Multimodal Interaction 2013/2014

Final exam, Mon, April 14, 2014, EDUC-GAMMA

Do not open this exam until instructed to do so.
Read the instructions on this page carefully.

INSTRUCTIONS

- Write down your name and student number below and on every additional paper you want to turn in.
- The exam is printed on 13 pages (including this one). The back of each page should be empty.
  It is your responsibility to check if you have a complete printout.
  If you have the impression that anything is missing, let us know.
- Use a pen, not a pencil. Avoid usage of the color red.
  Write your answers below the questions in the designated areas.
  If you need more space, please continue writing on the back of the preceding page.
  You can also use additional paper provided by us. You are not allowed to use your own paper.
- You may **not** use books, notes, and any other material or electronic equipment
  (including your cellphone, even if you just want to use it as a clock).
- You have max. 1:50 hours to work on the questions. If you finish early, you may hand in your work and leave, except for the first half hour of the exam.
- If you have read all the instructions above carefully, you can start with the exam.

Good luck!

YOUR NAME:	YOUR STUDENT ID:

PLEASE DO NOT WRITE BELOW THIS LINE

TOTAL NUMBER OF CREDITS (max. 100):	GRADE:

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

1. INTRODUCTION & MOBILE DEVICES

Question 1-1 (max. 6 credits) In the lectures, we looked at how user interfaces developed over time, for example, from CLIs to GUIs to NUIs. Complete the following sentences:

(a) CLI stands for ______________________________

A typical device used with it is ______________________________

(b) GUI stands for ______________________________

A typical device used with it is ______________________________

(c) NUI stands for ______________________________

A typical device used with it is ______________________________

(Note: It is sufficient to write down what the acronyms stand for. Detailed explanations are not required.)

Question 1-2 (max. 2 credits) Today's smartphones contain sensors that are to some degree related to three of the five human senses. What are the two human senses that are *not* supported by most current consumer devices yet (although they are currently being researched and might be integrated in future ones)?

ANSWER:

(Note: No explanation required. Just writing down the two correct senses will give you full credit.)

Question 1-3 (max. 4 credits)

(a) PPI (pixels per inch) is a measure indicating the pixel density of a screen. How is it calculated?

ANSWER:

(Note: No explanation required. Just writing down the correct formula will give you full credit.)

(b) Apple introduced so called retina displays for their mobile devices. They justify this name by saying that the pixel density of these screens is so high that the human eye cannot see the difference between two pixels anymore. Yet, the iPhone 5s has 326 ppi, whereas the iPad Air's display has a significantly lower pixel density of only 264 ppi. How can they justify that the latter is still a retina display?

ANSWER:

(Note: A rather short informal explanation in, e.g., one sentence could be enough to get full credit.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

2. TOUCH SCREENS & TOUCH-BASED INTERACTION

Question 2-1 (max. 6 credits)
(a) As the name "Opti" suggests, the following keyboard design is optimized for a certain kind of input. What kind of input is that and what does this design optimize?

ANSWER:

(b) Give two advantages and two disadvantages of the illustrated "split keyboard" design.

ANSWER:

(Note: No explanation required. Two short phrases for (a) and four for (b) could be sufficient to get full credit.)

Question 2-2 (max. 4 credits) The following interaction design is from a paper by researchers from the University of Calgary. Instead of just measuring one point of contact (as usually done in touch interaction), they calculate the size of the whole area covered by the thumb (i.e., the contact size). Different contact sizes are than mapped to different kinds of actions. For example, a larger contact size evokes zooming in a map application, as illustrated here:

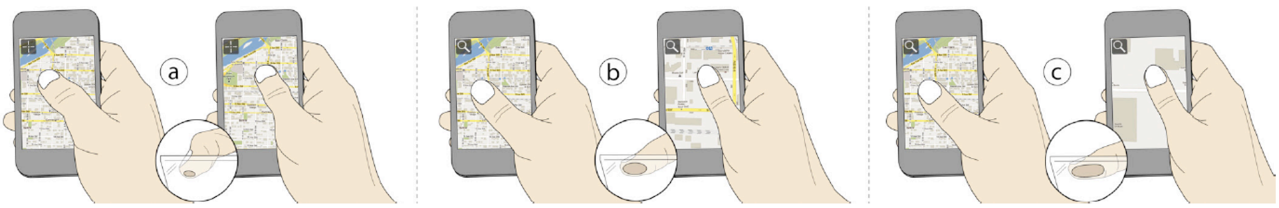


Figure 2. Walkthrough of pan and zoom example: movement with small contact size pans the map (a), increasing contact size switches to zoom (b), and further increasing the contact causes faster zoom operation (c).

