Sequence of Visual Behavior during Parking

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Abstract. The change of a driver's viewing direction during parking was investigated by studying the driver's focus points in each parking phase. Skilled drivers tend to observe the parking place to prepare the next motion even when the vehicle is not approaching the place; unskilled drivers look a long time in the vehicle's direction of travel to avoid contacting obstacles. This result suggests that helping a driver recognize the location of a parking place and a future position of the vehicle in the preparatory phase can be an effective parking assistance system.

Keywords: Parking, Visual Attention, Parking Support System.

1 Introduction

Parking and starting a car are among the most worrisome tasks for drivers. When parking a car, we must be careful not to collide with parked cars, passing vehicles, or obstacles around the car. The potential contact points or collisions change with time, making parking more difficult. Drivers should thus pay continuous attention to the moving locations in limited periods.

Considering such high mental loads, parking support devices are desired. Although low-velocity parking tasks do not cause serious accidents, various devices that support parking, such as rear-view monitors and proximity-warning systems, are actually being marketed. Automatic parking systems have also recently been marketed. It is not apparent, however, that such parking assistance devices provide real safety or assurance to drivers. To realize such assurance for drivers, the parking support devices should be well coordinated with the driver's natural attentive activity, including locations and moments where attention is focused. Knowledge of these locations and moments enables providing effective information to drivers to assist with parking and relieve the driver's anxiety.

It is difficult to directly grasp the sequence of a driver's changing focus points, but glancing directions and time length can be used as indexes. Glance activity itself is essentially random and sometimes lacks attention, so estimating a driver's focus of attention through glancing activity is difficult. To overcome this difficulty, glance directions from a number of parking trials were accumulated in order to cancel the randomness of eye motions in this study.

The following three parking/starting patterns are the most difficult tasks: backing into a parking space, backing out of a parking space, and parallel parking. This study

C. Stephanidis (Ed.): Posters, Part II, HCII 2013, CCIS 374, pp. 342–346, 2013.

concentrated on backing into a parking space, which is more common than parking nose-first in Japan.

2 Experimental

Figure 1 depicts the parking space used in the experiment trails (symbols in the figure will be explained later). Obstacles were formed with urethane-foam blocks and pylons with heights exceeding 1.0 meter so the driver could see them whenever the vehicle drew near. Those easily visible obstacles facilitated determining the driver's focus of attention. The parking space was narrow enough that drivers always had to reposition the vehicle into the final parking position.

Twenty participants, aged 21 to 74 (mean 42.5), tried the parking tasks. They drove cars routinely and they were not professional drivers such as taxi drivers or truck drivers. The drivers tried the task twice; the last trials were analyzed.

A sedan passenger car with a steering wheel on the right side was used in the trials. Vehicle velocity was measured using an acceleration sensor, and glancing activity was recorded using eye-mark recorder nac EMR-8.

Figure 1 presents details of the parking sequence. Backing into a parking space includes four different phases separated by vehicle direction (forward and backward); the phases are also shown in Fig. 1. Phases of the backward approach and retrying forward motion can be repeated in one trial because of the task difficulty. The transition between backward approach and position adjustment is defined as the moment when a rear bumper passes through the entry point of the parking space in the last backward approach. Labels of objects (explained later) are also shown in the figure.

The experiment trials were managed by an experimenter in the rear seat, and trials could be stopped whenever the participant wanted. The purpose and details of the experiment were explained to the participants by oral explanation and documentation, and informed consent was obtained. The experiment procedure, including a method of agreement of participants, was approved by the AIST ergonomic experiment committee before the experiment.

3 Method of Analysis

In this study, glance time length was measured in order to estimate focal points of attention. The eye-marks recorded were labeled with object labels (Fig. 1). A sequence of glances can be described as a transition of ratios of glancing time at objects in each phase, and again at each moment of a phase. The latter sequence of ratios indicates a continuous transition of attention in a phase and is expected to reveal subphases within a phase. The time length of the same phase differs from trial to trial, so time spans were normalized to 1.0 (100%). Glancing time lengths and locations of trials were accumulated in 2% time bins, and thus ratios of glancing locations of bins were obtained.

