Tortoise and the Hare Robot

Slow and steady *almost* wins the race, but finishes more safely

Daniel J. Rea[1], Mahdi Rahmani Hanzaki[2], Neil Bruce[1], James E. Young[1]
[1]University of Manitoba, [2]Sharif University of Technology
{daniel.rea, bruce, young}@cs.umanitoba.ca, mrahmani1373@gmail.com

***Abstract*— We investigated the effects of changing the tele-operation *feel* of operating a robot by modifying its speed and acceleration profiles, and found that reducing a robot's maximum speed by half can reduce collisions by 32%, while only increasing navigation task time by 10%. Teleoperated robots are increasingly popular for enabling people to remotely attend meetings, explore dangerous areas, or view tourist destinations. As these robots are being designed to work in crowded areas with people, obstacles, or even unpredictable debris, interfaces that support piloting them in a safe and controlled manner are important for successful teleoperation. We investigate modifying a teleoperated robot's speed and acceleration profiles on an operator remotely navigating through an obstacle course. Our results indicate that lower maximum speeds result in lower operator workload, fewer collisions, and are only slightly slower than other profiles with a higher maximum speed. Our results raise questions about how robot designers should think about physical robot capability design and default driving software settings, the robot control interface, and the relation of robot speed to control.**

Keywords—teleoperation, telepresence, human-robot interaction, control, acceleration

I. Introduction

Robots are becoming increasingly practical for investigating dangerous areas, attending remote conferences, or exploring crowded tourist sites. Yet, operators must navigate the remote areas without damaging or injuring people, the environment, or the robot itself – a task that remains challenging. Operator error remains a primary cause of teleoperated robot accidents [1], [2], highlighting the potential for improved interface technique and technology. Our approach investigates how to change operator driving behavior by artificially modifying a robot's driving properties in software, altering operator perception of the robot's physical properties and capabilities (speed, power, weight).

When operating a motor vehicle, people's perceptions of the vehicle are affected by different factors, such speed [3] or sound [4]. Intuitively, when one drives a heavy or large car, the inertia causes acceleration and braking to feel more resistance than with a small or light vehicle. This gives the driver physical cues as to how a vehicle responds to commands, helping a driver make better choices and potentially leading to safer driving. We propose that similar effects may occur when teleoperating robots – e.g. a robot that slowly accelerates and brakes may *feel* heavier and thus, perhaps, more dangerous to operate. Simple software changes can simulate such physical differences in a robot; we investigate how artificially changing a robot's driving feel, to be heavier or lighter, could impact teleoperation.

Fig. 1 A telepresence robot navigates a crowded obstacle course. We encourage operator behavior change by modifying the robot's speed and acceleration profiles.

A similar situation exists in video games, where designers define how their virtual racecar, airplane, or agent, responds to input using only software-defined movement – virtual worlds do not have the physical constraints of a robot. Different movement profiles can be used to impact the player experience and to shape the interaction. For example, faster vehicles are commonly the most difficult to control in games (e.g., see Nintendo's Mario Kart, or EA Sports' Need for Speed Series). We draw from this approach in video games, overlaying an artificial software control profile overtop of a robot's physical capabilities, for the purpose of shaping the teleoperator experience.

In this paper, we present research into how changing a robot's acceleration and speed profiles in software – the *feel* of a robot – impacts operator performance, operation safety, and perceptions of workload. Specifically, we aim to alter operator perception of robot weight and power by changing a robot's maximum speed and acceleration rates. We make these changes with the intention of shaping operator psychology surrounding the capability and safety of the robot.

We conducted an experiment where participants teleoperated a robot through an obstacle course, using different locomotion profiles. Our results suggest we can reduce the number of critical incidents (in our case, by 32%) by simply slowing the robot down, without a proportional negative impact on task completion: our 50% speed reduction only resulted in a 10% increase in time. Our result implies that it reducing a robot's speed, at least in crowded situations, may result in safer operation with only a small slowdown.

Our results highlight the importance of considering robot capabilities during all stages of product design. Both hardware and software configurations that impact robot acceleration and speed may further impact the user experience, and ultimately safety, in non-obvious ways. For example, while it may be intuitive to increase robot speed for enabling faster operation, our results show a more nuanced result, where slow and steady *almost* wins the race, but finishes safer.

