# Computer Graphics Tutorial 1

In this tutorial, our goal is to learn about the basic image processing operations such as cross-correlation, smoothing with Gaussian filters and template matching. You will be given a set of MATLAB scripts (m-files) and images for the tutorial and expected to code up the missing parts in these scripts.

## Running the Code

- Extract the given zip file from the course webpage (`http://www.inf.ed.ac.uk/teaching/courses/cg/index2017.html#Tutorials`).
- On a DICE machine, open the terminal, and navigate to the folder you extracted.
- Type `matlab15` to open MATLAB (if you typed this in a different folder, you will need to change the current directory in the left-hand panel in MATLAB).
- Open the file "cg17tut1.m" from the left-hand file browser.
- Click the first code section (MATLAB splits up code between %% markers).
- Press Ctrl+Enter to execute the selected code section.
- NOTE: when `pause()` is called, press any key in the terminal at the bottom of MATLAB to resume execution. You can abort programs with Ctrl+C here too.

## Questions

**1:** Let's start with the basic linear operation, Gaussian smoothing. In this exercise, you will generate Gaussian kernels for three different $\sigma = \{3, 5, 7\}$ by using the formula:

$$h(x, y) = \frac{1}{2\pi\sigma^2} exp(\frac{-(x^2 + y^2)}{2\sigma^2})$$

You will blur the given owl photo with these kernels. To do so, given image $I$ and Gaussian kernel $h$. you will implement the cross-correlation operator in "correlation2d.m" (NOTE: Arrays in MATLAB start at 1):

$$G(x,y) = \sum_{u=1}^{m}\sum_{v=1}^{n} I(x+u, y+v)h(u,v)$$

Save the blurred images for each $\sigma$ value.

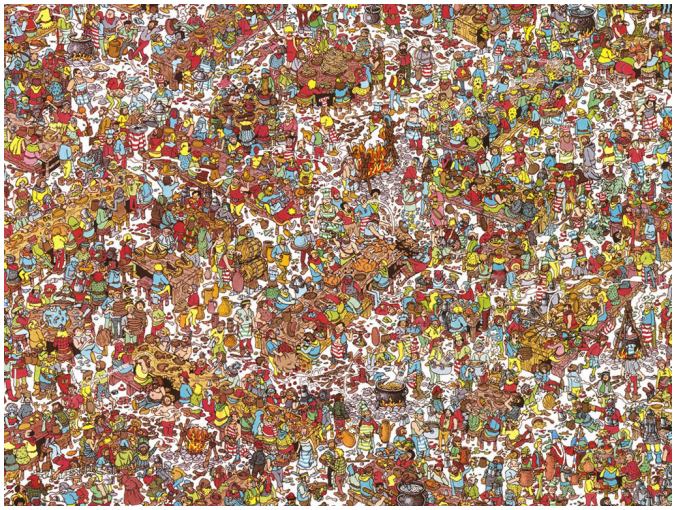
**2:** The cross-correlation operation can be thought as a "dot product" between local neighbourhood and kernel for each pixel:

$$G(x,y) = I^{sub}(x,y) \cdot h$$

where $I^{sub}(x,y) \in \mathbb{R}^{M\times N}$ is an image patch with the first pixel at $(x,y)$ and the same shape as the kernel $h \in \mathbb{R}^{M\times N}$

Please modify "correlationdot2d.m" and compare its run-time with "correlation2d.m".

**3:** After these exercises, we can finally meet our friend Waldo. You are provided a photo of Waldo (or Wally) and a very neatly organised farmer's market. You can substitute the kernel $h$ with Waldo's picture ("puzzle5_waldo.jpg") and apply the same cross-correlation measure from the previous exercise.



**4:** What would go wrong? If your search method could not find Waldo yet, maybe you should try a better matching function. Here is the normalized cross-correlation:

$$G(x,y) = \frac{I^{sub}(x,y) - I^{sub}_{mean}}{\|I^{sub}(x,y) - I^{sub}_{mean}\|} \cdot \frac{h - h_{mean}}{\|h - h_{mean}\|}$$

where

$$\|f\| = \sqrt{\sum_{u=1}^{m}\sum_{v=1}^{n} f(u,v)^2} \quad \text{is L2 norm}$$

and

$$f_{mean} = \frac{1}{H \times W}\sum_{y=1}^{H}\sum_{x=1}^{W} f(x,y) \quad \text{is mean of a given patch}$$