CS/RBE 549 Computer Vision Name:_____
Fall 2018 Monday 03 Dec 2018

Exam #2

DO NOT OPEN THIS EXAMINATION UNTIL YOU ARE TOLD TO DO SO!

Write your name at the top of this page now.

This examination is open book and open notes.

No electronic computing / communications devices are permitted. No wireless communication is allowed.

Write all your answers on the examination in the space provided. You may use the back of the examination for extra space. Partial credit will be given, but you must justify your work.

The examination will end exactly 85 minutes after it begins.
Good luck!

Problem 1: /40
Problem 2: /35
Problem 3: /15
Problem 4: /10
Problem 5: /01

Total: /101

1. **Optical Flow (40 pts):** Suppose the image brightness is given by

$$I(x, y, t) = I_0 + \frac{1}{2}[(x - c_1 t)^2 + (y - c_2 t)^2]$$

   a. (15 pts) What are I_x, I_y, and I_t? Hint: You should find that these derivatives have a simple form.

   b. (15 pts) Express the Optical Flow Constraint Equation $I_x u + I_y v + I_t = 0$ in the simplest terms possible for this image sequence.

   c. (10 pts) The equation from b. must hold for all *x*, *y*, and *t*. Find a constant solution for *u* and *v* that makes this true, that is, such that *u* and *v* do not depend on *x*, *y*, and *t*.

2. **Stereo Motion (35 pts):** In stereo imaging we can compute a point's world coordinates from left and right images as

$$\vec{X}^W = \vec{X}_{AVG}\frac{\left|\vec{B}\right|^2}{\vec{B}\cdot\vec{\Delta}}$$

a. (20 pts) Show that if the world point is in motion, we can compute its velocity as

$$\vec{V}^W = \vec{V}_{AVG}\frac{\left|\vec{B}\right|^2}{\vec{B}\cdot\vec{\Delta}} - \vec{X}_W\frac{\vec{B}\cdot\frac{d\vec{\Delta}}{dt}}{\vec{B}\cdot\vec{\Delta}}$$

b. (15 pts) Suppose that a moving world point is imaged as

$$\vec{X}_L^I = \begin{bmatrix}\frac{c}{2t}\\0\\f\end{bmatrix}, \vec{X}_R^I = \begin{bmatrix}\frac{-c}{2t}\\0\\f\end{bmatrix}$$

With the usual imaging geometry of $\vec{B} = [b \quad 0 \quad 0]^T, \vec{F} = [0 \quad 0 \quad f]^T$, what is $\vec{V}^W$? Express $\vec{V}^W$ in the simplest terms.

3. **Image Knowledge (15 pts):** Describe 3 sources of knowledge about *your* assigned object that could be exploited by a computer vision system. How robust is each of these knowledge sources?

4. **X-Ray Vision (10 pts):** As is well-known, the comic book hero Superman has X-Ray vision. Although the physics of x-ray vision are never quite explained, presumably, Superman's eyes are sensitive to photons in the x-ray spectrum, which can penetrate most objects. *Briefly* discuss some of the challenges imaging the world using x-rays.

5. **Teamwork (1 pt):** On a scale of 1 to 5, with 1 being the lowest, 3 is neutral and 5 being the highest, rate how well your project team is working together.