II. Related Work

Transportation researchers have looked to psychology to change driving behavior [5], [6]. This research has shown that many factors affect driving behavior, including the surrounding environment (i.e. perceived risk of a situation) [7], vehicle type [8], and driver mood [9]. Interfaces can also affect driving psychology, including novel techniques such as a haptic accelerator pedal [10], or traditional choices such as standard or manual transmissions [11]. Teleoperation of wheeled robots is similar to driving a vehicle, so we leverage and extend this research to robotics, investigating the effects of certain robot design choices on driver behavior.

Research in teleoperation has aimed to support operators by developing novel interface designs and technologies to make robots easier to control. Research approaches to improve interfaces for teleoperation include new or improved ways to control robots [12]–[17], show robot status and capabilities [14]–[16], leverage automation with mixed initiative interfaces [18], or display sensor data in new ways to improve an operator's understanding of the remote environment [19]–[23]. These works use explicit interface modifications in on-screen displays, different physical controls, or additional processing to automate some actions to make an operator more successful. Our work follows a different, complementary approach, aiming to improve teleoperation by only modifying a robot's speed and acceleration profiles with software.

Others have attempted to affect the psychology of the operator to shape their teleoperation behavior. For example, cues leveraging the human psychology of perception and attention may be used to direct operator's attention in non-distracting ways [24], subtle haptic feedback mechanisms can help operators unconsciously avoid obstacles [23], or automated movement can be designed to make an operator feel safer [25]. One motivation in these works is to utilize knowledge of psychology to affect operation experience or behavior; our approach follows this idea and investigates how speed and acceleration profiles of a robot can affect behavior.

III. Modifying Teleoperation Driving Profiles

Our approach for this initial investigation was to select a sample of simple teleoperation profile changes for comparison. Drawing from our psychology of driving project motivation, we selected three profiles: default robot, acceleration-limited robot, and speed-limited robot.

The default robot kept all settings unchanged from the manufacturer's provided settings. We assume that a default commercial-product setting would be a tested and reasonable control profile for the robot and task. Additionally, the default served as a comparison point for the other two driving profiles.

For the acceleration-limited robot, we aimed to create a sense of more mass in the robot by applying a simple limiter on the robot acceleration and deceleration. We anticipated that a heavier robot may elicit safer driving behavior, given that the operator knows that it is more challenging to correct the robot's movement and to stop.

For the speed-limited robot, we simply limited the robot's speed, without modifying the acceleration profile, inspired by a smaller vehicle that may have a lighter engine and so cannot move as quickly. We anticipated that this robot would feel lighter and less capable, and as such, perhaps would cause less stress as an operator may feel there is less risk to the robot's surroundings. Further, we anticipated that the lower speed would negatively impact task completion time.

IV. Experiment: the effects of Speed and Acceleration on Telepresence Robot Control

We performed a within-condition experiment as an initial investigation into the effects of speed and acceleration profiles on telepresence robot operation, where participants completed an obstacle-course navigation task with each of the three profiles: acceleration-limited robot, speed-limited robot, and default (Table 1).

A. Instruments

Our platform was a Double 2 robot (Fig. 2) with the height set to the lowest value. The Double used an iPad Air 2, which provided the driving profile-related computation and the camera feed from its built-in back camera. The robot was remotely operated using a Microsoft Sidewinder 2 Force Feedback Joystick with the feedback set to the default spring setting. A joystick was important as it enabled the operator to modulate the speed of the robot by how far they moved the stick from the center at-rest position. The user sat at a 21-inch screen iMac that only displayed the robot's camera feed. All communications took place over the university's wireless networks.

We measured driving performance in terms of completion time, collisions with obstacles, and subjective workload. Collisions were measured by a researcher present in the room with the robot, who watched and counted all collisions with obstacles in the course. The on-site researcher also recorded the completion time with a stopwatch. Subjective workload was measured via the NASA TLX [26] questionnaire, administered after each condition. The questionnaire included 3 extra TLX-like scales on Enjoyability, Confidence, and Weight Perception (light to heavy), and open ended questions for free-form participant feedback.

B. Manipulations

We used three different driving profiles in our experiment (Table 1), manipulated as a counterbalanced independent variable. The unchanged robot used the full capabilities provided by the manufacturer without change. The default maximum speed is 2.6 km/h, which we measured it accelerates to in approximately 2 seconds.

