

LOW COST PC SIMULATION TECHNOLOGY APPLIED TO NOVICE DRIVER TRAINING

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Summary: This paper describes a low-cost driving simulator designed to test the feasibility of training novice drivers. The simulator, based on personal computer technology, was fully interactive with steering, throttle and brake controls. Training and testing scenarios were defined procedurally using a scenario definition language (SDL) that required drivers to maintain safe speeds, negotiate curves and right angle turns, obey traffic control devices (markings, signs and signals) and interact with traffic and pedestrians that were controlled to represent cognitively challenging hazards. The SDL also allowed the event sequences in the scenarios to be conveniently rearranged from run to run to avoid drivers anticipating the occurrence of critical events. A pilot experiment was conducted to compare the simulation performance of a group of novice (unlicensed) drivers with a group of experienced drivers (more than ten years of driving) during two sessions. Performance measures included accidents and speed limit exceedances. Statistically reliable differences in performance were found between the novice and experienced drivers. These encouraging pilot study results suggest that low cost simulation may offer a way to teach novice drivers how to cope with cognitively complex driving hazards.

INTRODUCTION

The objective of this pilot project was to investigate the feasibility of training novice drivers to deal with cognitively complex traffic hazards using low cost simulator technology. Novice drivers, particularly males, have significantly elevated accident rates compared to experienced drivers (Williams, Preusser, et al., 1987). What training/experience can be administered to this novice-driving group that will ameliorate subsequent driving problems? Simulation technology can potentially provide experience over a significant portion of the driving task, involving behaviors including sensory-perceptual, psychomotor, cognitive, and time-sharing/divided attention skills. Driver simulation training environments can potentially be provided by relatively low cost PC (personal computer) technology, e.g. (Allen, Rosenthal, et al., 1999). Over the last few years the cost of PC technology has continued to drop while the capability has increased. This trend will probably continue over the next few years. PC technology can provide adequate cueing feedback for several sensory dimensions important to driving (i.e. visual, aural, proprioceptive) while motion cueing is probably not feasible for low cost devices.

A training simulator for young drivers must be capable of instructing a variety of skills and attitudes associated with driving. It is our hypothesis that a simulator with good fidelity cueing can train the basic psychomotor aspects of driving (steering and speed control) in simple and complex roadway and traffic conditions. More importantly, we hypothesize that a simulator with good scenario control can teach the range of cognitive skills required to deal with complex

roadway and traffic conditions including appropriate situation awareness, hazard perception, decision making under time pressure and general defensive driving techniques. Accident data typically show that driver accident record improves over the first few years of driving (e.g., Aizenberg, and McKenzie, 1997). This may be due to drivers learning and gaining experience in dealing with complex and critical hazard situations that do not occur with current training methods. A simulator can safely provide repeated exposure to complex hazard situations, and give drivers experience in the perception and decision making required to deal with them effectively.

METHODS

The simulator setup for this feasibility study was a desktop configuration as described elsewhere (Allen, Rosenthal, et al., 1999) and was based on an ordinary PC with a Pentium II 450 MHz processor. The visual display was presented on a 19-inch monitor and represented a 45-degree field of view including a rear view mirror inset in the upper right hand corner. A graphics accelerator card and software by Quantum 3D were used to generate textured scenes at a pixel resolution of 1024 x 768 and updated on the order of 20-30 Hz depending on the complexity of any given scene. Engine and crash sounds were produced using a high fidelity PC sound card, amplifier and speakers. The desktop steering unit included a torque motor to produce torque feedback to the driver based on commands from the simulator's simplified vehicle dynamics. A floor-mounted box contained throttle and brake pedals with simple spring constraints.

