Exercise Digital Image Processing

SS 2008

Exercise 2
Submit by May, 5th, 10AM, for exercise on May, 7th

Notes:

- You have a choice: Solutions to text exercises that do not involve programming can be in English or German, at your choice. Submission to text exercises can be made on paper or by email (scanned documents, PDFs, or Word/OpenOffice) to Eva.Hoerster@informatik.uni-augsburg.de before the above due date.
- Solutions to programming exercises must be submitted by email to eva.hoerster@informatik.uni-augsburg.de before the above due date. Only submit you source code (*.h and *.cpp files). Do not submit any executables, binary or object files, project or solution files, nor any other input data that can be downloaded from the course website (i.e. image or video data provided as part of the assignment). DO NOT COMPRESS YOUR SOURCE CODE FILES (rar, .zip, etc. is not allowed)! Your code must compile and run; if your code fails to compile, you will receive zero points for the exercise.

2.1 (35 points)
   a) What is a parallel projection? What is a perspective projection? Include the defining equations. (If you do not follow the notations from the lecture, specify exactly your coordinate system as well as each variable!)
   b) Illustrate the difference between parallel and perspective projection.
   c) The perspective projection of a 3D point \( \mathbf{X} \) to a 2D point \( \mathbf{x} \) in homogeneous coordinates can be expressed using the linear Equation \( \mathbf{x} = \mathbf{P} \mathbf{X} \), where \( \mathbf{P} \) is a 3x4 matrix defined up to a scale factor. Derive the 3x4 matrix \( \mathbf{P}_o \) for orthogonal projection in the camera frame. Compare the matrix \( \mathbf{P}_o \) with the matrix \( \mathbf{P} \).

2.2 (30 points)
Suppose that an image is created by a camera in a certain world. Now imagine the same camera placed in a similar world in which everything is twice as large and all distances between objects have doubled. Assuming perspective projection, compare the new image with the one formed in the original world. Prove your statement by an illustration and by equations.

2.3 (35 points)
Let \( \mathbf{M} \) denote the simple 3x4 projection matrix (only the focal length \( f \) as parameter) for the camera frame.
a) Using this matrix, compute the projection of the point \((X,Y,Z) = (6,10,18)\) in homogeneous coordinates (express your answer in terms of the focal length \(f\)), and convert your result to Euclidean coordinates.

b) Using the same matrix, compute the projection of the homogeneous point \((X,Y,Z,W) = (1,1,1,0)\) (again in terms of \(f\)). Note that this point has no corresponding Euclidean point. Is its projection still meaningful? Which Euclidean points project to the same location?