What is a major advantage of this "contact size approach" for zooming in a map application compared to multi-touch?

ANSWER:

(Note: a short phrase could be sufficient to get full credits. In the paper, they used one major advantage as motivation for their design, but if you can come up with other reasons, you could get full or partial credit as well.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

Question 2-3 (max. 4 credits)
(a) In the lecture, we saw a haptic touch screen technology developed by Disney Research where voltage is used to create surface variations that simulate rich 3D geometric features (such as bumps, ridges, edges, protrusions, texture etc.). Give a convincing example where this technology could be applied in a useful, beneficial way.

ANSWER:

(Note: a rather short illustration could be sufficient to get full credits.)

(b) In the lectures, we mentioned a lack of tactile feedback as a problem of touch screens in many situations. The above technology addresses one of them, but not all. Give an example of one situation where the lacking tactile feedback cannot be resolved by the above technology.

ANSWER:

(Note: a rather short illustration could be sufficient to get full credits.)

Question 2-4 (max. 3 credits) – Mandatory literature (paper 1) In the paper "The Performance of Touch Screen Soft Buttons", S. Lee and S. Zhai present a comparative study between hard buttons and soft buttons on touch screens with various settings, such as stylus and finger operation, or audio and vibrato-tactile feedback. Although their study concluded in clear results suggesting related optimum interface designs, it is not clear if they hold in a real-life implementation. Shortly explain why.

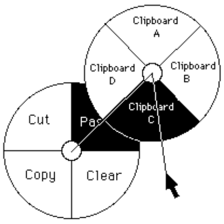
ANSWER:

(Hint: there is one major drawback in their approach that is discussed in the conclusion and that was also mentioned in the lecture. If you remember what it is, a short sentence or phrase could be enough to get full credit. Of course there might be other issues that could give you credit as well if described convincingly.)

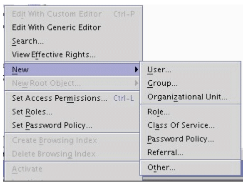
IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

3. DEVICE MOTION & RELATED INTERACTION

Question 3-1 (max. 4 credits) Pie menus are an alternative to common list-style menus (cf. images below). They are often used for pen-based computing. In one of the first papers on mobile interaction via tilting it was shown that they are suitable for this kind of interaction as well (Jun Rekimoto, Tilting operations for small screen interfaces, 1996).
Give one advantage that they might have for a tilt-based interaction compared to using a traditional list-style menu.



Pie menus



List menus

ANSWER:

(Note: a short phrase or sentence could be sufficient to get full credits.)

Question 3-2 (max. 3 credits) Assume you want to implement a 3D game on a mobile device (phone or tablet). Your game will feature a character moving and looking around in a first person view. There are different kinds of interaction modes to realize this, for example:

- Physical controller buttons (if they are available on the device)
- On-screen implementations of controller buttons (if the device has a touch screen)
- Tilting motions of the device (if it contains the necessary sensors, such as accelerometers)

(a) Give one advantage that physical controller buttons could have compared to a similar on-screen implementation.

ANSWER:

(b) Give one advantage that an on-screen controller implementation could have compared to tilting motions.

ANSWER:

(c) Give one advantage that tilting motions could have compared to physical controller buttons.

ANSWER:

(Note: a short phrase or sentence for each of them could be sufficient to get full credits.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

Question 3-3 (max. 2 credits) In the paper "Navigating on hand held displays: Dynamic versus Static Peephole Navigation" that you read in the first part of this course, Mehra et al. provide clear evidence that "dynamic keyhole navigation" yields a more accurate assessment of geometric features than "static keyhole navigation". This suggests that it might be a better interaction mode for map navigation apps. Yet, when applied to such a real life scenario, there are additional issues that we have to consider. Mention two of them that are not covered by the evaluation in the paper and that might cause problems in a real world scenario.

ANSWER:

(Note: a short phrase or sentence for each of them could be sufficient to get full credits.)

Question 3-4 (max. 7 credits) – Mandatory literature (paper 2) In their paper "Sensing-Based Interaction for Information Navigation on Handheld Displays," Rohs and Essl implemented and evaluated different approaches for navigation on small displays using different sensor technologies.

(a) One of the implemented approaches is the *halo* technique. Shortly describe this approach. Do not just explain it, but also shortly mention why it might be a good approach to visualize targets that are off screen.

ANSWER:

(Note: About 3 sentences could be sufficient to get full credits.)

(b) Different sensor technologies that they evaluated included: accelerometer, magnetometer, grid tracking with extended range, and optical movement detection. For each of these four, list one potential disadvantage.

