

CMSC498F Final

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- 1** Given two observations \hat{q}_1 and \hat{q}_2 with variances σ_1^2 and σ_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.

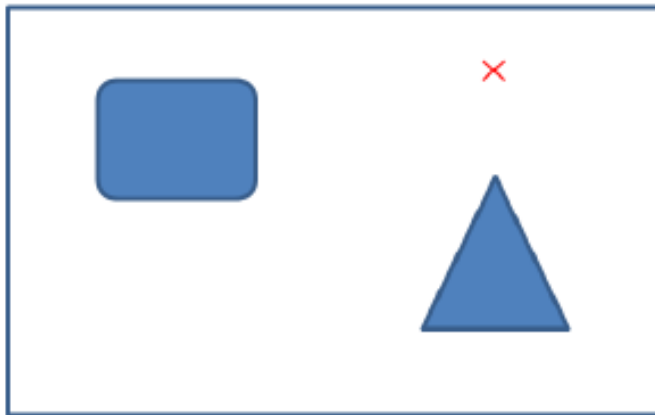
- 2** An ultrasound sensor measures distance $x = \frac{c\Delta t}{2}$. Here, c is the speed of sound and Δt is the difference in time between emitting and receiving a signal.

- (a) Let the variance of your time measurement Δt be σ_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 σ_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.



- (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 $p(\text{marker} \rightarrow \text{reading})$ 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 $p(\text{marker} \rightarrow \text{reading})$ assuming that you have an estimate of the probability to correctly identify a marker $p(\text{reading} \rightarrow \text{marker})$ and the probability $p(\text{marker})$ 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 10% right underneath it is 50% that is equipped with 4 markers. You know with certainty that you started from the entry closest 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?