The acceleration-limited robot was set to have half the maximum acceleration, but the same maximum speed, of the default. This was implemented using a simple first-derivative cap that limited how quickly the robot speed command could change (in both positive and negative directions). While this slows the robot down initially, the full speed capability means the robot can move quickly when necessary, e.g., over long distances. We expect avoiding obstacles to be more difficult, and as such, expect operators to be more careful to compensate.

The speed-limited robot was set to have half the maximum speed of the default, with no modification or restriction to the acceleration. This was implemented with a simple cap on speed. We expected the speed-limited condition to have roughly twice the completion time as the default, as it can move at only half the speed. However, we expected this robot to have a lower perceived workload than the acceleration-limited robot, given the easier control, and as an additional consequence, to perhaps have more collisions due to less-careful driving.

C. *Task*

Participants piloted our robot through an obstacle course (Fig. 3, Fig. 4). They were instructed to complete the task as quickly as they could, while hitting as few obstacles as possible. Our task was designed to simulate navigating a crowded conference or office environment, where there are many obstacles in the form of people or furniture.

Our obstacle course consisted of static obstacles placed at 60cm intervals, with a path that changed each condition. The path through the obstacle course was marked with arrows throughout the course, to ensure that participant memory or spatial mapping was not a confound in the experiment. The obstacles stayed in the same place for each course design, but the path through the course was changed by changing the arrow position. Each course was designed to have the same number of turns and the same Manhattan distance (Fig. 3).

Fig. 2 The Double 2 robot (from doublerobotics.com)

Table 1. The three driving configurations for our robot.

Configuration	Speed	Acceleration
Default	Max	Max
Speed-limited	Half	Max
Acceleration-limited	Max	Half

D. *Procedure*

Participants were briefed that we were testing three telepresence robots that were identical in all ways except their motors, and that they would be helping us select the one that was easiest to control – this deception (that we changed the motors, not the software) was to encourage the idea the robots may feel differently the way vehicles with different engines may feel different. We explained the obstacle course and measurement methods, and the participant read and signed our consent form.

The researcher explained the robot controls, and allowed the participant to practice with the robot. Participants practiced again before each condition, to reduce short-term learning effects of the robot profile, and was always done with the upcoming condition's movement profile. Once the participant indicated that they were feeling comfortable, or after a five-minute period passed, the researcher brought the robot to the obstacle course (Fig. 4); the participant stayed in a separate room and could not externally see or observe the robot. The participant completed two laps of the course to mitigate learning effects and increase the amount of data collected. After each condition, we administered the post-condition questionnaires.

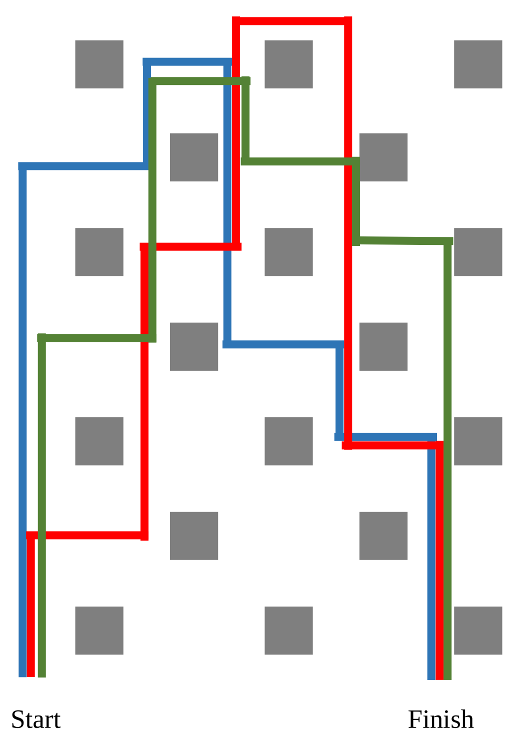

Fig. 3. The three courses (labelled red, blue, or green).

After all three conditions, we administered the post-test questionnaire, and debriefed the participant on the deception- that the robot was the same, but only the software changed.

V. Results

We conducted the experiment with 19 participants (8 female, average age of 27) recruited from our local university campus. We performed repeated measures ANOVAs on TLX sum, number of collisions, and time to completion.

Outlier analysis indicated three participants being at least 1.5 times the inter-quartile range of our data in at least two statistical tests. In addition, we observed that these participants demonstrated poor spatial awareness while driving the robot, for example, repeatedly getting the robot stuck without noticing, resulting in repeated similar collisions and long completion times, uncharacteristic of other participants. We excluded them from our analysis as outliers, resulting in n=16.