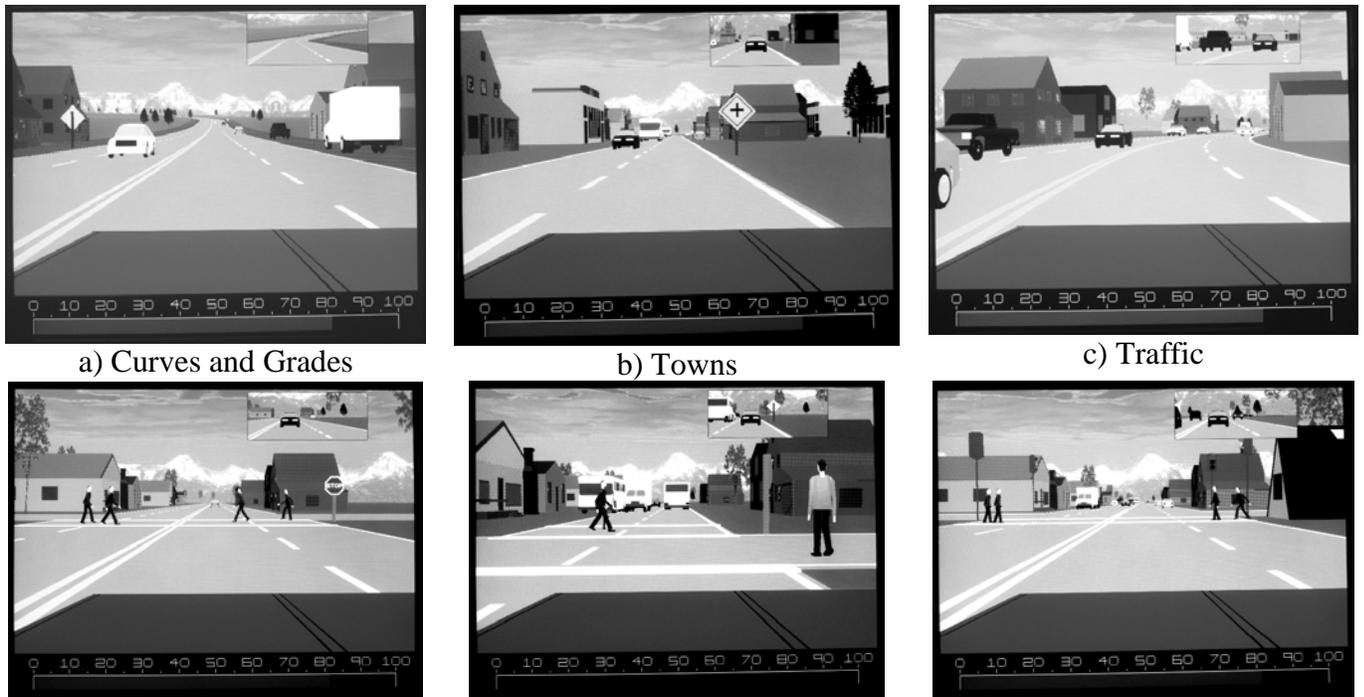
To overcome the narrow field of view limitation of the visual display, two buttons were provided on the steering wheel, which allowed the field of view to be directed to the left or right by 45 or 90 degrees respectively. One push of the left button redirected the field of view 45 degrees to the left, which also revealed the driver's side rearview mirror. Pushing the left button a second time directed the field of view 90 degrees to the left which allowed looking sideways down cross streets. Similar views to the right side were obtained by pressing the right button mounted on the steering wheel. Each button press moved the display regard by 45 degrees up to a maximum of 90 degrees from the straight-ahead orientation. Button presses in the opposite direction were required to move the display regard back to the straight-ahead orientation.

The above method for obtaining view to the side was used as a simple expedient for obtaining a low cost, high-resolution display with quasi-wide field of view. Effective wide fields of view could also have been obtained with additional monitors and image generators or head mounted displays, e.g. (Allen, Rosenthal, 1999). Both of these alternatives would have represented much more costly hardware platforms to achieve high-resolution displays. The alternative used here was felt to be a reasonable compromise to achieve a low cost simulation platform. The task of redirecting the field of view with the buttons was picked up relatively quickly by the subjects, and was felt to represent an extra but not unreasonable workload. The relatively narrow 45-degree field of view also minimized the possibility of simulator sickness.

