16.400 Human Factors Engineering

Massachusetts Institute of Technology
6th September 2001

Driving Simulator Lab

1 Introduction

The use of MIT's newly acquired driving simulator will allow you to experiment with factors in human engineering. As groups of engineers in the *HFEMIT Car Team* you will look at one aspect of the Human Factors involved in the design and implementation of an early warning system (EWS) for automobiles. The challenge is learning how to study human factors.

1.1 Problem Statement

With the advance of technology, the investigation of Early Warning Systems in cars has become a *hot* topic with car companies around the world. Some automobile manufacturers are investigating the implementation of these devices. One of the key factors in this and any other warning device is to ensure that the Human Factors considerations are dealt with, in as complete a manner possible.

The simulator allows you to investigate some of these Human Factors concerns, and come to conclusions about certain aspects of early warning systems. As a group, you will have the job of picking a Human Factor to study for an early warning system, so that the effectiveness/applicability of these systems can be investigated.

The study will be conducted in a “mock working environment.” You will have the opportunity to discuss your ideas with a Group Manager (either Dr. Young or Dr. Yeh) if you want to ensure that the company would benefit from your study. This is a very real concern in car companies today, some of your ideas may well help you in the future!!

1.2 Details of the Lab

The following details are pertinent to the lab:

- We will divide the class into 6 teams. (That means each team will have 8-10 members.)
- Each group will be allowed 3 or 4 road sections of 1750-2000ft each (if you are designing 4 sections try to keep the sections below 2000ft), on which to design their scenarios.
- The groups will have to setup the scenarios according to what they wish to study, as well as reduce the data into a meaningful form.
- Everyone will have a chance to drive the simulator
- A group technical report will be handed in summarizing each group’s conclusion.

2 Conception of the Research Task

This phase allows the various groups to determine what they would like to study with the simulator. We suggest keeping your study reasonably simple, since it will still be a large task to reduce all of the data at the end of the lab. We would encourage you as a group to come up with your own Human Factors to study. Several areas which you can pursue, or use as a basis for your ideas are listed below:

(**If you have other ideas please pursue them**, but quickly pass them by Dr.Young or Dr. Yeh—If you want an opinion on your study ideas, let them know what your ideas are, and they will give appropriate feedback. This is the conceive phase!

- *Study of warning times/distances*—what is a desired warning time taking into account:
    - Environment
    - Road shape
    - Visibility
- *Study of warning methods* (mainly auditory)
    - Warning frequency
    - Warning type: Verbal vs. Alarm
    - Warning tones
    - Warning phrases
- *Reaction to warning*, when obstacle is present vs. when obstacle is not present at time of warning
- *Warning effectiveness*
- *Warning command vs. "common sense"*...i.e. a "swerve" command when there is an oncoming car—will the operator swerve, or stop? How dependant does the human become on the warning system?

Here you will decide what you want to study, and investigate whether it is feasible for the amount of time allotted, and for the equipment being used. *If you are careful in this phase, you can save a lot of pain, and hardship later. This essentially determines the rest of the lab for you.*

3 Design Phase

During the design phase you will design a set of 3-4 tracks per group. These tracks should reflect what you wish to study, so here you will be designing to your own specifications.

It is suggested that you draw out the sections of the road with the various details, such as oncoming cars, and areas where you will record data, before trying to program PDE files. You will then be able to quickly *implement* the code into the simulator for operation.

3.1 How do I link what I want to study to the road section?

This is essentially what your design problem is. There are many solutions to this question, so find one and evaluate your results after you have done your test. The use of the STI driving simulator will be the main means. For an introduction to the simulator, see (http://web.mit.edu/16.400/www/auto_sim/Help/Introduction.htm)

3.2 What can the simulator do?

With the simulator you can:

- Vary the shape, and size of the track (1-lane, 2-lane, etc., hills, turns, intersections, etc). Note that some of these functions are a little harder to program than others—sample files of the basic features have been provided.

- Vary the traffic conditions (cars ahead, behind, on-coming cars, cross-traffic, pedestrians etc).

- Put in traffic lights, "cop stops", obstacles on the road etc—we will try to have everyone drive at 45-55 mph.

- Vary the environment (put in buildings, put in trees, etc. on the side of the road)

- Change the auditory sounds for warnings (they are just .WAV files, so you can make your ***own*** warnings and evaluate the results).

- Record data in specified sections of the road, or at specified times in your file (you will all want to record data—but you won't want data for every part of the scenario—you just want it for the important parts of the section!).

This is just a short list of what the simulator is capable of. If you follow the following link you will find some of the commands that will be available to you when you design your road section (http://web.mit.edu/16.400/www/auto_sim/Help/SDL.htm).

