EXAM COMPUTER VISION, INMCV-08

April 8, 2014, 14:00-17:00 hrs

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During the exam you may use the book, lab manual, copies of sheets, **provided they do not contain any notes.**

Put your name on all pages which you hand in, and number them. Write the total number of pages you hand in on the first page. Write clearly and not with pencil or red pen. ***Always motivate your answers.*** *The total number of points to be earned is 9, one is added for free. Good luck!*

Problem 1. (2.0 pt) Consider a surface of the form

$$z = d + ax^2 + by^2,$$

a. (1.0 pt) Assuming a homogeneous texture with texture constant ρ_0, determine the observed texture density $\Gamma(u, v)$ under parallel projection ($u = x$,$v = y$).

b. (0.5 pt) Assuming we observe the density $\Gamma(u, v)$ you derived, and you were able to derive the surface normal at each point. What extra assumption would you need to make to reconstruct the surface (z values) itself (up to a constant distance)?

c. (0.5pt) Neither shape from shading nor shape from texture derive surface normals unambiguously from a single image. Which method offers tighter constraints on the surface normal and why?

Problem 2. (2.5pt) Consider the three axioms for *shape* granulometries in the case of binary images which are modelled as subsets X of space $\mathbb{R}^2$. A granulometry is a set of operators $\{\beta_r\}$ with r from some totally ordered set, such that

$$\begin{aligned} \beta_r(X) &\subseteq X, & (1)\\ \beta_r(X_\sigma) &= (\beta_r(X))_\sigma, & (2)\\ \beta_r(\beta_s(X)) &= \beta_{\max(r,s)}(X), & (3) \end{aligned}$$

in which X_σ denotes the scaling of set X by a positive factor σ such that

$$X_\sigma = \{(x, y)|(\sigma^{-1}x, \sigma^{-1}y) \in X\} \quad (4)$$

i.e., the operators are invariant to scaling

0.5 **a. (0.5 pt)** Show that for any *shape* granulometry, all β_r must be *idempotent*.

Consider an attribute thinning ψ_λ with boolean criterion Λ

$$\Lambda(C) \equiv (\mu(C) \geq \lambda) \quad (5)$$

with C a connected set and μ some measurement on that set.

0.75 **b. (0.75pt)** What property must μ satisfy to ensure that $\{\psi_\lambda\}$ adheres to the second axiom of shape granulometries.

0.75 f **c. (0.75pt)** Show that the absorption property holds, i.e:

$$\psi_s(\psi_t(X)) = \psi_{\max(s,t)}(X) \qquad \forall s, t \in \mathbb{D}.$$

20 ≠ 2.5 with $\mathbb{D} \subseteq \mathbb{R}$ the range of μ, and that therefore $\{\psi_\lambda\}$ is a shape granulometry.

Problem 3. (2.5 pt) Suppose a camera sees cars approaching on an intersection, and through tracking features on the cars detects linear motion with vanishing points $(u_1, v_1) = (-20, 0)$ and $(u_2, v_2) = (20, 0)$, respectively.

a. (1.0 pt) Compute the normal to the plane in which the intersection lies as a unit vector in camera-centric coordinates (z-direction along optical axis). Do you need to know camera constant f?

b. (1.0 pt) Express the angle α between the roads at the intersection as a function of (unknown) camera constant f.

c. (0.5 pt) What is f assuming the roads cross at right angles?

Problem 4. (2.0 pt) Consider a stereo pair of images from two cameras as shown below with $O_L = (-10, 0, 0)$ and $O_R = (10, 0, 0)$, $f = 20$

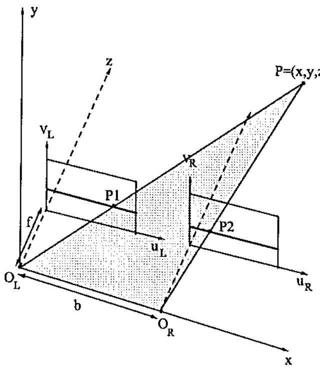

Figure 1: *Standard stereo set-up.*

a. (0.5 pt) The key to successful shape-from-stereo is solving the *correspondence problem.* A common approach is feature-based correspondence. Describe the approach and give a practical example of features that could be used.

b. (0.5 pt) Suppose a feature is detected in the left camera image at $(u_L, v_L) = (0, 0)$. Where should we look in the right image for a corresponding feature?

c. (0.5 pt) Given the above observation, but in the absence of a matched point in the right image, what constraints on the (x, y, z) position can be given?

d. (0.5pt) Suppose matching features are found in the right image at $(u_R, v_R) = (-1, 0)$ and $(u_R, v_R) = (1, 0)$. Which is the correct match, and what is the (x, y, z)-position of the object?