Subjects were presented with driving scenarios that included varying roadway alignment, cross sections, interactive traffic and pedestrians, and traffic control devices (i.e. signs, signals and delineation). The driving scenarios required about 20 minutes to complete at the nominal 45-mph speed limit plus the slowing and stopping required by interaction with signals, traffic and pedestrians. The scenarios were programmed with a Scenario Definition Language (SDL) that allowed all features of the driving scenes to be easily specified as lists in a text file. Each line of

the list represented the specification of the location or starting point of feature or time sequence, and the attributes of the feature or time sequence. Typical scenario situations are illustrated in Figure 1.

Events were set up relative to the appearance of the driver in both time and distance. Time critical events were triggered on the basis of time to go, so that subjects were presented with constant decision times independent of their speed. This is accomplished in the SDL by having an event (e.g. signal green to yellow, pedestrian stepping off the curb, vehicle pulling into subject's path) triggered at a critical time defined as distance to go divided by subject vehicle speed. The time to go is continuously computed as the subject approaches an event horizon, and the event is triggered upon reaching the event horizon. This event control procedure was originally developed for driver decision-making research (Allen, Schwartz, et al., 1978), and allows events to be triggered with critical timing (e.g. stop or go at a signal, stop or slow down or change lanes to avoid an encroaching vehicle or pedestrian, etc.).



D) Intersections with Traffic and Pedestrians
 Figure 1. Typical Driving Scenario Elements

Subjects included 16 novice drivers and 10 experienced drivers (>10 years driving) equally divided by gender. All subjects (novice and experienced drivers) were exposed to two experimental sessions. The first session included indoctrination and a familiarization run. Both sessions consisted of three formal data collection runs lasting approximately 20 minutes each.

RESULTS

As illustrated in Figure 2, total accidents decreased with experience in the simulator ($p < .05$). Novices had twice as many accidents in their first session as the experienced drivers, and the novice accident rate dropped to near that of the experienced drivers in the second session. It is

this two way interaction between driving experience and session that suggests some utility to novice driver simulator training. The session by run interaction in Figure 2 indicates that the novice high accident rate occurred on their first run in the first session ($p < .05$).

