University of Illinois at Urbana-Champaign
Department of Computer Science

Midterm 2

CS 498: Virtual Reality
Spring 2017

Name:
NetID:

- Print your name and NetID, *neatly* in the space provided above.
- Throughout the exam, please print legibly.
- This is a *closed book* exam. No notes, books, dictionaries, calculators, laptops, smartphones, or virtual reality interfaces are permitted.
- Write your answers in the space provided for the corresponding problem. **Don't forget to write your answers on the scantron for the MC and T/F questions**
- If any question is unclear, ask us for clarification.

Question	Points	Score
Problem 1	30	
Problem 2	30	
Problem 3	6	
Problem 4	4	
Problem 5	8	
Problem 6	12	
Problem 7	10	
Total	100	

1. Multiple Choice (30 points; 2 each): Circle one choice only for each part.

   (i) What is the minimum number of frames per second at which apparent motion occurs, rather than frames perceived individually?

   (a) 2 (b) 5 (c) 10 (d) 24 (e) 60

   (ii) Which eye movement serves to fill in detail?

   (a) saccade (b) pursuit (c) lazy rectus (d) opto-kinetic (e) vestibulo-ocular

   (iii) Why does a moving rectangular object appear to "waggle" (shear) on the screen?

   (a) Vestibulo-ocular reflex (b) Photoreceptor saturation

   (c) Slow pixel switching speed (d) Line-by-line display scanout (e) Optical distortion

   (iv) Which of the following is not used by researchers to measure VR sickness?

   (a) Electrocardiogram (b) Electrogastrogram (c) Galvanic Skin Response

   (d) Skin Pallor (e) Galvanic Vestibular Impulse

   (v) How does the lighthouse approach used in HTC Vive achieve visibility?

   (a) Laser-photodiode pair (b) Camera-LED pair (c) Retroreflective markers

   (d) Chemtrail-Olfactory pair (e) Laser-Camera pair

   (vi) How many 3D points attached to a freely moving rigid body need to be observed in an image so that there is a unique solution for rigid body tracking?

   (a) 1 (b) 2 (c) 3 (d) 4 (e) 6

(vii) Which motion does NOT cause vestibular mismatch when moving an avatar using a controller?

(a) Straight motion, constant velocity (b) Straight motion, constant acceleration

(c) Rotation in place, constant angular velocity (d) Rotation in place, constant angular acceleration

(viii) According to the PnP problem, how many degrees of freedom are left if n = 2?

(a) 0 (b) 1 (c) 2 (d) 3 (e) 6

(ix) Which of the following is not used for aural localization?

(a) Interaural Level Difference (b) Interaural Tonal Difference (c) Interaural Temporal Difference

(d) Spectral Distortion (e) Pinna Shape

(x) What could be a negative effect of using the HTC Vive controllers for a long period of time time?

(a) Phantom Limbs (b) Gorilla Arms (c) Scapular Fatigue (d) Ghost Limbs (e) Ghost Hands

(xi) Let p be the exponent in the Blinn-Phong shading model. What happens as p is increased?

(a) The color shifts toward red (b) The surface appears more white

(c) The surface looks flattened (d) The surface appears less reflective

(e) The surface looks more mirror-like

(xii) Which part of the vestibular system measures linear accelerations?

(a) Otolith organs (b) Ad nauseam (c) Cochlea

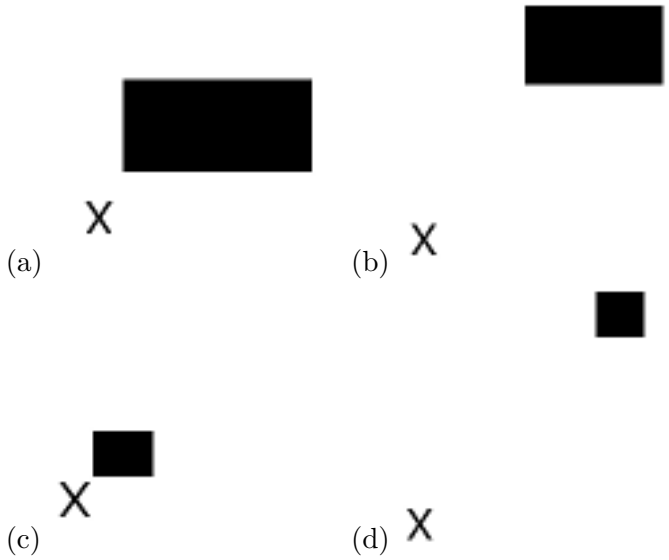
(d) Ganglion cells (e) Semi-circular canals

(xiii) What physical sensor is commonly used for yaw correction in current head-mounted displays?

(a) Radio sensor (b) Gravity sensor (c) Linear accelerometer

(d) Magnetometer (e) Thermobaric sensor

(xiv) According to Fitts's law, which of the following has the lowest index of difficulty? X is the pointer, the rectangle is the UI object.



(xv) As commonly used in class, what does IMU stand for?

(a) Intensive Management Unit (b) Irish Missionary Union (c) Interface Motion Utility

(d) Inertial Measurement Unit (e) Interactive Multisensor Utility

2. True or False (30 points; 2 each): Circle one choice only for each part.

(i) **T / F:** A slow-switching LCD display causes blurring of the stationary objects to be perceived as the user turns her head.

(ii) **T / F:** Saccades occur to keep slow-moving object in view over time.

(iii) **T / F:** Any interaction mechanism from the real world can be simulated in VR.

(iv) **T / F:** The optokinetic reflex is a combination of smooth pursuit and saccades.

