ECE 148 **Signal Processing Applications** **Spring 2025**

Assignment 3: Digital Lowpass and Highpass Filters

Due: Tuesday, April 29

1. **(Impulse invariance)** Formulate a *3 x 3* matrix operator as the *moving average filter* in the discrete form and apply the *moving average filter* to the given image for smoothing. Show the result of the lowpass-filtering process.

2. Produce composite images to illustrate the smoothing effect in the form of weighted superpositions onto the original image.

3. **(Equation conversion)** Formulate a *3 x 3* matrix operator as the *gradient filter* in the discrete form and apply the *gradient* filter to the image for edge detection. Your results should include (a) edge profile of the images in the horizontal direction, (b) edge profile in the vertical direction, and (c) the combined edge profile.

4. Produce composite images to illustrate the edge-detection effect in the form of weighted superpositions onto the original image.

5. **(Equation conversion)** Formulate a *3 x 3* matrix operator as the *Laplacian filter* in the discrete form and apply the *Laplacian filter* to the given image for peak detection. Show the distribution of peaks.

6. Produce composite images to illustrate the peak-detection effect in the form of weighted superpositions onto the original image.

Note:

(a) Raw image data will be provided.
(b) The size of the operations is *3 x 3* in this assignment for simplicity. The size can vary in practice.
(c) All images and sub-images in this assignment are magnitude-only.
(d) *Gradient* and *Laplacian* operators are digital filters, formulated by converting the first and second-order differentiation to the discrete format.
(e) The moving average filters are formulated by the impulse invariance conversion technique.
(f) Weighted superposition means $(1-\alpha)(\text{original image}) + (\alpha)(\text{filtered image})$, where the weighting coefficient is $0 < \alpha < 1$.