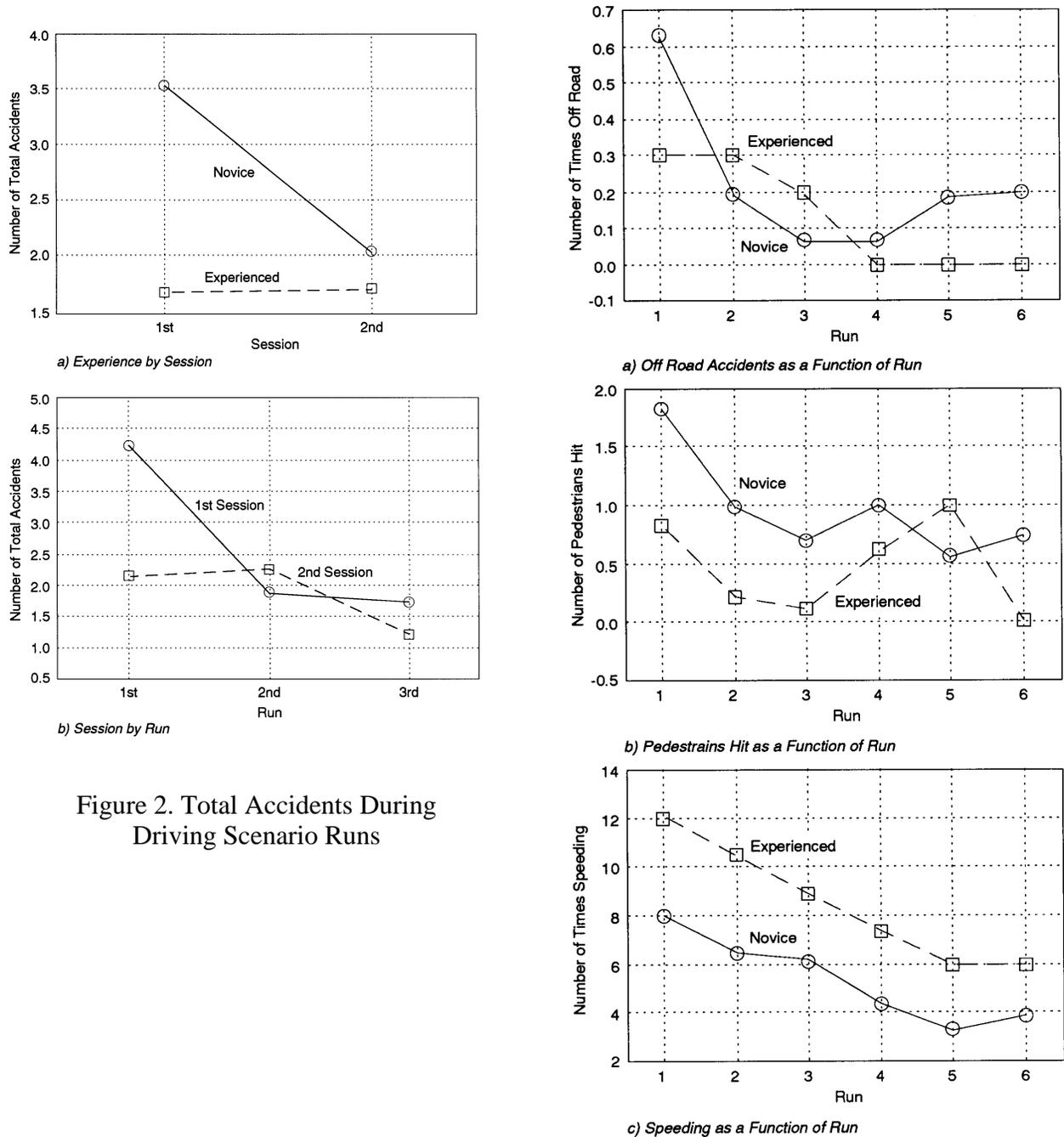


Figure 2. Total Accidents During Driving Scenario Runs

Figure 3. Accidents and Speeding Occurrences as a Function of Simulator Run

In order to get some idea of the learning curve for the novice drivers, data was also analyzed over the six runs without regard for session. This analysis was carried out for several intermediate variables as illustrated in Figure 3. Each of these two-way interactions (run by

experience) was found to be statistically reliable ($p < .05$). The two accident categories, Off Road and Pedestrians Hit, were components of total accident data in Figure 2. Speeding occurrences were the total number of times the subjects exceeded the posted speed limit of 45 mph. The data show experienced drivers starting off high and approaching the level of novice drivers. Accident data seems to converge relatively quickly, while the speeding incidences show a fairly slow convergence. The speeding data show that drivers are generally accommodating to the simulator, but note that the difference between novice and experienced drivers is about 4 occurrences for run 1, while on run 6 it is only about 2 occurrences.

DISCUSSION

The accident rate for the experienced drivers is essentially the same in both the first and second sessions. The accident rate for novice drivers, however, starts out fairly high and then by the second session it approximates that of the experienced drivers. Accidents are a key safety variable and the novice group had about the same number as the experienced group by the second session. This suggests that a simulator can provide training to reduce accidents in complex and critical road/traffic situations. It is not clear that novice-driving performance is stable by the end of the second session. This was a very limited pilot study, however, and the performance results show a general sensitivity to experimental design treatments in spite of the limited number of subjects.

The study reported herein suggests that a low cost PC based simulator may have the potential of providing training in skills required for safe driving. The approach reported herein includes a variety of hazard situations that have not necessarily been optimized in terms of the situational variables. Further work should be devoted to the inclusion of critical hazard situations and the optimization of situational variables that will train and test for detection and recognition (situation awareness), judgment, and decision-making skills in cognitively complex situations.

References

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