Accelerometer:

(Notice that this question continues on the next page!)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

(Question 3-4, continued)

Magnetometer:

Grid tracking with extended range:

Optical movement detection:

(Note: A short phrase for each could be sufficient to get full credits. Notice that they listed potential disadvantages when introducing these technologies in section 2, but you don't have to list the same ones here. If you know other, correct ones – e.g., some that we discussed in the lecture – you can of course use them as well.)

4. MOTION TRACKING & RELATED INTERACTION

Question 4-1 (max. 3 credits) In the lecture, we discussed different potential advantages that interaction using finger tracking via the phone's camera could have. Yet, we also saw that each of these advantages have negative effects or impose other possible challenges. For each of the following advantages that we discussed, write a short statement or example that illustrates a related potential disadvantage or a related negative issue that might arise.

Advantage: No need to touch (e.g. while eating or driving)

Potential disadvantage or resulting challenge:

Advantage: No hiding of content with finger

Potential disadvantage or resulting challenge:

Advantage: Hand can move in 3D

Potential disadvantage or resulting challenge:

(Note: in each case, a short phrase could be sufficient to get full credits.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

Question 4-2 (max. 9 credits) – Mandatory literature (papers 3 and 4)

(a) In their paper "Gestural Interfaces: A Step Backward In Usability", Norman and Nielson present seven fundamental principles of interaction design that are independent of technology. Two of them are *visibility* and *feedback*. List four of the other ones.

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

(Note: no explanation needed. The related word or phrase could be enough to get full credits.)

(b) In their paper, Norman and Nielson critically discuss gestural interfaces for tablets and smartphones by bringing examples from today's mobile interaction designs that violate the principles mentioned above. Bring one example from "Kinect-style" gestural interfaces (i.e., interfaces that are operated by tracking the motions of a user's body or parts thereof such as hands and arms) where the two principles *visibility* and *feedback* are violated or implemented in a way that can easily lead to critical situations or unpleasant interaction experiences.

(a) Visibility:

(b) Feedback:

(Note: no detailed description needed as long as it is clear what you mean.
Some convincing short notes or phrases could be enough to get full credit.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

5. MOBILE AUGMENTED REALITY (AR)

Question 5-1 (max. 5 credits)

(a) What are the three characteristics that define an AR system according to Azuma's paper from 1997?

1. ______________________________

2. ______________________________

3. ______________________________

(Note: this question refers to the formal definition of augmented reality (AR) given in this paper. The respective phrases are sufficient to get full credit. No detailed explanation is needed.)

(b) When it comes to concrete systems, we often distinguish between immersive and non-immersive AR. Give an example for a technology that can be used to create systems belonging to each of these two categories.

One technology that enables us to create immersive AR systems is:	One technology that enables us to create non-immersive AR systems is:
______________________	______________________

(Note: just listing the technology or device is sufficient. No explanation is required.)

Question 5-2 (max. 6 credits)

(a) Shortly describe the idea of tangible user interfaces.

ANSWER:

(Note: no detailed explanation or formal definition is required. A short phrase summarizing the major characteristic of this concept and the idea behind it could be enough to get full credits.)

(b) Assume we implemented an augmented reality system on a smartphone, and we want to use a tangible interface for interacting with it. Give one advantage and one disadvantage that such an interaction could have in this context.

Potential advantage:

Potential disadvantage:

(Note: a short informal description could be enough to get full credits.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

Question 5-3 (max. 7 credits) The image to the right shows the Layar mobile augmented reality browser, where virtual information is superimposed onto a life image of the real world in dependence of the user's current location, the direction where the device is pointing, and it's orientation.

(a) What sensors are used to create such a system? In particular, what sensor is used to get:

1. The life image of the real world?
2. The user's current location?
3. The direction where the device is pointing?
4. The device's orientation?

(Note: no explanation required. Writing down the sensor's name is sufficient to get full credit.)

(b) Discuss this system with respect to the formal definition of AR systems by Azuma (cf. question 5-1 above). In particular, for each of the three criteria that you listed above, shortly illustrate if it fulfills them or not (and why).

1st criteria:

2nd criteria:

3rd criteria:

(Note: one sentence or phrase per criteria could be sufficient to get full credits.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

6. MOBILE VIRTUAL REALITY (VR)

Question 6-1 (max. 2 credits) What are the two most important characteristics of virtual reality (VR)?

1. ______________________________

2. ______________________________

(Note: this question refers to the informal description from Wikipedia discussed in the lecture. The respective phrases are sufficient to get full credit. No detailed explanation is needed. Other phrasings or descriptions – if correct – might get partial or full credit as well.)

Question 6-2 (max. 8 credits) Fish Tank VR and Shoebox VR are two advanced approaches to realize VR on handheld devices. While they can both create the same images, they are implemented differently, which in turn results in different characteristics.

