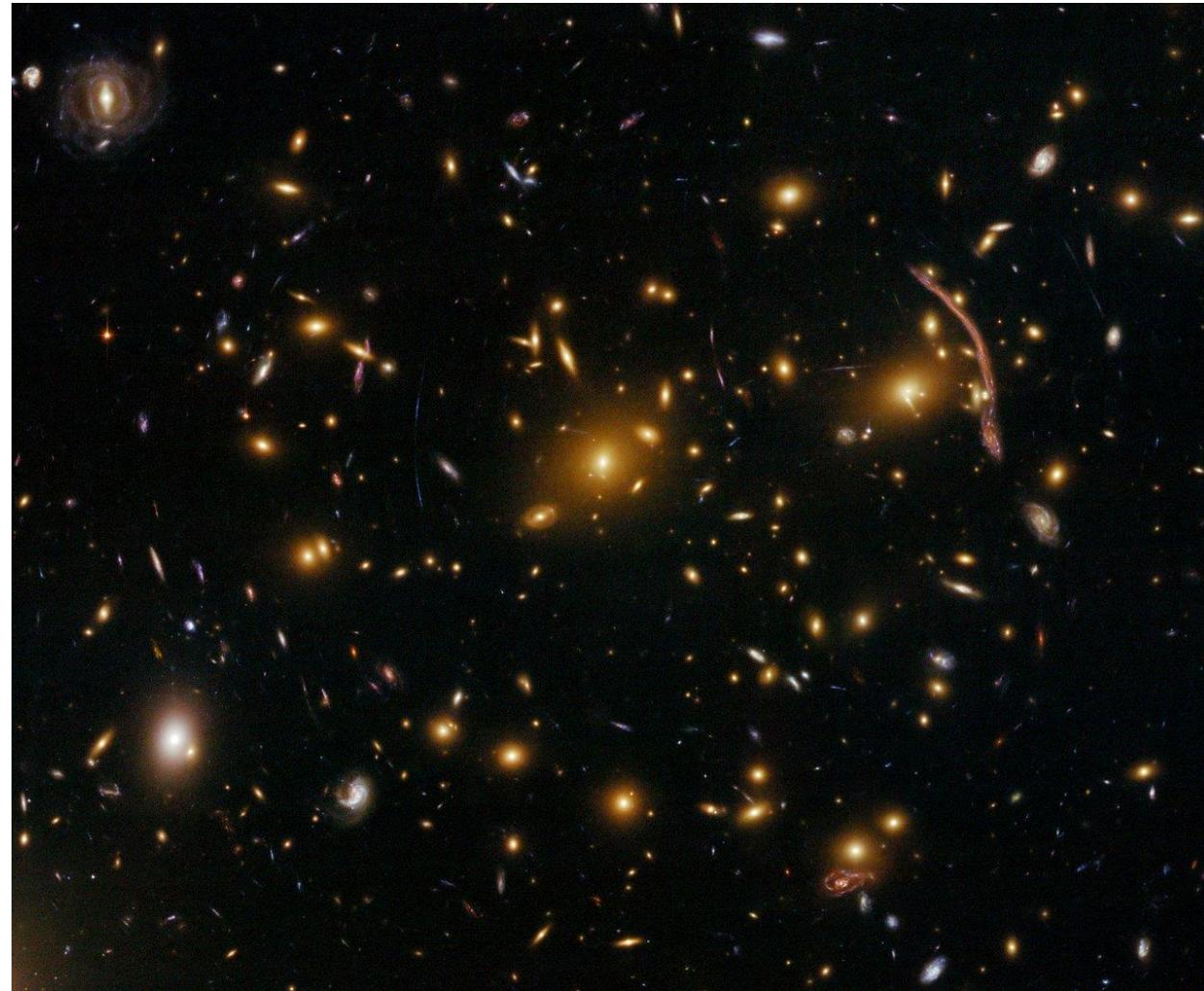
(Fall 2025-2026)