We found an effect of driving configuration on completion time, ($F_{2,30}$=8.2, η^2 =.35, p<.001). Marginal means are shown in Fig. 5c. Bonferroni corrected post-hoc tests showed the default profile was faster than the acceleration-limited profile (mean difference = 42.8 seconds, p<.01, 95% CI [15.0 seconds, 70.5 seconds]).

We found an effect of driving configuration on number of collisions, ($F_{2,30}$=6.2, partial η^2=.29, p<.01). Marginal means are shown in Fig. 5b. Bonferroni corrected post-hoc tests showed the speed-limited profile had fewer collisions than the acceleration-limited profile (mean difference = 6.4 collisions, p<.01, 95% CI [1.5 collisions, 11.2 collisions]).

We found an effect of driving configuration on subjective workload, ($F_{2,30}$=4.4, partial η^2=.23, p=.02). Marginal means are shown in Fig. 5a. Bonferroni corrected post-hoc tests showed the speed-limited profile was less demanding than the acceleration-limited profile (mean difference = 16.4 points, p=.01, 95% CI [3.1 points, 29.8 points]).

To better understand the effects of each condition on different types of workload, we performed an ANOVA across the 6 individual TLX scales with Holm-Bonferroni correction, a standard practice with the TLX [27]. We found a trend of driving configuration on temporal load, ($F_{2,36}$=4.6, partial η^2=.20, p=.068). Marginal means are shown in Fig. 6a. Default had highest temporal load (mean=12.0 points, 95% CI [8.7 points, 13.0 points]). Acceleration-limited had second

Fig. 4 Our obstacle course with a specific path shown. There were three paths through the same obstacles (one per condition), marked with different colored arrows. Only one set of arrows is visible per condition.

highest temporal load (mean=12.4 points, 95% CI [9.1 points, 13.6 points]). Speed-limited had the lowest temporal load (mean=8.9 points, 95% CI [6.8 points, 11.1 points]).

We found an effect of driving configuration on perceived performance, ($F_{2,36}$=4.6, partial η^2=.25, p<.04). Marginal means are shown in Fig. 6b. Note higher scores mean worse perceived performance. Acceleration-limited had the worst perceived performance (mean=10.8 points, 95% CI [8.8 points, 12.9 points]). Default had second worst perceived performance (mean=10.6 points, 95% CI [8.6 points, 12.6 points]). Speed-limited had the best perceived performance (mean=7.2 points, 95% CI [5.2 points, 9.1 points]).

We found an effect of driving configuration on perceived effort, ($F_{2,36}$=5.6, partial η^2=.24, p=.04). Marginal means are shown in Fig. 6c. Acceleration-limited had highest frustration (mean=10.3 points, 95% CI [7.7 points, 12.8 points]). Default had second highest frustration (mean=8.5 points, 95% CI [6.1 points, 10.8 points]). Speed-limited had the lowest frustration (mean=7.3 points, 95% CI [5.1 points, 9.4 points]). All other tests were not significant.

VI. Discussion

Overall, our speed-limited robot profile had the strongest performance; it had the lowest subjective workload, least number of collisions, and second fastest completion time. Surprisingly, the speed-limited robot had only a 10% slower completion time than the quickest (the default profile), even though it was limited to 50% of the maximum speed of the

