Resit Exam for The Human Controller, WB 2306
Tuesday, August 23, 2011
14:00-17:00

Instructions

- *Do not forget to write your name (with initials) and your student-number on each of your sheets.*
- *The ideal answer is well-motivated but clear, short and to-the-point. In general, more than a few sentences is not needed to answer correctly!*
- *Writing down non-relevant information may work against you in judging your knowledge about the question.*
- *Please switch off your phones*

Each of the 8 questions is worth a full point for the final grade (and each sub-question 0.25 points, unless stated otherwise).
When answering the questions, you can use the written material that was put at your disposal during the course. Good luck!

Question 1

a) How many types of senses are available to humans? Name them, and the body location of their respective main sensory organs.
b) Which two senses are mainly used when designing support systems for human operators? Give an example for each.
c) Explain in your own words what an observation window is, and draw one for the auditory system, showing boundaries and resolution.

Suppose you have to design a driving simulator and have only a limited budget available to recreate naturally occurring cues.

d) In which ways could you realize a good perception of vehicle speed for test subjects? Name at least three cues, each based on a different source of sensory perception (i.e. a different organ).

Question 2

Suppose you are an experienced motor cyclist riding your old bike over a smooth asphalt road, and are trying to maintain a straight heading. You're looking around at the country side, and then suddenly notice a short patch of old road (with several cracks and small holes) straight ahead of you, which might cause you to fall at this speed.

Suppose you think you are too late to change your heading, and decide you can't avoid the holes.

a) What neuromuscular mechanisms will you use to help you to maintain your heading? Draw – in the same graph – a bode-plot of two admittance's: one just before seeing this old road patch (dashed line) and another afterwards, while driving over the rough road part (solid line).

b) How could a motorcycle designer improve the produced bike's ability to maintain a straight heading (i.e., the 'disturbance rejection' characteristics), with a simple mechanical solution? Explain how this would affect your neuromuscular settings.

Suppose you think you are still able to avoid the rough patch of road if you make a very fast steering maneuver.

c) How would you call this steering action in control engineering terms? To what extent would you be able to successfully do this if you're riding a borrowed motorcycle from a friend, instead of your old one? Motivate your answer.

d) To what extent will the 'mechanically improved' bike from question b) be helpful or harmful to the steering maneuver from question c? Motivate your answer.

Question 3

In robotic surgery the 'Da Vinci' system is the only commercially available tele-manipulation system. One of the hypothesized benefits is that it improves eye-hand coordination during laparoscopic surgery. However, the system does not have haptic feedback.

a) Draw a block scheme of the surgeon using the Da Vinci system, showing main system components as blocks, naming the signals that represent the lines, and including *all available feedback loops* (note that if feedback is not readily available to the human, a system block needs to be added that describes information processing devices).

b) One of the other hypothesized benefits is that the Da Vinci system would allow remote surgery: a doctor in London operating a patient in Amsterdam. Do you think the currently available technology allows this? Briefly motivate your answer.

c) Suppose good haptic feedback can be added, to further improve the system. How would the surgeon, patient and society benefit from good haptic feedback?

d) Explain arguments for and against the full automation of some robotic surgeries.

Question 4

In order to safely explore buildings that are on fire, a remote-controlled unmanned aerial vehicle (UAV) has been developed. In order to facilitate the control, the UAV has been automatically stabilized in the horizontal plane. The human-machine interface for the operator consists of a screen which shows a frontal camera view, and a joystick with which the operator can command velocity in the horizontal plane.

a) Name three cues that the human operator missing with the remote controlled UAV, which he/she would experience if he/she would be present inside the vehicle.

Some preliminary tests show that operators have trouble to steer the UAV through a crooked escape trajectory inside the building.

b) Describe four metrics that can be cheaply and easily measured (or constructed) that would indicate that operators are having trouble to operate the UAV.

Suppose that in order to improve an operator's UAV control, he/she is asked to perform several abstract training trajectories over and over again, until he/she is very familiar with the UAV dynamics.

c) What part of control behaviour has he/she learned, according to Rasmussen's theory? Explain how your four metrics (from question b) are affected by this learning.

Suppose an operator is asked to use a UAV to explore inside an unknown building, and there is no preparation time to study any maps or indications.

d) What part of Rasmussen's behavior is now lacking? Explain how this will affect your four metrics.

Question 5

a) Describe in your own words how the semi-circular canals in the vestibulary organ work.

b) Which transfer function provides a good description of the semi-circular canals? Explain the variables in the transfer function. Give the Bode plots as well (magnitude and phase).

c) What is the bandwidth of the semi-circular canals?

d) You are sitting in a train that is waiting to depart the station, looking through the window at another waiting train next to you. Explain the common experience of being fooled into thinking your train is moving, only to find out it was the other train that is moving.

Question 6

Depth perception is an important cue for photographers and movie makers, when trying to make beautiful pictures and illusions.

Anyone who likes to make pictures knows how disappointing it is to try and capture a magnificent wide mountain-top view with a photograph.

a) Name 7 depth perception cues that a human being can use in everyday life, and explain why the feeling of depth doesn't come across on such a mountain-top picture, by mentioning which of the 7 cues mention in a) are absent or non-existent. What is a good way to increase the feeling of depth on a picture?

Who ever has been to the tower of Pisa, has probably stumbled over hordes of tourists making similar pictures as shown to the right.

b) Explain this optical illusion in terms of depth perception cues, and explain which cues mentioned in a) cause this illusion to break, even when you're standing close to the photographer.

