Editorial

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Vehicles generally operate in a closed-loop driver-vehicle-road environment, where a human driver acts as an intelligent 'controller' to manage the intended driving direction, while maintaining the stability of the vehicle through applications of appropriate steering and/or braking/acceleration manoeuvres (Gordon and Best, 2006; Plumlee et al., 2006).

It is thus essential to investigate the handling dynamics and stability characteristics of vehicles in conjunction with the driver dynamic behaviour in a closed-loop manner. However, owing to significant difficulties associated with characterisation and modelling of human drivers with respect to human perception and neural and muscular dynamics, the handling properties of vehicles have been mostly explored in an open-loop manner assuming negligible human driver contributions. The fundamental theories for analyses of open-loop vehicle handling dynamics and stability have thus been well developed, although challenges continue to exist in effective modelling of tyres, particularly in the transient state. The continued development in open-loop vehicle dynamics has considerably contributed to advances in various vehicle control systems for handling dynamics and stability enhancements (Ghoneim et al., 2000; Hac and Bodie, 2002; Trachtler, 2004).

The increasing demands in vehicle active safety and the emerging developments in electric/hybrid vehicles are currently the primary motivation for developing a higher level of vehicle handling/stability controls through adaptation of novel technologies such as by-wire (Ancha et al., 2007), in-wheel motor drives, driver-assist controller designs, etc. These, in turn, require further developments in analytical and experimental vehicle handling dynamics and stability methodologies, involving closed-loop driver-vehicle-road system interactions. In addition, the developments in effective vehicle handling performance metrics have been limited by our somewhat insufficient knowledge of essential control properties of the human drivers.

This Special Issue of the *International Journal of Vehicle Design* (IJVD) compiles the most recent advances in vehicle handling dynamics and control, which address some of the above-stated challenges. The research papers presented here cover topics related to improved understanding of handling dynamics and stability, objective/subjective handling metric correlations, driver modelling, vehicle dynamics state measurement and estimation, vehicle handling and stability controls, control of hybrid electric vehicles, and vehicle autonomous driving.

Some of the future research efforts/directions in vehicle handling dynamics and control are briefly listed below:

- Design synthesis of suspension kinematics/dynamics properties in enhancing vehicle handling dynamics and stability, where a combination of analytical formulations and multi-body dynamic simulations would be desirable. This is also very important in view of the coordination of the mechanical/regenerative braking system of electric/hybrid vehicles, and vertical motion controls of in-wheel motor drive.
- Further developments in tyre models capable of predicting transient and steady-state tyre forces/moments with greater accuracy and computational efficiency, and supported by experimental data, would be of extreme significance.
- Further efforts in characterising psycho-physical properties of human drivers through development in more effective measurement techniques and metrics would be most worthy for developing closed-loop driver-vehicle-road system handling analyses tools and integrated vehicle control systems. These would also help to establish correlations between the objective and subjective handling performance measures.
- Novel methodologies in vehicle dynamics state estimations based upon an optimal combination of low-cost sensors and vehicle modelling would be desirable in the context of a specific or a class of control targets.

- Developments in integrated power/energy management and vehicle dynamics/stability controls, and scalable integrated control/management architectures with flexibility in customerisation would be vital for developments in electric and hybrid vehicles.
- Identification of optimal combinations of actuators for vehicle handling dynamics and stability controls coupled with ride controls considering the closed-loop driver-vehicle-road system interactions, and enhanced compromise in vehicle handling responsiveness and stability, need to be further explored.
- By-wire technology, in-wheel motor drive, and their integrations in view of the closed-loop driver-vehicle-road system.
- To explore alternative vehicle/mobility concepts (e.g., three-wheeled vehicles, four-wheeled vehicles with variable track-widths, wheelbase and ride height, novel wheeled mobility concepts, etc.) would be desirable.

The Guest Editors would like to express their sincere appreciation to all the authors for their valuable technical contributions and most of all to the reviewers for their immense efforts. The Guest Editors would also like to thank Prof. M. Dorgham and Dr. K. Deng for crafting this opportunity and for their guidance.

References

Ancha, S., Baviskar, A., Wagner, J.R. and Dawson, D.M. (2007) 'Ground vehicle steering systems: modelling, control, and analysis of hydraulic, electric and steer-by-wire configurations', *International Journal of Vehicle Design*, Vol. 44, pp.188–208.

Ghoneim, Y.A., Lin, W.C., Sidlosky, D.M., Chen, H.H., Chin, Y-K. and Tedrake, M.J. (2000) 'Integrated chassis control system to enhance vehicle stability', *International Journal of Vehicle Design*, Vol. 23, pp.124–144.

Gordon, T.J. and Best, M.C. (2006) 'On the synthesis of driver inputs for the simulation of closed-loop handling manoeuvres', *International Journal of Vehicle Design*, Vol. 40, pp.52–76.

Hac, A. and Bodie, M.O. (2002) 'Improvements in vehicle handling through integrated control of chassis systems', *International Journal of Vehicle Design*, Vol. 29, pp.23–50.

Plumlee, J.H., Bevly, D.M. and Hodel, A.S. (2006) 'Control allocation in ground vehicles', *International Journal of Vehicle Design*, Vol. 43, pp.215–243.

Trachtler, A. (2004) 'Integrated vehicle dynamics control using active brake, steering and suspension systems', *International Journal of Vehicle Design*, Vol. 36, pp.1–12.