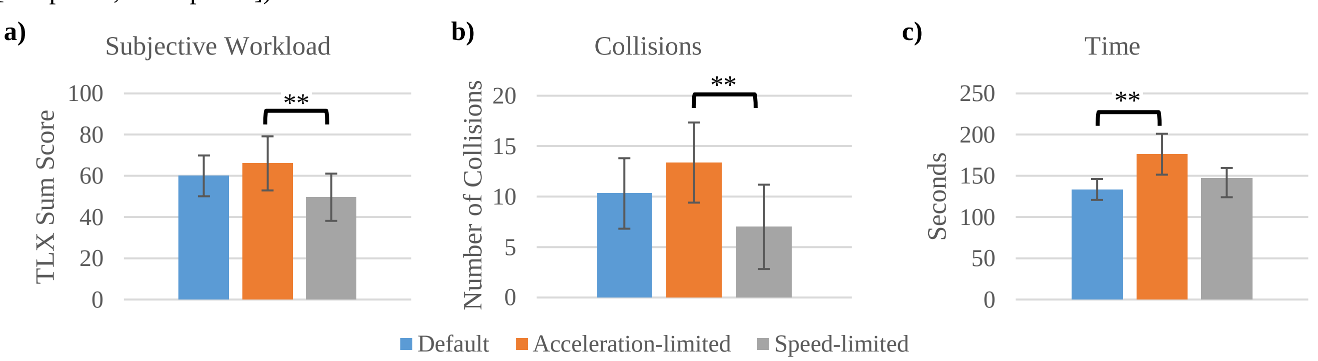

Fig. 5 ANOVA results; error bars show 95% confidence interval. We found main effects of profile on all measures a) Workload (range [0,120]): speed-limited was less demanding than acceleration-limited. b) Collisions: speed-limited had less collisions than acceleration-limited. c) Time: default was faster than acceleration-limited (is p<=.01).**

other two profiles. Interestingly, we could not detect a difference between the speed-limited and default profile's completion time. Though we did not perform equivalency testing, this result suggests that it is unlikely a large effect exists between the two profiles.

The acceleration-limited robot performed poorly. Participants perceived it as having the highest workload, they hit the most obstacles with it, and completed the courses in the slowest times. In each measure, post-hocs found at least one profile statistically better performing than acceleration-limited.

The default profile was only the best performer in terms of completion time, although it was not found to be statistically different from the speed-limited profile. Interestingly, in both collisions and subjective workload, we could not statistically distinguish it from either of the other profiles. While it is likely still the middle performer in these measures, default's measured means were closer to the acceleration-limited profile's performance, rather than the speed-limited profile.

When we looked deeper into the individual TLX scales, we found that the speed-limited profile was perceived as requiring less effort to pilot (agreeing with the overall workload result), and achieving higher perceived performance. Better perceived performance is interesting, as the speed-limited profile was 50% slower and had a negative impact on completion times (10% slower) on average. We found an interesting trend in perceived temporal load which, if confirmed with more data, would imply that people may have felt less rushed, even with the slower speed. This may suggest that people perceive collisions as a more stressful occurrence than slow movement, even when our obstacles where harmless cardboard. It is possible this effect could be stronger if real people are around the robot.

While our results imply that the acceleration-limited robot performed badly, we note that there should be a relationship between all three of our measures: collisions take time to recover from, so perhaps the high number of collisions increased the completion time, and the stresses from both these factors contributed to a worse perceived workload. Less crowded and collision-prone environments than ours may result in the acceleration-limited profile performing differently.

Our results suggest that, in some conditions such as our crowded setup, a speed-limited robot can help operators avoid collisions without a large increase in lost time. Further, we found evidence that operators may perceive collisions with obstacles to be more stressful than a slower travel time. How this result generalizes to different tasks and robot speed configurations remains important future work. These results suggest that it may prove useful to investigate dynamic speed limits placed by software, based on the surrounding environment.

VII. Future Work and Limitations

We hypothesized slower acceleration would promote cautious driving behavior because it is harder to control. However, it appeared future implementations should be more nuanced than ours; we halved both acceleration and deceleration, but the deceleration anecdotally appeared to make it difficult for participants to stop and correct their path if they moved the robot incorrectly. Acceleration and deceleration perform different functions: slowing down is often about safety (stopping, driving carefully). Thus, we recommend robots have asymmetrical acceleration and deceleration curves, and how such asymmetry should be handled is interesting future work.

Our choice of joystick as an input should be considered with our results. It allowed for modulation of speed control (vs discrete forward and backward buttons), but may have made it hard to maintain speed due to the difficulty of holding a joystick in a precise position. This was likely not a problem for the speed-limited robot, as participants could easily keep the joystick at the maximum radius by pushing against the unmoving plastic limiter at the joystick's edge. For other profiles, this would result in a fast speed that was potentially unsuited for our environment. Other mappings of joystick to speed or acceleration should be investigated, as well as other input devices.

One difficulty we encountered in our work was objective measurements. While measuring collisions and time allowed us some insight into a participant's driving style, it hides other aspects, such as physical effort (constantly adjusting the controls, straining to maintain a precise joystick position), or whether they truly thought the robot was more powerful or heavier. While we took TLX measurements for subjective load, other objective measures could be investigated, such as by analyzing the paths taken by the joystick, or participant facial expressions. Further, new measurement techniques or experiment designs should be developed to better measure if perception of a robot has changed driving behavior.

