UNIVERSITY OF BRASÍLIA, DEPARTMENT OF COMPUTER SCIENCE

# Assignment 2: Where are the Airplanes?

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## 1 IMAGE DENOISING

In this assignment you will implement an image processing algorithm to determine the approximate location of parked air planes in a zoomed part of the Dallas/Fort Worth International Airport. The satellite *RGB* images you have access to have their $Y$ (luminance), $C_b$ and $C_r$ (chrominances) components corrupted by Gaussian noise, impulsive salt-and-paper noise and texture caused by the presence of an unwanted frequency components, respectively. The first step of your algorithm is to generate a single denoised image. Figure1.1 (a) and (b) show examples of a noisy and a denoised image, respectively. To perform this task, use spatial and frequency domain filtering. With the exception of the Fast Fourier Transform, do not use any built-in function to perform filtering.

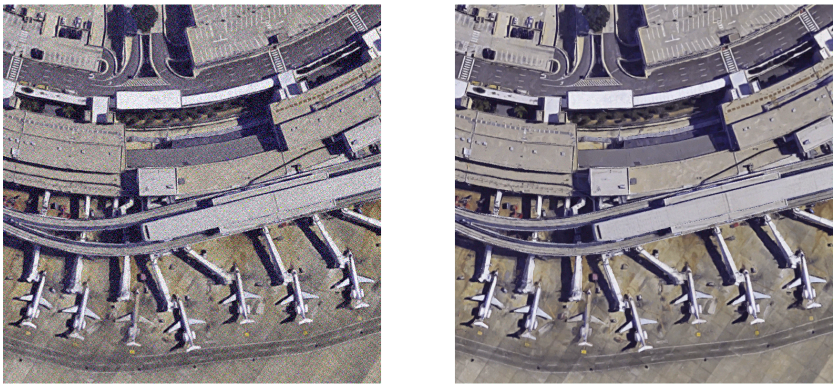

Figure 1.1: Zoomed part of the Dallas/Fort Worth International Airport: (a) noisy image; and (b) denoised image.

# 2 Finding the Airplanes

Next you will use the denoised image generate in Section 1 to find where the airplanes are parked. First you must manually define an airplane template. Figure 2.1 shows an example. Airplanes must be found via the normalized cross-correlation in the $YC_bC_r$ color space (you must implement the convolution algorithm). You will need to generate slightly rotated versions of your template in order to contemplate all the airplanes that appear in the image (you may use any built-in function to perform image rotation). Taking a vertical axis as the reference, rotate the template from $-45°$ to $45°$ using $9°$ increments. The output of your algorithm are the approximate locations of the airplanes. You are free to propose additional techniques to improve the accuracy of your algorithm.

Figure 2.1: Airplane template.

# 3 Normalized Cross-correlation

$$\gamma(x, y) = \frac{\sum_s \sum_t \left[w(s, t) - \overline{w}\right] \sum_s \sum_t \left[f(x + s, y + t) - \overline{f}(x + s, y + t)\right]}{\left\{\sum_s \sum_t \left[w(s, t) - \overline{w}\right]^2 \sum_s \sum_t \left[f(x + s, y + t) - \overline{f}(x + s, y + t)\right]^2\right\}^{\frac{1}{2}}} \tag{12.2-8}$$

where the limits of summation are taken over the region shared by $w$ and $f$, $\overline{w}$ is the average value of the mask (computed only once), and $\overline{f}(x + s, y + t)$ is the average value of $f$ in the region coincident with $w$. Often, $w$ is referred to as a *template* and correlation is referred to as *template matching*. It can be shown (Problem 12.7) that $\gamma(x, y)$ has values in the range $[-1, 1]$ and is thus normalized to changes in the amplitudes of $w$ and $f$. The maximum value of $\gamma(x, y)$ occurs when the normalized $w$ and the corresponding normalized region in $f$ are identical. This indicates *maximum correlation* (i.e., the best possible match). The minimum occurs with the two normalized functions exhibit the least similarity in the sense of Eq. (12.2-8).