3.3 Some helpful suggestions for your road sections

You should define 3-4 different conditions that can be compared and that allow you to test the hypothesis you want to study. For instance—if you are interested in the difference in the response to a male or a female voice giving a warning you may create three sections of road with an obstacle that are identical except for the warning: (a) no warning prior to the appearance of the obstacle, (b) a male voice giving a warning, and (c) a female voice giving a warning. Another possible research design would study two independent variables, such as warning content (for instance "slow" vs. "break") and the warning voice (male or female). Here you would create the four combinations of content and voice and study the effect of the independent variables on the responses to warnings.

Note that in order to compare the different conditions they must be identical in everything except the independent variables.

3.4 Some helpful suggestions on making your groups work well

Since the project is similar to what would be done in an engineering group, you are encouraged to adopt a similar structure as is used in the workforce.

- Your group manager will be Dr. Young and Dr. Yeh—they are who you work for—your bosses. They want results—you must give them to them. They will answer certain questions such as approving the direction of your research & design. They won't be there to answer software questions—they are too busy.

- You will have specialists available to you to answer your technical questions on PDE programming, and other fine details. Email tatsuki@mit.edu if you have difficulties (attach the PDE file if you want), and I will get the PDE file to the appropriate people to assist you. These specialists in real companies cost $$, so try to do the basic stuff yourself.

- As a group it is therefore suggested you break the work down into *equal* parts, and delegate. To do this a team leader may be necessary, to ensure that there is communication, and to ensure that everyone is participating, and getting their respective parts done. The team leader is not an enforcer. He/She is a person who ensures that the group stays on a track towards their goals.

Some other considerations:

- During the initial phases, have a couple of group members work on the track programming, while a couple of people work on devising ways to reduce and use the output (trust me—you will want a way to reduce the output, and you will want to start thinking about methods of doing this early!!). This way, when you get the output, you are a couple of steps ahead of the game. BUT to pull this off there must be COMMUNICATION between the track programmers and the data reducers!

- On a similar note...during the design testing phase, I only want to see at most 2-3 group members come to test the PDE files. This will reduce crowding in the lab, and may save time. The output will be given to you if you bring a disk with you (so you might want to do this to help the output side of things).

4 Implementing Your Design

Once you have a good idea of what you will be designing, you will need to implement your design, so that it can be run to get your data. This is essentially taking the designed road track and turning it into the code and running it on the simulator. The code is simple to program, and if any assistance is needed with certain things we can provide it. We have provided a base road model for you to work with as a base, all you have to do is add what you want to add!!!

The following file is provided on the web:

- Sample PDE file with command syntax guide (http://web.mit.edu/16.400/www/auto_sim/sample_roadway.pde)

There are more sample PDE files on the simulator to look at (in C:/STISIM/Projects directory). There are also PDE files from the last year's class (in C:\STISIM\16.400lab_fall2000 directory). You can use these as baseline models for your experiment if you wish to, and modify them to fit your variables.

4.1 What will the design be done on?

The design will be done in a simple code scheme that describes the road characteristics, as well as the scenery of the simulator surroundings. The help file for the simulator code language is on the web (http://web.mit.edu/16.400/www/auto_sim/Help/SDL.htm).

4.2 Some key points to remember when designing the PDE files of code:

- The section distance should begin at ZERO ft and end at 1500-2000ft. Both the beginning and end sections of the road must be as defined, to ensure continuity of the road in the program. Please make the first 50ft and last 50ft of your road section straight, flat, 2-lane road—so that the random MIT CHALLENGE track can have continuity (this extra 100ft do not count for the 2000ft limit).

- You have 3-4 sections, so make sure what you study makes sense to the sections you use (i.e. Create 1 section, and modify *only* the variables you wish to study in the others).

- You do not have to have the fanciest road section to do well. All you need to do is ensure that you get the results you want.

- Any moving cars on your test section must be out of sight of the vehicle, both when it enters, and when it exits the road section defined by the PDE.

- Remember you can record the data you want to in an output file...under multiple headers. So, to make your data sorting easier at the end, use descriptive headers—so that you can find the data quickly, and know what section(s) of the PDE it refers to. To use the provided MATLAB script to retrieve your data block, please make your headers one word (i.e. some_thing_like_this_with_under_score-or-hyphen-but_not_with_white_space).

- You can test your files at the times listed on the schedule on the web page—we prefer if one or two members of the group come to eliminate crowding (also remember people will get anxious to test near the deadline—so schedule appropriately). Use simulators for testing and verifying only. Bring your PDE file to work on. Please do not start from scratch on the simulators.

- Each group is provided a directory to put their files on the simulator (C:\STISIM\16400lab_fall_2001\Group#). If you design any new sounds or signs (or whatever), please put them in the provided directory.

- Please make sure no virus is on your floppy disk.

- *Any events (warnings etc.) or changes in driving conditions should be self-evident and should not require giving any specific instructions to the participant.*

4.3 How will the data be collected?

You will use BSAV and ESAV commands in your PDE files to start and stop saving data. The types of data you can save are documented in the online help pages. Sample output data file is posted on the class web page so that you can start working on how to retrieve and analyze data before you get your final data file.

