17-645 Midterm, Fall 2019

Christian Kaestner and Eunsuk Kang

Name: _____

Andrew ID: _____

Instructions:

- Not including this cover sheet, your exam should have **6** pages. Make sure you're not missing any pages. **Write your Andrew ID on every page.**
- All questions in this midterm refer to the scenario on the first page.
- The exam has a maximum score of **51** points. The point value of each problem is indicated. We allocated approximately one point per minute.
- Clearly indicate and write your answers in the space provided for each problem. We cannot give you points for answers we cannot find or read. Write concise, careful answers; short and specific is much better than long, vague, or rambling.
- We give an amount of space commensurate with what we expect you to need for each question. If you need more space, use this cover sheet, the scenario page, or other pages and make it obvious in your first answer where to find the rest of the answer. **Do NOT write answers on the back side of pages.**
- You may not use calculators, cell phones, laptops, or any other electronic or wireless devices, nor consult with your friends or colleagues. **You may consult handwritten or printed notes and books**.
- Good luck!

Scenario

You work as a software engineer in a small startup in the hot market of smart home-exercise equipment. There are many competitors, but the startup distinguishes itself by focusing on detailed feedback to the athletes (primarily strength, endurance, and mobility training) and personalized feedback on exercise form that even a private coach might miss. The product comes as a smart phone app to be connected to a TV or speaker to show or speak instructions, three external cameras to record the exercise from three angles, a pulse sensor, and bracelets with gyro sensors for arms and legs to measure movement and impact. For example, when lifting weights, performing push ups, or holding a stretch, the system will give feedback on form (e.g., arm placement, back curvature) and suggest the number of repetitions and hold durations that best work for the athlete's goals.
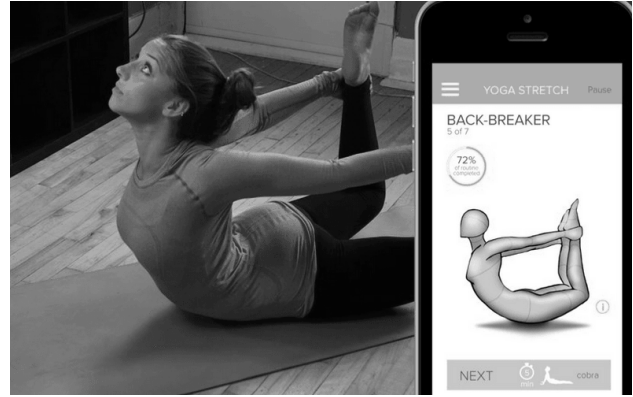
The plan is to sell the hardware nearly at cost (about $250 for the cameras and sensors), reusing the customer's existing smart phones and TVs and then earn money primarily from a subscription service for the actual functionality.

The startup has a relatively small team. The founder has a PhD in robotics and has conducted prior machine-learning research to accurate tracking of body positions without the explicit markers of past motion capture techniques, which is the foundation of the product. The startup has hired two more data analysts that work on model building and refinement, who work closely with experienced trainers and athletes. You are part of the software team that is responsible for the app (iPhone only right now) and the cloud backend and operations. You team has 4 developers that are smart, but relatively inexperienced having just recently graduated. You also have two additional interns on your team.

There is quite some buzz on social media about the product since the startup has managed to secure several well known athletes as beta testers and spokespeople. Unfortunately, the product is not available for sale yet, only about 100 prototypes are used by test users. You are hoping to get to the market soon.

The product's recommendation are very precise, but they tend to encourage athletes to train at the very limits of their ability. While fortunately no accidents have happened yet, there were a few close calls. You are thinking about a feature that will automatically initiates a cell phone call to emergency responders with a prerecorded messages when the system detects an accident or medical condition. You make this feature your personal project and plan a prototype.

1

Question: Architecture [14 points]

In the current system all computations are performed on a smartphone that is connected to the sensors over bluetooth. Unfortunately, the phones computational resources vary from model to model and especially memory seems to be problematic on many devices. You decide that you will either have to sell the product with an extra hardware module for the computation (adding roughly $200 to the original $250 hardware cost of the product) or move all serious computations from the phone to the cloud.

[4 points] Identify two qualities for which buying extra hardware is better and justify why it is better. Make sure the answer and justification is grounded in the scenario.

[4 points] Identify two qualities for which moving to the cloud is better and justify why it is better. Make sure the answer and justification is grounded in the scenario.

[6 points] You feel you do not have enough information to make an informed decision. What additional data would you collect to inform the decision (be precise about the measurement) and explain how the measured data would influence your decision one or the other way. Make sure the answer and justification is grounded in the scenario.

Question: Version Control [7 points]

[4 points] While you try to convince *everybody* in the company to use *git* for version control, the founder argues that all the overhead of using *git* is annoying and useless: Why not just use Dropbox (or similar cloud storage service with automatic syncing), that also creates an off-site backup and allows you to go back to older versions of each file. In the context of this scenario, how would you justify the use of version control?

[3points] What limitations of using Git can you anticipate in the project of this scenario?

Question: Test Coverage [4p]

Your intern is proud to have achieved 100% statement coverage for the code they wrote to assure data quality from the cameras. Does this mean the code is correct? Why or why not?

Question: Model Quality [10 points]

[4 points] You are worried about false positives from the model in your emergency response feature and consequences of these false positives. How can you integrate the model predictions in a user experience such that false positives are acceptable or can be mitigated? Make sure the answer is grounded in the scenario.

[6 points] You plan to design telemetry to be able to measure the model quality for the emergency responder feature *in production*. In the context of the scenario, suggest a realistic way to assess model quality:

- Describe what data you would gather:

- Describe how you would determine model quality with that data (give a specific measure):

Question: Requirements and Risks [16 points]

Consider the following potential requirement for the emergency response feature:

> *Emergency responders must be contacted immediately when the user of the product has a seizure.*[1]

[2 points] What are environmental entities and software components in this system?

[4 points] What are environmental assumptions and software specifications that are necessary to establish the above requirement?

---

[1] Note: A *seizure* is a sudden, uncontrolled electrical disturbance in the brain that might cause dangerous effects on the user's body, including loss of consciousness or awareness, and is typically externally recognizable by uncontrolled shaking of the entire body or parts of the body.

[6 points] The following diagram shows an incomplete fault tree that is intended to show how the system may fail to satisfy the above requirement. Complete the fault tree to identify potential root causes for the failure. Your tree must be detailed enough to capture basic events that are predicated over properties of an AI component (accuracy, inference time, etc.).
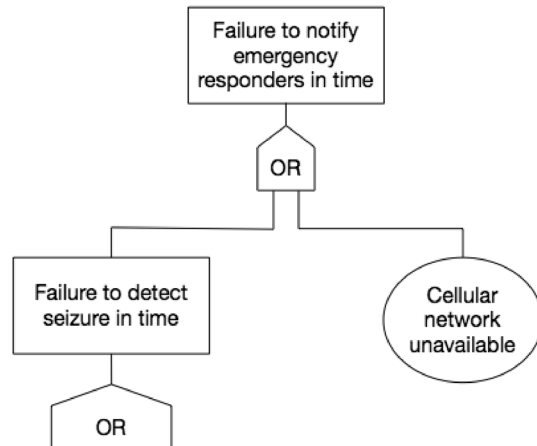
[4 points] Suggest a design recommendation to reduce the risk of the failure that the system fails to detect a seizure in time.