(a) Complete the following sentences:

1. For Fish Tank VR, the device's ______________________________

   is used to track ______________________________.

2. For Shoebox VR, the device's ______________________________

   is used to track ______________________________.

(Note: giving the name of the sensors and what they track in this context is sufficient to get full credit.)

(b) Both approaches only work if certain conditions are fulfilled.
Give one example for each of them where it will fail, i.e., not result in a realistically rendered image.

1. Fish Tank VR doesn't work correctly, if

   ______________________________.

2. Shoebox VR doesn't work correctly, if

   ______________________________.

(Note: no explanation required, but a short statement is sufficient to get full credit.)

(c) Both approaches have potential advantages but also potential issues with respect to usability.
Give one potential usability problem for each of them.

1. Potential usability issue for Fish Tank VR:

   ______________________________.

2. Potential usability issue for Shoebox VR:

   ______________________________.

(Note: no explanation required, but a short statement is sufficient to get full credit.)

IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

Question 6-3 (max. 6 credits) The following issues can all provide cues that help people experience and perceive depth in a 3D image created with computer graphics:

Pictorial depth cues:
- Occlusion
- Linear perspective
- Size gradient
- Relative height
- Texture gradient
- Relative brightness
- Areal perspective
- Depth-of-focus
- Shadows
- Shading

Oculomotor cues:
- Accomodation
- Convergence

Binocular depth cues:
- Binocular disparity

Motion related cues:
- Motion parallax
- Kinetic depth

In general, we can assume that applying Fish Tank VR or Shoebox VR visualizations to a standard 3D graphic on a mobile phone increases the perception of 3D because they have a positive impact on some of the depth cues listed above.

(a) Give two depth cues that might improve and thus result in a better 3D perception when Shoebox VR is used, and shortly explain why.

1.

2.

(b) Give one depth cue from the list above that is *not* influenced by Shoebox VR visualization and shortly describe why.

(Note: no detailed explanation is needed. In all three cases, a small sentence shortly describing the reason could be sufficient to get full credit.)

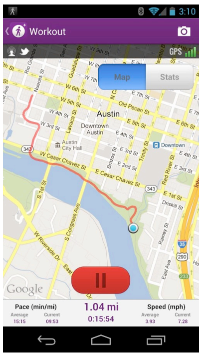
IF YOU NEED MORE SPACE TO ANSWER THE QUESTIONS, MAKE A MARK AND CONTINUE WRITING ON THE BACK OF THE PREVIOUS PAGE.

7. COMPARING DIFFERENT CONCEPTS (2D VERSUS VR VERSUS AR)

Question 7 (max. 9 credits) Assume you want to design an app for a smartphone that provides a navigation aid for pedestrians and you are considering three different options:

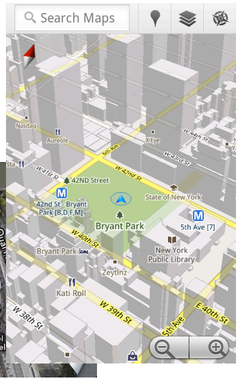
1. A map-based version, where the directions are illustrated, for example, by a track on a traditional, flat 2D map.
2. A pure 3D version, where the directions are illustrated, for example, by a track in a 3D rendering of the environment including buildings, elevations, etc.
3. An AR version, where the directions are illustrated, for example, by arrows superimposed on the life video feed from the device's camera.

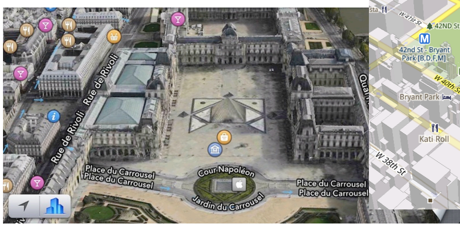
The following images illustrate these three cases (although they should not be seen as strict implementation of them, as there are various ways to actually visualize such a setup).

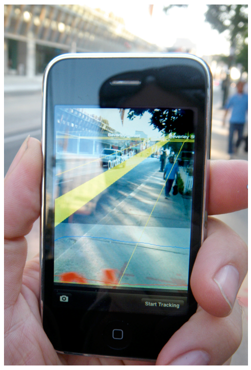


2D MAP

3D MAP, EITHER SYMBOLIC (RIGHT) OR FULLY RENDERED (BOTTOM)







AR APP

For each of the three cases, give one possible advantage that it might have compared to the other ones.

1. A map could be better because …

2. A 3D version could be better because …

3. An AR version could be better because …

(Note: this is an open question, verifying if you can apply what you have learned to a related concrete scenario. Referring to some characteristic that was discussed in the first part of the course is ok and welcome, but please mark it accordingly.)