

# CARNEGIE MELLON UNIVERSITY

## 24658/42640: Image-Based Computational Modeling and Analysis

Due Date: 10:00am on September 17, 2025

### Homework 2

**Problem 1 (5 points)** In image processing, boundary detection is the most critical step. Given a 2D image  $\phi(x, y)$ , how to detect boundaries of different regions?

**Problem 2 (20 points)** Implement the following linear and non-linear filters using the finite different method to smooth the image  $\phi(x, y)$ , and apply your code to the given 2D image (foot.pgm). Please output your results in .pgm format and visualize them using IrfanView or other software.

a) Linear filtering

$$\partial_t \phi - \nabla^2 \phi = 0,$$

generate two results using different iterations.

b) Non-linear filtering

$$\partial_t \phi - \text{div} \left( g(|\nabla \phi|) \nabla \phi \right) = 0,$$

where  $g(|\nabla \phi|) = \frac{1}{1 + |\nabla \phi|^2 / \lambda^2}$ ,  $\lambda$  is an input parameter. Generate two results using

different iterations and  $\lambda$  values (for example, 1 and 10), compare and discuss your results.

Please summarize your results and show all the .pgm files in images (including the input foot.pgm for comparison).

### Appendix: pgm format description

P2	-- pgm file, grey scale image
# Created by IrfanView	-- comment
149 136	-- dimensions, dim_x, dim_y
255	-- the max intensity value, the range is [0, 255]
41 28 41 66 85 66 57 66 66 ...	-- the intensity value at each grid point,
...	(dim_x*dim_y) values