Final Exam

1. Given two observations $\hat{q}_1$ and $\hat{q}_2$ with variances ${\sigma_1}^2$ and ${\sigma_2}^2$ of a normal distributed process with actual value $\hat{q}$. The optimal estimate can be calculated by minimizing the expression

$$S = \frac{1}{{\sigma_1}^2}(\hat{q} - \hat{q}_1)^2 + \frac{1}{{\sigma_2}^2}(\hat{q} - \hat{q}_2)^2$$

   Calculate $\hat{q}$ so that S is minimized.

2. An ultrasound sensor measures distance $x = \frac{c\Delta t}{2}$. Here, c is the speed of sound and Δt is the difference in time between emitting and receiving a signal.

   a) Let the variance of your time measurement Δt be ${\sigma_t}^2$ What can you say about the variance of x, when c is assumed to be constant? Hint: how does a change in Δt affect x?

   b) Now assume that also c is changing depending on location, weather, etc. and can be estimated with variance ${\sigma_c}^2$. What is the variance of x now?

3. SIFT feature description and detection a.) Describe the four computational steps of SIFT feature description and detection.

   b.) Describe SURF features, and discuss how and why the computations of these features are more efficient than SIFT

   c.) Describe one other feature detector from the literature.

4. Assume the following scene shown in Fig.1 with a background plane of 5m distance and two objects (a rounded rectangle and a triangle) at 1m distance as drawn below.

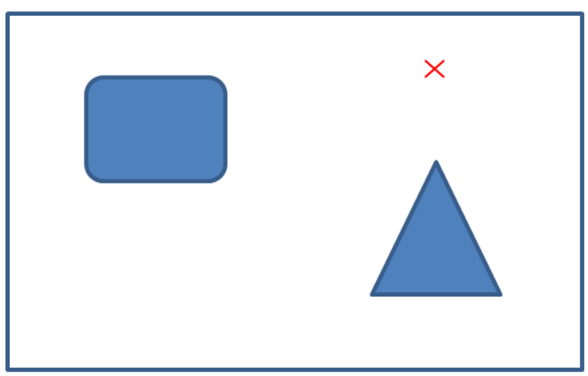

Figure 1: The scene.

   a.) The camera is moving towards the scene with the direction of translation denoted by the red cross (the so-called Focus of Expansion). Draw the flow field qualitatively.

   b.)) What is the aperture problem in computing optical flow? How is it related to the linear constraint on optical flow ("brightness constraint") determined by the differential technique for computing flow?

   c.) Describe the Lucas Kanade optical flow algorithm.

5. Assume that the ceiling is equipped with infra-red markers that the robot can identify with some certainty. Your task is to develop a probabilistic localization scheme, and you would like to calculate the probability $p(marker|reading)$ to be close to a certain marker given a certain sensing reading and information about how the robot has moved. a.) Derive an expression for $p(marker|reading)$ assuming that you have an estimate of the probability to correctly identify a marker $p(reading|marker)$ and the probability $p(marker)$ of being underneath a specific marker.

   b) Now assume that the likelihood that you are reading a marker correctly is 90%, that you get a wrong reading is 10right underneath it is 50that is equipped with 4 markers. You know with certainty that you started from the entry closests to marker 1 and move right in a straight line. The first reading you get is "Marker 3". Calculate the probability to be indeed underneath marker 3.

   c.) Could the robot also possibly be underneath marker 4?