Exercise 6: Human factors of automated driving

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Introduction

In this assignment you will apply your knowledge on human factors to analyze data collected in a simulator study [1]. The aim of the assignment is to (1) get acquainted with video reduction to retrieve human factors measures; (2) investigate the driver's response process to a critical situation when driving an automated car; (3) assess the effectiveness of an auditory warning to re-engage the driver in the driving task.

Note: In this assignment, you will be watching videos recorded during the experiment. The participants gave permission to use the videos for educational purposes. **It is forbidden to share the data outside the class.**

Note: MATLAB Grader will not be used for this exercise. Be sure to document your answers in the MATLAB script.

Note: You are encouraged to discuss your solutions with others but you must write and submit your own code implementation and answers.

Deadline: October 31, 2021 (23:59)

Learning objectives

After having performed this assignment, you shall be able to:

- Annotate video clips with the purpose of studying human factors
- Distinguish and interpret the driver's response process
- Understand the role of human factors in the design and evaluation of automated driving

Preparations

1. Download the material from Canvas. The folder `src` includes a toolkit for annotating the videos (`Exercise_video_annotations.m`), and a MATLAB script for analyzing the data (`Exercise_data_analysis.m`). The latter needs to be completed to solve the exercise.

Tasks

The assignment consists of two parts. In the first part you will annotate some videos (data reduction). Data reduction is the process of manually viewing video to derive additional measures that cannot be collected from the CAN bus of the vehicle (e.g., hands and feet movements). This process is routinely done in naturalistic studies (remember the annotations done for the 100-car study) but suffers from subjectivity. Sometimes, it is not clear how to annotate a particular frame. If this happens, discuss with your colleagues to come to an agreement. The second part requires to complete a script to analyze the data from the simulator and from your annotations to investigate the drivers' response process.

Part A - Video annotation

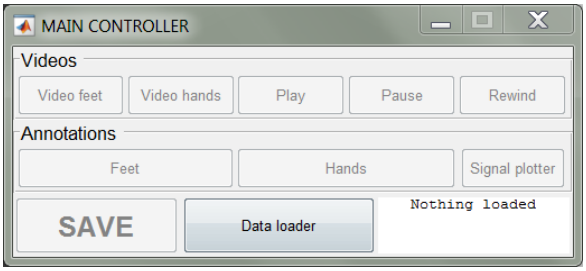
1. Open and run the script `src/Exercise_video_annotation.m`. The script starts the tool to annotate the videos. Please, do not change the code of this toolkit.
2. When the toolkit starts, the interface shown in Figure 1a.
3. Click on Data loader. A new window appears where you can select the data of the participant you want to analyze (Figure 1b). Select one of the participants (e.g., Participant ID 2) and click Load
4. Once the data are loaded, the buttons in the main interface activate (Figure 2a).
5. Click on the dedicated button for the video you want to watch and the annotation you want to perform. For example, click on Video feet under the *Videos* section, and Feet under the *Annotations* one. New windows will open (Figure 2b).
6. Now you can annotate the video frame-by-frame. Use the right/left key to move through the frames. When you want to annotate a frame (or consecutive frames) click on the right button in the annotation window (e.g., Rest). All the previous (consecutive) frames that were *not* annotated will be labelled as the category you just selected. To overwrite an annotation, move to the frame you want to change and click a new category. If you click on the button Not coded, the annotation of the previous (consecutive) frames will be erased.
7. The annotations should be done according to the coding scheme in Table 1. Note: **A movement includes the transition towards the target position, and the dwell time on that target position**.
8. Finish to annotate both videos (feet and hands) for both participants (ID: 2, 3). **Remember to save** when you have finished annotating each video.
9. Once you are finished with all the annotations, close the toolkit and move to part 2.

Part B - Data analysis

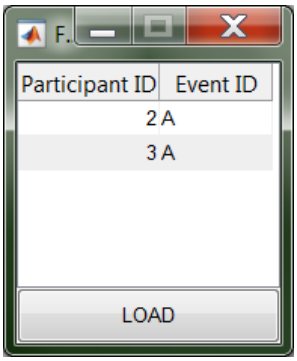
1. Open the script `src/Exercise_data_analysis.m`. The script is for analyzing the data (collected during the experiment and from the video annotations). The data is contained in the structure data.
2. The script needs to be completed. Complete the code below `=== YOUR CODE HERE ===`. The script contains the boilerplate and the guidelines to solve the exercise. Read the comments in the code carefully.
3. You are also required to answer some questions. Write your answer in the script as a comment. If you need to watch again the videos, you can use the toolkit `Exercise_video_annotation.m`, or you can open the videos in `data/data_participants/`.

