# **Summaries**

## Morales, J. et. al. (2009), “Virtual steering limitations for reversing an articulated vehicle with off-axle passive trailers ”, 35th Annual conference of IEEE Industrial Electronics.

The paper proposes a methodology for reversing an articulated vehicle. By using the proposed method, firstly the reversing problem can be converted into forward motion problem. It is done by considering the rear-most trailer of the articulated vehicle as virtual tractor and the forward direction of this virtual tractor coincides with the reverse direction of actual articulated vehicle. This approach results in a virtual steer angle which is required by virtual tractor to follow the pre-defined path for virtual tractor steer axle (or rear-most axle of actual articulated vehicle). Secondly, this virtual steer angle is then converted (translated) to actual steering angle of articulated vehicle using inverse kinematic relations of articulated vehicle. The paper finally validates the approach with a path following robot (Auriga-α) with two off-axle hitch passive scaled trailer.

It can be concluded from the paper that the approach described within the paper is relevant while considering the application complexity. However, controller performance can be further improved to have better (i.e. close to zero path-tracking error, both in straight and curved sections) path following of pre-defined reference path.

## Salvucci, D. et. al. (2004), “A two-point visual control model of steering”.

This paper describes an approach to describe the human driver steering behavior. Through the literature research presented in the paper, it has been established that human driver uses two visual points for operating steering, which can also be correlated to steering being the two level control phenomenon. This is incorporated by using two points, namely, ‘near point’, and ‘far point’ in the model. The ‘near point’ is referred to a point closer to vehicle and at the center of the lane, which is being used to monitor the present lateral position and stability, and the ‘far point’ which is a salient point at distance farther than near point and given a specific distance of this point, steering corrections can be predicted corresponding to the upcoming path deviations. The paper describes steering by following equation:

The first two terms in the equation represent the proportional part of PI controller corresponding to ‘near point’ and ‘far point’ respectively, and the last term represent the integral part of PI controller. The paper also presents the validation of this model using three studies. First is the curve negotiation, where these points are moved using additional segments. It was observed that when only ‘far point’ is used for maneuvering then the driving is smooth but less accurate and when only ‘near point’ is used then the driving is more accurate compared to ‘far point’ but with jerky behavior. Second is the corrective steering, where two conditions (one with increasing initial heading angle at constant velocity and second with constant initial heading angle at increasing velocity) was analyzed. It was observed that driving styles can be distinguished and also increasing speeds will result in shorter times for completing the maneuver. Third is lane change study, where driver model was tuned to represent the multiple drivers. It was observed that qualitatively the steering behavior of driver model represent the driver but quantitatively it was not possible in the mentioned conditions.

It can be concluded that the two point approach of modeling steering behavior of the driver is a relevant. However, the paper presents the approach based on visual perception of driver, which can vary depending on the driver characteristics (it is relevant for the paper’s objective), therefore, the quantification is not important/possible in the presented context.

Although, this two-point approach can also be employed for path following controller to have enhanced path tracking. The two-point approach can be realized by utilizing two look-ahead times (or preview lengths), and proportional term for steering controller can be represented by following equations:

Where, represents the proportional gain. represents the near point (small preview length), represents the far point (large preview length), and represents the relation between the two lengths. represents the virtual steer angle corresponding to , and represents the virtual steer angle corresponding to and & represents their weightage in the controller. It is clear that in order to apply this proportional controller for steering, two fractions and one factor needs to be determined first. This can be achieved by creating an optimization routine in relevant scenarios to determine the optimal range for these variables.