The resulting data file will probably be about 1 Mbytes. To retrieve your data block, a simple MATLAB script program is provided. To use this program:

1. Download retrieve_data_block.m from the class web page, and save it in the same directory as your data file.

2. Launch MATLAB. On Athena machines, type 'matlab &'.

3. Move to the directory with your data file by typing, 'cd /path/to/your/data/directory'.

4. Call the script with the name of the data file, the title of the data block you want, and the name of the output file by typing 'retrieve_data_block('datafile.dat', 'data_block_title', 'output.txt')'.

If the data block with the specified title is found, it will be written to the output data file with the specified name. The output file is a text file, so you can use MATLAB, MS Excel, Xess, etc. to import this file for your analysis.

Feel free to modify the script, retrieve_data_block.m, and if you made useful upgrade, please share it with your colleagues by emailing it to tatsuki@mit.edu.

4.4 A general comment

We usually don't want the participants in an experiment to know what is studied in the experiment and what our hypotheses are (people are known to alter their behavior according to what they know about an experiment). Each group should therefore avoid discussing their research hypothesis and experimental design with people from other groups until after the experiment has been run. Imagine you are in a real car company, you do not want your test subjects knowing what you are testing.

5 Operation and Conclusions

Once your PDE files are submitted, I will randomly string your PDE files into two long roads—**the MIT Grand Prix Challenge 2001 A & B**—in support of human factors engineering. The Grand Prix A will be made of PDE files from groups 1, 2, and 3; while the Grand Prix B will be made of PDE files from groups 4, 5, and 6. There may be one or two extra PDE's for you to drive, just to add some fun to the experiment :).

Once the challenge is set up, each individual will drive the whole grand prix. The members of group 1, 2, and 3 will drive the Grand Prix B; while the members of groups 4, 5, and 6 will drive the Grand Prix A. This will give each group plenty of data to study!! The driving should take about 20 minutes per person depending on what kind of speeds you all drive at. Please sign up, and book a time to drive the simulator. If you can't make any of the times, please email tatsuki@mit.edu and we can make suitable arrangements.

If you feel uncomfortable driving the simulator, please email me at tatsuki@mit.edu , and we will make suitable arrangements.

6 Conclusion and Write Up

Once everybody has done the lab, the output files will be collected for each student (and once again randomized to protect your identity—each group will have the identifiers of their members so that they can exclude members data). The output will then be posted on the web so that everybody can access all of the data. Now your job will be to reduce the data into something useful, and hopefully answer the question you had in the conceive section. You may also use other groups' data if you feel that it is useful for your problem—but don't bank on it at the beginning, because there may not be any compatible data.

The conclusions should be drawn, and the overall experiment evaluated. A group report on the study should be compiled and handed in. This report should contain:

1. **Abstract** - a brief description of the study (~75-150 words)

2. **Introduction -** the rational for the study, some theoretical background (if you want), the practical rational for the study, the hypotheses.

3. **Method** - description of the devices used and of the specific experimental design. Ideally the method section should be written so that a reader who has not seen the experiment can still replicate it if she or he has the necessary equipment.

4. **Results** - description of the data analysis and the findings, relative to the hypotheses raised in the introduction.

5. **Discussion** - discussion of the results, their practical and theoretical implications, possible limitations of the study (Why didn't we get what we expected? Why can't we necessarily generalize the results to other conditions?), suggestions for future research.

6. **List of references**

7. **Appendices -** the print out of the PDEs, routines/programs/spreadsheets written to analyze the results, some intermediate results of the computations, etc.

7 Schedule

September 10, Monday: Group list posted

September 12, Wednesday: Simulator Quick Tour (E40-292)

September 13-18:	PDE Coding/Testing/Verifying. Sign up for simulator time by 6pm of the previous day. If you sign up after that time or would like to sign up for time slots outside of 16.400 slots, please let me know by email. Sign up sheets are posted outside of E40-292 & 287.
September 18, Tuesday:	PDE Files Due
September 19-21 (22,23):	Everyone Drives the Grand Prix
September 24-27:	Analysis
September 27, Thursday:	Report Due

I would like to take this chance to thank Dr. Meyer & Dr Maltz, for his help in the development and implementation of this lab; Dave Willis who TA'ed this class last year and developed much of this document.

Please, Please, Please.....comment on this lab, and any other lab in this course. Let us know if you liked it :), hated it :(, too long :(, too short :|, or just right :) or whatever (if you fell asleep during it... and crashed the simulator car.). We are trying to do our best to help you gain what you can from the course....so unless you let us know.....we won't learn. I can't read minds YET :). Email me tatsuki@mit.edu if you have any suggestions /criticisms/ improvements or you plain liked the lab :) --It won't affect your final mark in any way!!