Submission

Submit your solutions (the whole `Material` folder, including the folders `data`, `jsonlab` and `src`, compressed in .zip format) in the assignment in Canvas. It is sufficient if at least one group member submits your solution in Canvas. See deadline above. For this exercise, the deadline is set to the end of the course, not exactly after two weeks as for the previous exercises. See that you submit well ahead of the deadline, to leave the possibility for a (potentially necessary) re-submission.

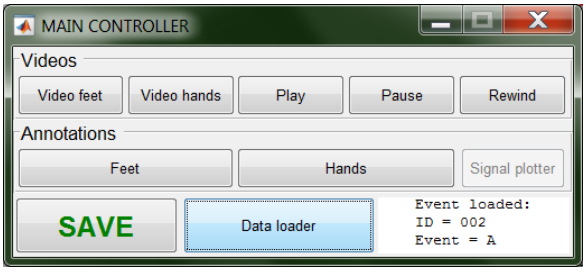


(a) The main interface of the toolkit for annotating the videos.

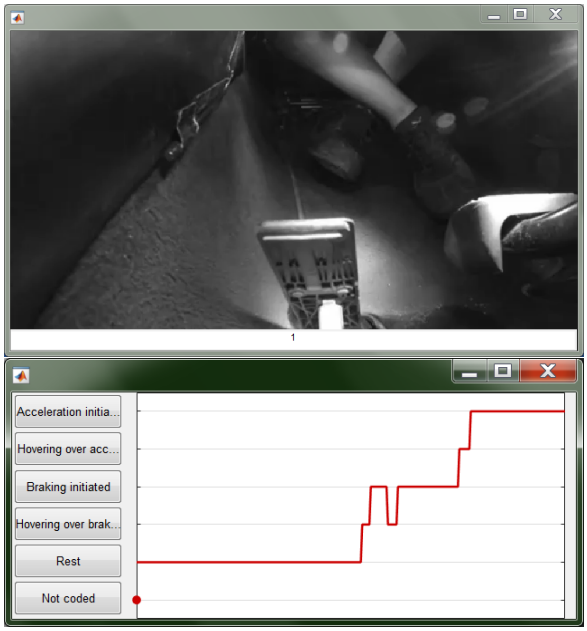


(b) The interface to load the participants' data.

Figure 1: First two steps to load participant data.



(a) The main interface for annotating the videos. When the data are loaded, the buttons activate. In the bottom right corner you can see details of the data loaded.



(b) Windows for displaying the video (top), and for displaying the annotation (bottom).

Figure 2: Next two steps to start the annotation procedure.

Table 1: Data Coding Scheme. A movement includes the transition, which leads towards the target position from the initial position, and the dwell time on that target position.

Feet movements	
Not coded	-
Unknown/Other	Frame where the movement cannot be accurately evaluated, or it cannot be coded according to this coding scheme.
Rest	Frame where both feet are resting, e.g., on the floor.
Hovering over brake pedal	Frame where the foot hovers over the brake pedal. The frame before the braking is initiated should belong to this category.
Braking	Frame where the braking starts, i.e., when there is a noticeable movement of the brake pedal until the braking maneuver ends.
Hovering over accelerator pedal	Frame where the foot starts hovers over the accelerator pedal. The frame before the acceleration is initiated should belong to this category.
Accelerating	Frame where the acceleration starts, i.e., when there is a noticeable movement of the accelerator pedal until the accelerating maneuver ends.
Hands movements	
Not coded	-
Unknown/Other	Frame where the movement cannot be accurately evaluated, or it cannot be coded according to this coding scheme.
Hands off wheel	Frame where both hands are not touching the steering wheel, because they are resting (e.g., on the lap) or they are performing other non-driving related tasks
Hands on wheel	Frame where at least one hand touches or grabs the steering wheel.

References

[1] Alberto Morando et al. “Users’ Response to Critical Situations in Automated Driving: Rear-Ends, Sideswipes, and False Warnings”. In: *IEEE Transactions on Intelligent Transportation Systems* 22.5 (2021), pp. 2809–2822. DOI: 10.1109/TITS.2020.2975429.