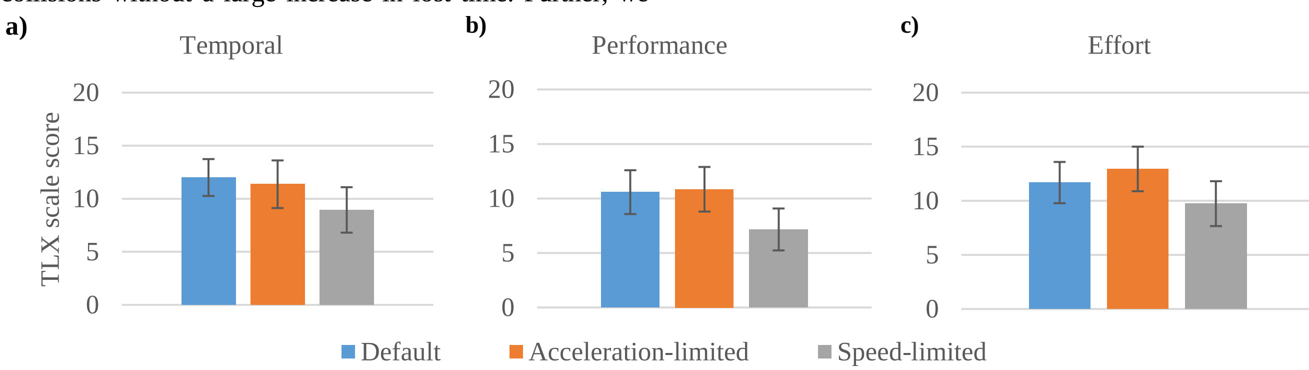

Fig. 6 Post-hoc ANOVA results for TLX sub-scales (lower is better), range [1,20], error bars show 95% confidence interval. Main effects found for Performance and Effort (p<.05) and a trend for Temporal (p=.068).

VIII. Conclusion

We investigated how changes to a robot's acceleration and speed profile can impact operator performance and driving behavior. Our results indicate that such changes can indeed modify operator performance, in terms of task completion time, critical incidents, and workload. In particular, we found that simply slowing down a robot can reduce collisions (by 32%) and lower workload, while not being as slow as one may expect – in our case, halving the speed only resulted in 10% longer task completion times. These results point to the importance of exploring the effects of robot motor control design choices to improve the ease of piloting a teleoperated robot, and indicate that such choices may be even handled dynamically in software, without major hardware changes.

References

[1] S. Giese, D. Carr, and J. Chahl, "Implications for unmanned systems research of military UAV mishap statistics," *IEEE Intell. Veh. Symp. Proc.*, no. Iv, pp. 1191–1196, 2013.

[2] K. W. Williams, "A Summary of Unmanned Aircraft Accident / Incident Data: Human Factors Implications," *FAA Civ. Aerosp. Med. Inst.*, no. December 2004, p. 18, 2004.

[3] M. a. Recarte and L. M. Nunes, "Perception of speed in an automobile: Estimation and production.," *J. Exp. Psychol. Appl.*, vol. 2, no. 4, pp. 291–304, 1996.

[4] N. Kubo, V. Mellert, R. Weber, and J. Meschke, "Engine sound perception – Apart from so-called engine order analysis," in *CFA/DAGA*, 2004, pp. 867–868.

[5] J. A. Groeger and J. A. Rothengatter, "Traffic psychology and behaviour," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 1, no. 1, pp. 1–9, 1998.

[6] J. A. Groeger, "Trafficking in cognition: Applying cognitive psychology to driving," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 5, no. 4, pp. 235–248, 2002.

[7] J. A. Michon, "A critical view of driver behavior models: what do we know, what should we do?," *Hum. Behav. traffic Saf.*, pp. 485–520, 1985.

[8] C. Eyssartier, S. Meineri, and N. Gueguen, "Motorcyclists' intention to exceed the speed limit on a 90km/h road: Effect of the type of motorcycles," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 45, pp. 183–193, 2017.

[9] L. Precht, A. Keinath, and J. F. Krems, "Effects of driving anger on driver behavior – Results from naturalistic driving data," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 45, pp. 75–92, 2017.