(v) **T / F:** When displaying a menu, it is most comfortable to turn off head tracking so that the menu follows the user's head.

(vi) **T / F:** Vection is one of the main causes of simulator sickness in VR.

(vii) **T / F:** If you close one eye while looking into a VR headset, then you have no perception of depth.

(viii) **T / F:** The illusion of self-motion is what is commonly referred to as the McGurk effect.

(ix) **T / F:** Sound waves are transverse waves.

(x) **T / F:** When moving the avatar using a controller, it is more comfortable to immediately jump to walking speed, rather than gradually increase speed.

(xi) **T / F:** Just Noticeable Difference between aural tones increases as the frequency decreases.

(xii) **T / F:** The Painter's Algorithm approach correctly handles the case of a depth cycle among primitives (triangles).

(xiii) **T / F:** Ganglion cells detect color.

(xiv) **T / F:** Using the controller to rotate the avatar in place at constant angular velocity causes a mismatch between the vision and vestibular systems.

(xv) **T / F:** The Shannon-Weaver model of communication serves as the basis of communication theory in engineering

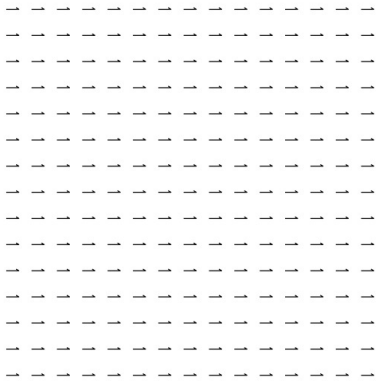
3. Latency in the Graphics Pipeline (6 points):
   Name four methods of latency reduction in the graphics pipeline.

4. Vection (4 points):
   Name 4 methods a developer can use to reduce visually-induced motion sickness.

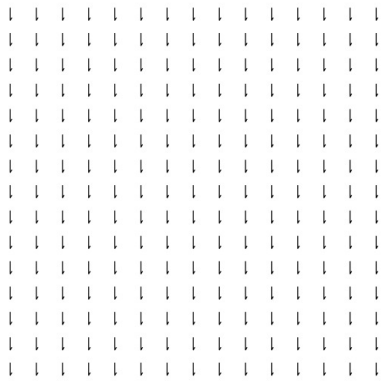
5. Head Tracking (8 points):

   Describe four sensors used in the Oculus Rift for head-tracking as studied in class. For each of the sensors, describe the measurements they produce used in sensor fusion computations. For example, for an IMU sensor, describe vector direction and magnitude together with their physical interpretations, and, briefly, what these measurements are used for in head tracking. (You do not need to provide sensor fusion formulas, just a verbal description of the algorithms will be enough.)

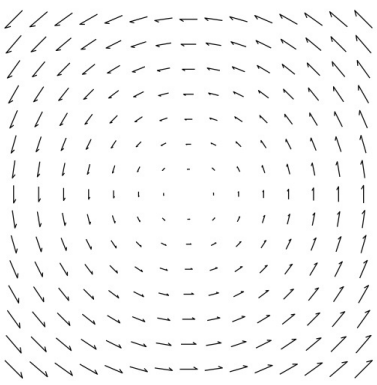
6. Optical flow (12 points):
For each of the images below, imagine you are wearing a perfectly functioning VR headset and describe head motions that result in corresponding optical flows. Assume that x axis runs from left to right, and y axis runs from bottom to top of each image. Describe each in terms of yaw, pitch, roll, x, y or z and indicate the direction of motion (positive vs. negative, clockwise vs. counterclockwise). State any other assumptions you are using in your description. Use right hand coordinate for this question.



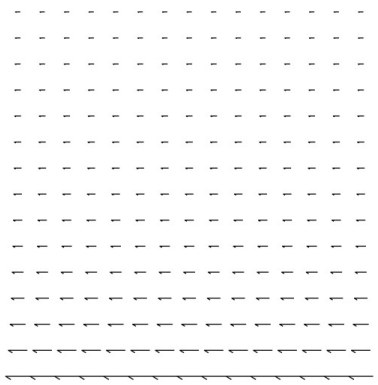
(a)



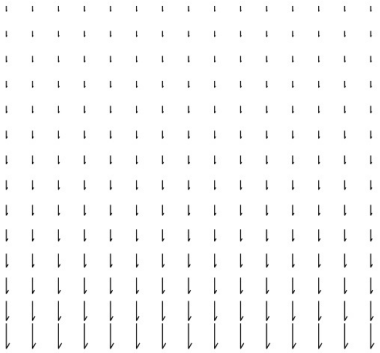
(b)



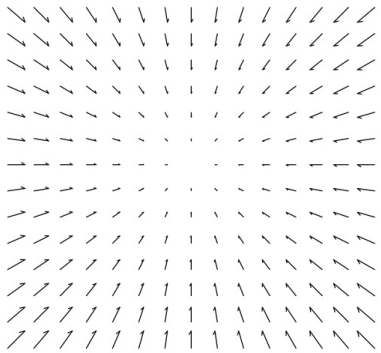
(c)



(d)



(e)



(f)

(a)

(b)

(c)

(d)

(e)

(f)

7. Barycentric calculations (10 points):

   Consider an equilateral triangle in the image plane that is formed by three points: $p_1 = (0, -3)$, $p_2 = (0, 3)$, $p_3 = (3\sqrt{3}, 0)$. The RGB values at each of these points are $(6, 3, 9)$, $(21, 0, 18)$, and $(33, 0, 12)$, respectively. Use the interpolation method based on barycentric coordinates to find the RGB values to apply by a rasterizer at the point (0, 0). Show your work for full credit.