CAP 5400 Digital Image Processing
QUIZ 2 (sample questions)

Sample Questions: (expect 4-5 questions on each exam)

- Explain the idea of compass operator for implementation of gradient-based edge detector. Give some examples. Compare this implementation to the directional-derivatives based implementation.
- Explain the idea of gradient-based grey level edge detection (based on directional derivatives, df/dx and df/dy). Define edge strength and edge direction (give formulas). Show how the Sobel operator implements this approach.
- Derive **in details** the Hough Transform for the curve $y = \alpha x(x^4 + \beta x^2) + 51$. Suggest three implementations: (a) using thresholded gradient amplitude (location) information only, (b) using both thresholded gradient amplitude and direction, (c) using both location and edge strength information.
- Derive **in details** the Hough Transform for the curve $y = ax^4 + bx + 3$. Suggest two implementations: (a) using thresholded gradient amplitude (location) information only, and (b) using both thresholded gradient amplitude and direction.
- Give the formula for the **convolution theorem.** Explain its importance in image analysis. Explain the potential speed up achieved using Fourier domain processing vs. spatial domain convolution.
- Prove one-dimensional conjugation property for Fourier Transform (F.T.), i.e. given f(x) prove that

$$F.T.[f^*(x)] = F^*(-\varsigma)$$

Hint: $F(\varsigma) \equiv \int_{-\infty}^{\infty} f(x) EXP(-j2\pi\varsigma x)dx$ and $f(x) \equiv \int_{-\infty}^{\infty} F(\varsigma) EXP(j2\pi\varsigma x)d\varsigma$

Hint: $f(x) \otimes h(x) \equiv \int_{-\infty}^{\infty} f(a)h(x-a)da$

- Prove shift property of 1D Fourier Transform, i.e.

$$f(x+c) \Leftrightarrow F(\alpha) EXP(j2\pi\alpha c)$$

Hint: $F(\alpha) \equiv \int_{-\infty}^{\infty} f(x) EXP(-j2\pi\alpha x)dx$ and, $f(x) \equiv \int_{-\infty}^{\infty} F(\alpha) EXP(j2\pi\alpha x)d\alpha$

- Describe the use of Fourier Transform for image filtering. Next, describe in detail band-pass and high-pass filtering of images. Suggest and compare applications of these two techniques. Consider the image below; suggest the way to remove the fence using frequency filtering.

- Describe the idea and applications of the **Generalized Hough Transform**. Why would you utilize it instead of the "regular" Hough Transform?

- Explain **in details** the Hough Transform for circle detection. Provide the steps of the algorithm. Suggest two implementations: (a) using thresholded gradient amplitude (location) information only, and (b) using both thresholded gradient amplitude (location) and the value of the gradient (edge strength).

- Derive **in details** the Hough Transform for the curve y=ax^13+bx^2+66. Describe parameter space and explain all steps of the algorithm. Suggest two implementations: (a) using thresholded gradient amplitude (location) information only, and (b) using both thresholded gradient amplitude and direction.

- **Prove** (give all the steps) scaling property of 1D Fourier Transform, i.e.

$f(kx) \Leftrightarrow (1/k)F(\alpha/k), k > 0$;

Hint: $F(\alpha) \equiv \int_{-\infty}^{\infty} f(x) EXP(-j2\pi\alpha x)dx$, $f(x) \equiv \int_{-\infty}^{\infty} F(\alpha) EXP(j2\pi\alpha x)d\alpha$

- Give the formula for the convolution theorem. Explain its importance in image analysis. Explain the potential speed up achieved using Fourier domain processing (when using Fast Fourier Transform - FFT) vs. spatial domain convolution. Indicate computational complexity of 1D FFT and 2D FFT.

- Derive **<u>in details</u>** the Hough Transform for line detection. Suggest two implementations: (a) using thresholded gradient amplitude (location) information only, and (b) using both thresholded gradient amplitude and direction.

- Prove linearity property of 1D Fourier Transform, i.e.

$$af(x) + bg(x) \Leftrightarrow aF(\alpha) + bG(\alpha)$$

Hint: $F(\alpha) \equiv \int_{-\infty}^{\infty} f(x) EXP(-j2\pi\alpha x) dx$ and, $f(x) \equiv \int_{-\infty}^{\infty} F(\alpha) EXP(j2\pi\alpha x) d\alpha$

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