[10] R. C. McIlroy, N. A. Stanton, and L. Godwin, "Good vibrations: Using a haptic accelerator pedal to encourage eco-driving," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 46, pp. 34–46, 2017.

[11] M. Blommer, R. Curry, R. Swaminathan, L. Tijerina, W. Talamonti, and D. Kochhar, "Driver brake vs. steer response to sudden forward collision scenario in manual and automated driving modes," *Transp. Res. Part F Traffic Psychol. Behav.*, vol. 45, pp. 93–101, 2017.

[12] J. E. Young, Y. Kamiyama, J. Reichenbach, T. Igarashi, and E. Sharlin, "How to walk a robot: A dog-leash human-robot interface," in *2011 RO-MAN*, 2011, pp. 376–382.

[13] D. Sakamoto, K. Honda, M. Inami, and T. Igarashi, "Sketch and run: a stroke-based interface for home robots," *Conf. Hum. Factors Comput. Syst.*, pp. 197–200, 2009.

[14] S. Hashimoto, A. Ishida, M. Inami, and T. Igarash, "TouchMe: An Augmented Reality Based Remote Robot Manipulation," *Int. Conf. Artif. Real. Telexistence*, pp. 1–6, 2011.

[15] a Leeper, K. Hsiao, M. Ciocarlie, L. Takayama, and D. Gossow, "Strategies for human-in-the-loop robotic grasping," *Human-Robot Interact. (HRI), 2012 7th ACM/IEEE Int. Conf.*, pp. 1–8, 2012.

[16] A. Singh, S. H. Seo, Y. Hashish, M. Nakane, J. E. Young, and A. Bunt, "An interface for remote robotic manipulator control that reduces task load and fatigue," *RO-MAN*, pp. 738–743, Aug. 2013.

[17] S. Radmard, A. Moon, and E. A. Croft, "Interface Design and Usability Analysis for a Robotic Telepresence Platform," in *RO-MAN*, 2015, p. 6.

[18] D. F. Glas, T. Kanda, H. Ishiguro, and N. Hagita, "Teleoperation of multiple social robots," *IEEE Trans. Syst. Man. Cybern.*, vol. 42, no. 3, pp. 530–544, 2012.

[19] H. A. Yanco and J. Drury, "'Where am I?' Acquiring situation awareness using a remote robot platform," in *IEEE Systems, Man and Cybernetics*, 2004, vol. 3, pp. 2835–2840.

[20] A. Settimi, C. Pavan, V. Varricchio, E. Mingo Hoffman, A. Rocchi, K. Melo, N. Tsagarakis, and A. Bicchi, "A modular approach for remote operation of humanoid robots in search and rescue scenarios," *Model. Simul. Auton. Syst.*, vol. 8906, pp. 192–200, 2014.

[21] C. W. Nielsen, M. A. Goodrich, and R. W. Ricks, "Ecological interfaces for improving mobile robot teleoperation," *IEEE Trans. Robot.*, vol. 23, no. 5, pp. 927–941, 2007.

[22] D. Saakes, V. Choudhary, D. Sakamoto, M. Inami, and T. Igarashi, "A teleoperating interface for ground vehicles using autonomous flying cameras," in *International Conference on Artificial Reality and Telexistence (ICAT)*, 2013, pp. 13–19.

[23] A. Hacinecipoglu, E. I. Konukseven, and A. B. Koku, "Evaluation of haptic feedback cues on vehicle teleoperation performance in an obstacle avoidance scenario," in *2013 World Haptics Conference, WHC 2013*, 2013.

[24] D. J. Rea, S. H. Seo, N. Bruce, and J. E. Young, "Movers, Shakers, and Those Who Stand Still: Visual Attention-grabbing Techniques in Robot Teleoperation," in *Human-Robot Interaction*, 2017, pp. 398–407.

[25] C. Basu, Q. Yang, D. Hungerman, M. Singhal, and A. D. Dragan, "Do You Want Your Autonomous Car To Drive Like You?," in *Human-Robot Interaction*, 2017, pp. 417–425.

[26] S. G. Hart and L. E. Staveland, "Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research," in *Human Mental Worload*, 1988, pp. 139–183.

[27] G. Hart, Sandra, "NASA-task load index (NASA-TLX); 20 years later," *Hum. Factors Ergon. Soc. Annu. Meting*, pp. 904–908, 2006.