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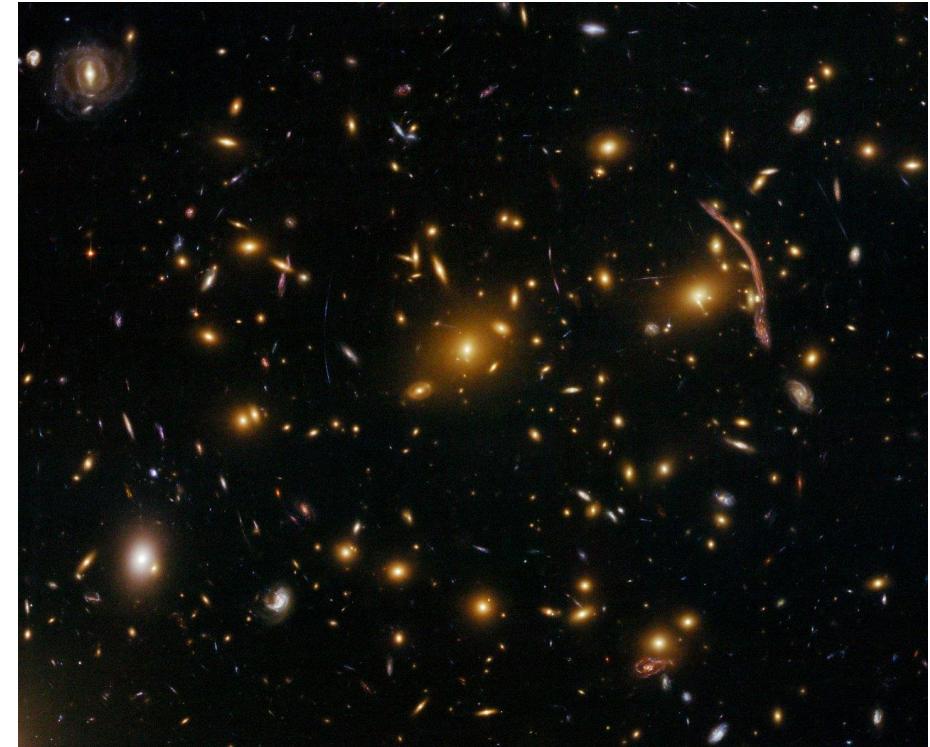
Lab 7: Detecting Features in Space, SIFT and ORB in Action

SIFT and ORB

Hubble, "Star Cluster NGC 3603"

> **Story:**

- **Object: NGC 3603,** a massive **young star cluster**

- **Captured by:** Hubble Space Telescope

- **Instrument: ACS (Advanced Camera for Surveys)**

- **Distance:** ~20,000 light-years away

- **Why useful:** Contains **thousands of visible stars,**

  - Ideal for OpenCV processing.

Lab 7: Steps

> **What to do (right now):**
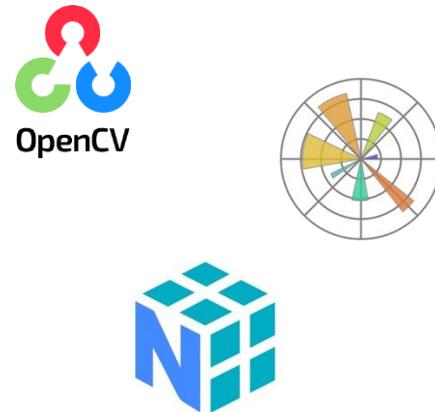
- **Download** the starter **Python code** and the **space image** into the same folder.

- **Open the code** and go **step by step**, filling every **TODO**.

- After each step, **run the file** to make sure it still works before moving on.

> **How to work (step-by-step):**

- Copy/paste **one block at a time** (Steps 1 → 11) so the file is always runnable.

- When a step mentions saving a figure, **check the saved image** appears in your folder.

- Use the **official docs** (OpenCV/matplotlib) for functions, flags, and parameters.