In the "Lord of the Rings" movie trilogy, hobbits had to be filmed next to humans. Since it was hard to hire hobbits as actors (sorry to burst your bubble: they don't really exist..) different techniques had to be employed in order to maintain the illusion that normal-sized humans were small. One of the most challenging parts was to beautifully film 'hobbits' interacting with humans in the same shot. An example shown in

‘The Making of…” is a full-body shot of a small hobbit sitting next to a tall wizard on the ‘drivers-seat’ of a horse cart.

c) Explain how two equally-sized actors can be filmed so that it seems that a hobbit is sitting next to tall wizard; given a fixed camera viewpoint.

d) In movie-making, depth is usually shown by moving camera-position, making the shots more beautiful. This is very challenging in the situation explained in c). During the filming of the Lord of the Rings, a new technique was developed to make such a shot possible. Note that this was a (electro-)mechanical solution, not computer-animated special effects! Explain how this solution would work?

Question 7

a) Explain the difference between a pursuit display and a compensatory display. Draw a block-diagram to illustrate your answer.

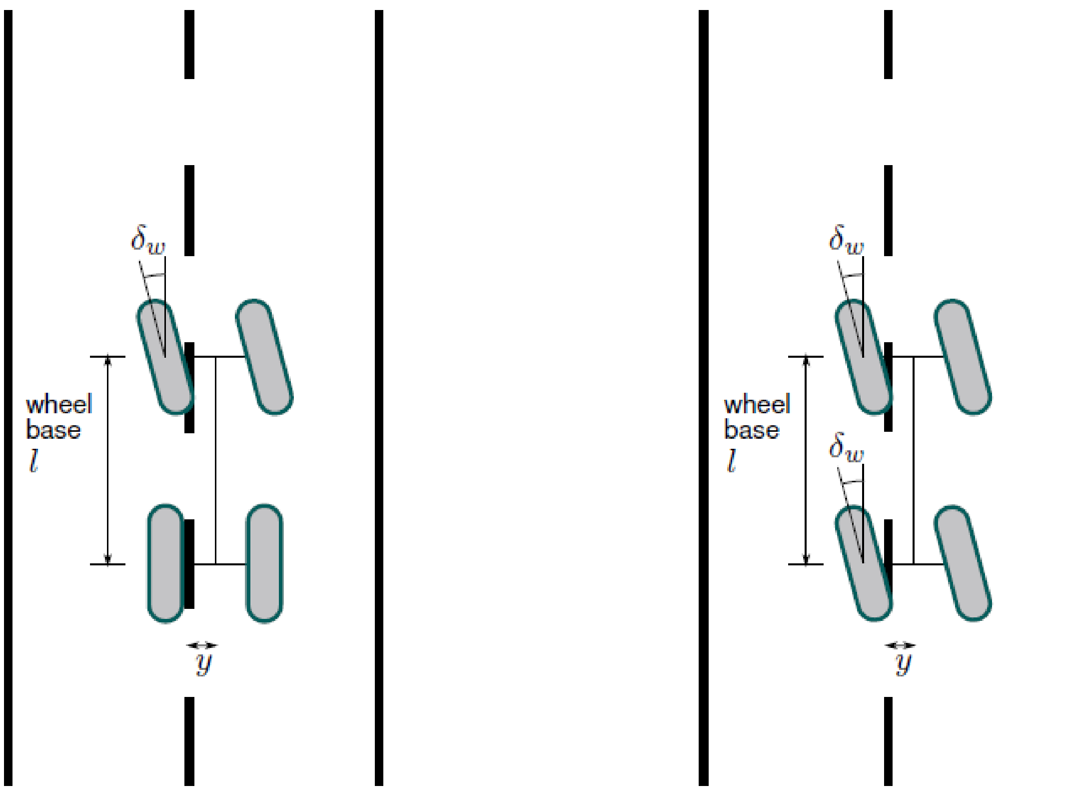
b) What effect does the choice for a pursuit or compensatory display have on the performance of a tracking task? Motivate your answer.

c) Use a bode-plot to explain crossover-frequency and phase margin.

d) Use the McRuer Crossover Model to explain the relationship between cross-over frequency, effective time delay and performance of a tracking task.

Question 8

Normally, cars are steered with front wheels only (left part of the figure). But advances in technology have stimulated car manufacturers to explore steering on all four wheels. At high speed, lane change maneuvers with such a system can be performed by turning both the front and rear wheels into the direction of the lane change (right part of the figure).



For this question, assume that the lane change maneuver with such a car is performed by deflecting all wheels with an equal amount; i.e. the car is purely moving sideways in addition to its forward motion*. Furthermore, consider that steering wheel and heading (with respect to the road heading) angles are small, and that the cosine or sine of these angles can be approximated by the angle itself.

a) Assuming that tyre dynamics can be neglected, give the transfer function for the lateral position y in response to a steering wheel input δ_w for a conventional car driving with a contant speed V. What is the order of this transfer function?

b) Assuming the car driver could only observe the lateral position with respect to the road, y, what could be the type of equalization selected according to McRuer's simplified precision model?

c) Discuss how human control will deviate from the assumption above if the human operator can select any feature from the visual field in front of him/her.

d) Again, assuming that tyre dynamics can be neglected, give the transfer function for the lateral position y in response to a steering wheel input δ_w of the car with the proposed four-wheel steering. What is the order of this second transfer function?

e) What would now be the type of equalization selected according to McRuer's simplified precision model?

** Note that since you can't make turns with the proposed set-up, in reality the rear steering wheel angle will not be fully equal to the front wheel steering angle. Also, the steering ratios will be velocity dependent, so that at low speeds the vehicle can make a shorter turn, and at high speed the vehicle can make sideways movements.*