Assignment for Module 1 — Image Formation, Sampling & Filtering

Course: Computer Vision
Module 1: Foundations of Computer Vision
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Purpose

This assignment consolidates foundational computer vision concepts through analytical and coding exercises. Students will revisit the mathematics of image formation and sampling, implement and analyze basic filtering operations, and reflect on aliasing, convolution, and edge-detection behavior.

Submission Format

• Report (.pdf) with answers, visual results, and code snippets.
• Code (.ipynb) notebook uploaded to Google Colab or GitHub.
• Deadline: two weeks from release.

Task 1 — Image Formation & Sampling (20 pts)

Goal: Understand image representation, resolution, and aliasing.

1. Download the provided high-resolution test image (or use `skimage.data.camera()`).
2. Create downsampled versions at factors 2, 4, 8.
3. Use both naïve sampling (no blur) and prefiltering (Gaussian blur before downsampling).
4. Visualize and discuss aliasing effects.
5. Explain in ≤100 words why prefiltering avoids aliasing (Nyquist theorem reference).

Deliverables: images at each level, explanation, frequency spectra plots.

Task 2 — Linear Filters & Convolution (20 pts)

Goal: Implement and compare smoothing filters.

1. Implement convolution manually (no cv2.filter2D).
2. Test with Box filter (3×3, 5×5) and Gaussian (σ=1,2).
3. Compare with cv2 outputs.

4. Discuss trade-off between smoothing and edge sharpness.
Bonus: Demonstrate convolution commutativity numerically.

Task 3 — Edge Detection (25 pts)

Goal: Detect and analyze image edges.

1. Implement Sobel and Prewitt filters manually.
2. Compute gradient magnitude and orientation.
3. Visualize edge maps; compare with OpenCV built-ins.
4. Derive relation between gradient direction and edge orientation.

Bonus: Use Canny detector and analyze thresholds.

Task 4 — Geometric Transformations (20 pts)

Goal: Explore affine and perspective warps.

1. Use cv2.warpAffine and cv2.warpPerspective.
2. Implement translation, rotation, scaling, perspective warp.
3. Describe how the transformation matrix changes geometry.

Evaluation Rubric (100 points)

Section	Points	Description
Task 1	20	Sampling & aliasing analysis
Task 2	20	Filter implementation & comparison
Task 3	25	Edge detection & explanation
Task 4	20	Transformation correctness & discussion
Reflection & presentation	15	Clarity, report quality, reproducibility

Suggested Readings

- Szeliski, *Computer Vision: Algorithms & Applications*, Ch. 2–3.
- CS280 Berkeley (2024) Lecture 1–3 slides.
- MIT 6.819 Sampling and Reconstruction lab.
- OpenCV docs: https://docs.opencv.org/4.x/d4/d13/tutorial_py_filtering.html