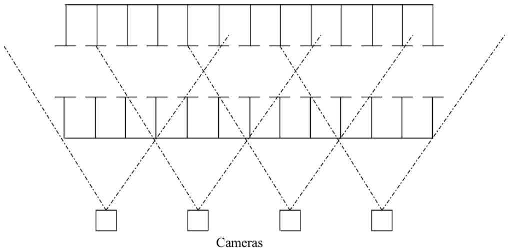
Computer Vision

Professor: James L. Crowley

M2R GVR — Mid-term Exam, November 2011

Duration: 3 hours

Test conditions: All documents and reference materials are authorized. You may NOT communicate with anyone other than the exam Proctor or the course professor. You must answer all questions in INK on the official exam paper. You may use scratch paper to prepare your answer, but your scratch paper will not be graded. You may respond in English or French (or both), but you MUST write legibly. Illegible text will not be graded. Use mathematics as well as English and/or French to communicate.



Overhead View

1) You have been hired as an engineer to design a vision system to monitor a parking lot. The parking lot is defined by a set of painted white lines as shown above. Your system employs a network of cameras mounted on poles, such that every part of the parking lot is observed by at least two cameras. Your system will detect and track cars and people and display their positions using a common reference frame as seen from an overhead view.

a) (2 points) Describe how to use a Hough Transform to detect the painted parking lines. How big should the Hough array be?

b) (2 points) Describe how to use the detected lines to calculate the projective homographic transformation for an overhead view.

c) (2 points) Describe how to use the projective homographic transformation to transform the image into an overhead view.

d) (2 points) To align the overhead views, you ask a pedestrian with a red suit to walk through the parking lot. Assume that only one pedestrian is present in the parking lot. Describe how to use the color of the pedestrian's suit to detect the pedestrian. Describe how to estimate the image coordinates of the feet of the pedestrian.

e) (2 points) Describe how to use the position of the pedestrian's feet to determine a transformation that aligns the overhead views for two images. Write the transformation as a matrix expressed in homogeneous coordinates.

2) You are asked to compute the gradient of an image $\vec{\nabla} P(i,j)$ using convolution with sampled Gaussian derivatives, $\vec{\nabla} G(i,j,\sigma)$.

a) (2 points) Give the formulae for the sampled Gaussian derivatives as well as the formulae for the 2D convolution with an image.

b) (2 points) What is the minimum size support window that can be used for a Gaussian derivative with $\sigma=2$?

c) (2 points) What is the computational cost (number of additions and multiplications) per pixel when the derivatives computations are implemented as 2-D convolutions?

d) (2 points) Can the calculation be implemented as series of 1D convolutions? If yes, how? If no, why not?

e) (2 points) Given the Gradient of the image $\vec{\nabla} P(i,j)$ in the row and column directions, give a formulae to determine the derivative at pixel (i, j) in an arbitrary direction θ.