> **Tools you must use:**
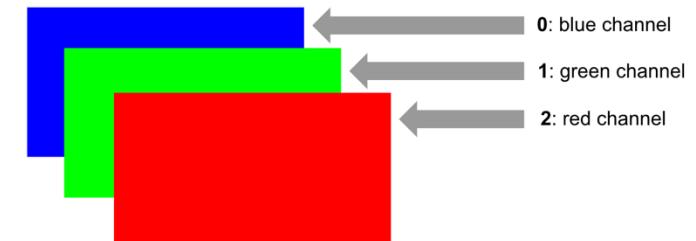
- **OpenCV** (cv2):
  - Install (if needed): pip install opencv-python

- **Matplotlib** (plt):
  - Install (if needed): pip install matplotlib

- **NumPy** (np) — array handling (already used in code).

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Tips & reminders

> **Tips & reminders:**

- **BGR vs RGB:** OpenCV colors are **BGR** tuples in cv2.drawKeypoints and cv2.imwrite.

  - (e.g., pure blue is (255, 0, 0) in OpenCV.)

- **Flags & parameters:** You must **find them in the docs** (e.g., rich keypoints flag, nfeatures for ORB).

0: blue channel

1: green channel

2: red channel

> **Academic integrity:**

- Fill **your own** TODOs. Use documentation, not full code from AI.

- In the report, include: your code, **all images**, and short answers as requested.

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Report Format (short, personal, verifiable)

› **1. Image Loading and Channels (1 mark)**
- a) Show your code output for both:
    - IMREAD_GRAYSCALE
    - IMREAD_COLOR
- b) Include printed shapes from each version (img.shape).
- c) Explain in **1–2 lines** what changed and what the extra dimension represents.

› **2. SIFT Detection and Visualization (2 marks)**
- a) Include your **SIFT keypoints image** (sift_keypoints.jpg).
- b) What color did you choose for visualizing SIFT keypoints?
    - Give the RGB values you used and name the color.
    - Explain how you designed it.
- c) Write the number of keypoints detected and the descriptor shape.
- d) Explain what a **keypoint** represents in one sentence.

› **3. ORB Detection and Visualization (2 marks)**
- a) Include your **ORB keypoints image** (orb_keypoints.jpg).
- b) What color did you choose for ORB visualization?
    - Give the RGB values and name the color.
    - Explain how you designed it.
- c) Write the number of keypoints and descriptor shape.
- d) What value did you use for nfeatures? Try at least two values and describe how the number of detected points changed.

› **4. Strongest Keypoints (1 mark)**
- a) Include your **top 50 keypoints** images (sift_top50.jpg and orb_top50.jpg).
- b) Explain what **response** means for a keypoint (in your own words).
- c) Why might strong keypoints be more useful in later matching steps?
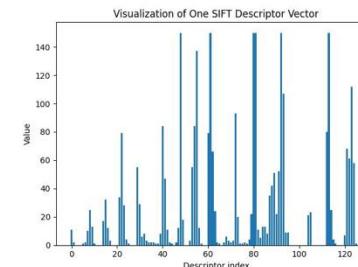
› **5. Descriptor Values (2 marks)**
- a) Paste the first few printed values from both SIFT and ORB descriptors.
- b) Explain what a **descriptor** represents.
- c) Describe one difference between SIFT and ORB descriptors (length, data type and value range).

› **6. Descriptor Visualization (2 marks)**
- a) Include your **bar chart image** (sift_descriptor_plot.jpg).
- b) Mention the **matplotlib** function you used (check docs).
- c) Explain what the bar chart shows (each bar represents what?).

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Reminder

> **Your Report Must Contain:**
> - **Your final Python code** (the complete version you ran).
>   - Paste it at the end of the report or attach it as an appendix.
>   - Make sure all comments and TODOs are filled.

> **Include All the Following Images (in the correct section):**

File Name	Description
sift_keypoints.jpg	All detected SIFT keypoints
orb_keypoints.jpg	All detected ORB keypoints
sift_top50.jpg	Top 50 strongest SIFT keypoints
orb_top50.jpg	Top 50 strongest ORB keypoints
sift_descriptor_plot.jpg	Bar chart visualization of one SIFT descriptor vector

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