4 Results

4.1 Forward Approach Phase

The obtained transition of glancing ratio is presented in Fig. 2(a). When beginning the approach, drivers stared intently at entrance points (a) and (b). After that, drivers watched the road edge in front of the vehicle (f). Finally, drivers refocused on entrance points (a) and (b). This sequence suggests that drivers recognize the target parking location and plan a future vehicle track by first glancing at the entrance points. The driver should avoid contacting the front edge of the road, and, at the same time, should position the vehicle in a planned location to make the next backward approach easier. In the last step, the driver understands well the location of the front obstacle and refocuses attention on the entrance location to prepare the next backward move.

4.2 Backward Approach Phase

In the backward approach (Fig. 2(b)), the driver still stares at entrance points (a) and (b), and glances to the opposite side from the driver increase later, suggesting that avoiding contact with the vehicle opposite the driver imposes a greater visual workload. In this phase, several retries of one trial are accumulated.

4.3 Retrying Forward Motion

When retrying forward motion (Fig. 2(c)), the driver looks forward (f) first and then refocuses on entrance points (a) and (b), similar to the early approach phase. Several retries are accumulated in this phase.

4.4 Final Position Adjustment Phase

In the last backward approach and position adjustment phase (Fig. 2(d)), the driver looks in several directions in a short time. This phase can be divided into two subphases. The driver pays more attention to entrance points (a) and (b) in the earlier subphase and focuses on objects behind the vehicle in the later subphase. These visual activities are for avoiding a collision and position adjustment.

5 Discussion

Drivers can have several strategies for determining and confirm the location of the parking space and the future track of his/her vehicle for preparation. It is plausible that such differences of strategy affect parking efficiency. The difference between a strategy that results in quick and smooth parking and a strategy that causes several

retries can suggest a good design principle for parking-assistance technology, since such a support device enables the driver to control the vehicle as a skilled driver.

In the following analysis, a skilled driver's trial is defined as a trial in which there was just one retry in backing a vehicle into a parking place. Since one participant provides only one trial, this definition contains both the driver's natural skill and an occasional strategy taken in a trial.

Figure 3 presents visual attention ratios of two groups, skilled drivers and unskilled drivers (more than two retries). The phases shown are the approach phase (with three subphases) and the beginning of the backward approach phase. In the earlier approach, attention of skilled drivers seems to confirm the entrance point (b) while unskilled drivers spend less time looking at the entrance points. In addition, in the final subphase of approaching, skilled drivers look at the entrance area, while unskilled drivers watch the front of the vehicle. This suggests that unskilled drivers were too cautious of contacting front obstacles and failed to confirm the target location, which is necessary to plan a future track.

For designing parking support systems, the result suggests that it is important to give information for early confirmation of a future parking position and a track to it.

6 Conclusion

This study investigated the transition of driver's visual attention when backing into a parking space. In each phase, a driver focuses attention on collision avoidance, preparatory target position recognition, and adjusting his/her vehicle positions, and the ratios of these visual activities varied with time. Preparatory visual attention was also found to play an important role for smooth parking. In order to assist parking by offering information at appropriate times, we should also clarify triggers or conditions for attention changes. Another problem is whether offering such information at appropriate times really provides assurance to drivers, and this should be clarified in human-machine interaction studies.

