You have 1 hour and forty-five minutes for this exam; it totals 105 points, so you can roughly pace yourself at a point a minute for the questions.

Please put your name and SSN on this piece of paper, then write your answers on a separate sheet writing only your SSN on that sheet! At the end of the exam, return both sheets to the proctor.

It goes without saying that I expect you to do your own work; any ethical violations will be handled in accordance with the published Hopkins policies regarding academic ethics.

NAME: ____________________________

SSN: ______________________________

I. Short Answer Questions (4 pts each): Answer these questions in at most a sentence or two. Points will be deducted for excessively long answers

1. List one geometric difference that would be noticeable in images formed by a pinhole and an orthographic camera.

2. Name two different color representations.

3. What is the aperture problem?

4. What camera model does the factorization method for structure from motion assume?

5. plus several more of these

II. Medium Answer Questions (10 pts each): These might require a brief derivation. If you don’t have a calculator, feel free to express your final answer in products and sums of numbers. As above, be brief; I’m usually only looking for key ideas or key words, not an essay!

1. Suppose I want to convolve a 100x100 image by a 11x11 Gaussian mask. How much computation does separability save me assuming I produce an output image the same size as the input?

2. Suppose a camera calibration gives me a transformation (R,T) such that a point in the world maps to the camera by \( \hat{p} = R \hat{w} + T \).
   a) Given calibrations of two cameras (a stereo pair) to a common external coordinate system,
provide an expression that will map points expressed in the coordinate system of the right
camera to that of the left.

b) What is the length of the baseline of the stereo pair?

3. Given a non-verged stereo system, show that the disparity map of a planar surface is a linear
function of pixel coordinates in the image. Hint: recall that a planar surface is of the form \(a x + b y + c z = d\) for a point \(p = (x,y,z)\) on the surface.

4. a) Write one line of matlab code that could compute the image that results by subtracting the
mean of each 3x3 neighborhood from the center pixel (assume the image you are starting
with is called “im”). (Hint: use conv2).

b) Recall that the variance of a sequence of values is \(\sum(x^2)/n - (\sum x/n)^2\). note the latter
expression you’ve already computed in part a. Now, write a second line of matlab code that
computes the variance.

III Long Answer (15 pts)

Assume you have a binary image where 1 indicates the presence of an edge, and 0 indicates no
edge:

a) Write out a Hough transform algorithm for detecting circles. In case you don’t recall, the
form of the equation is \((x - c_x)^2 + (y - c_y)^2 = r^2\) where \((x,y)\) is a point on the circle,
\((c_x,c_y)\) is the center, and \(r\) is the radius;

b) State the time complexity of your algorithm; and

c) Suppose I say that I don’t know the radius; can you still solve the problem? If so, how
does the complexity change?