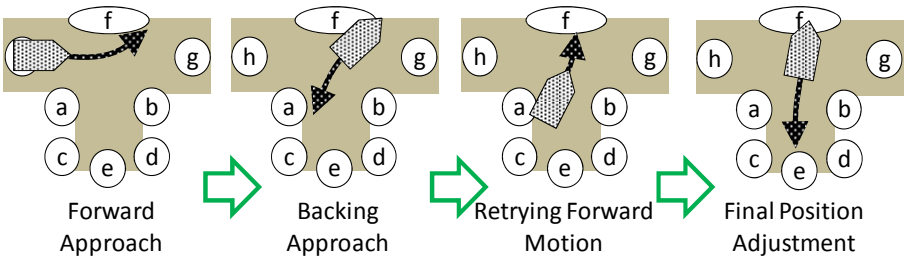

Fig. 1. Four Phases of Backward Parking Task and Obstacle Labels

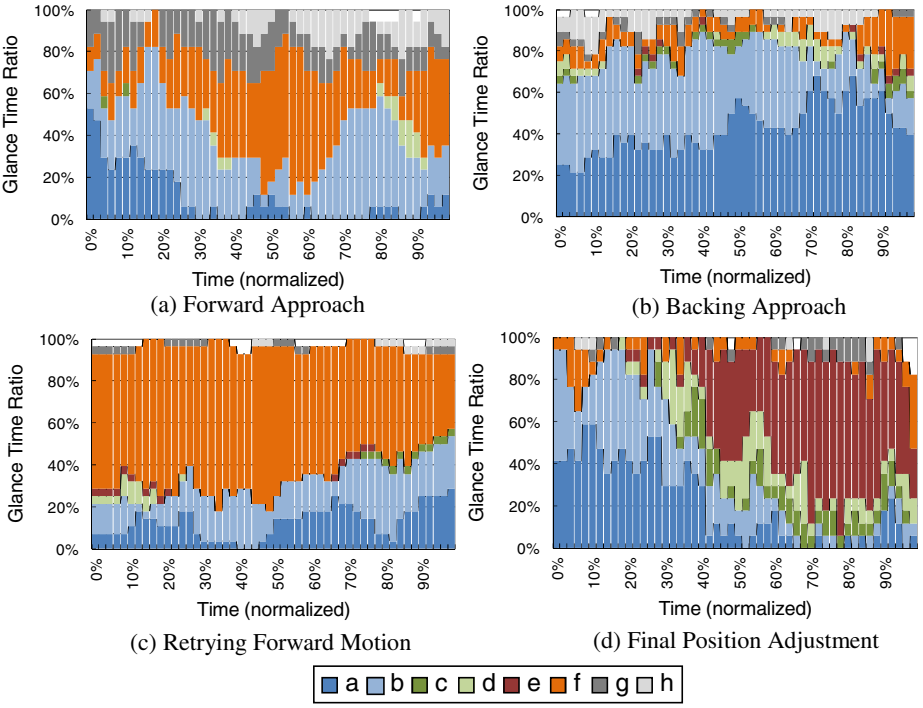

Fig. 2. Transition of Time Ratio of Staring Direction by Parking Phase

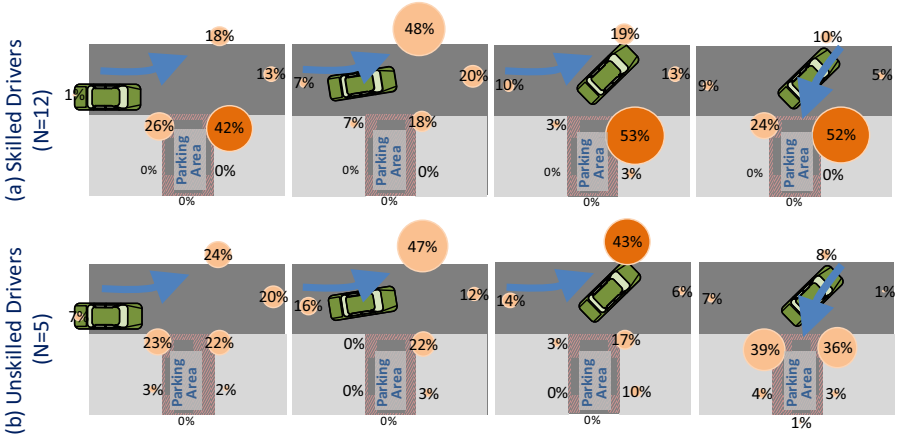

Fig. 3. Difference of Staring Direction by Parking Skill Level