Design of Forward Collision Warning System Using Relative Acceleration Estimation and Multi-object Tracking

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Time-to-Collision (TTC) can be used to design Forward Collision Warning Systems (FCWS). In previous studies, TTC is defined as the relative distance divided by the relative velocity. Since the relative acceleration is ignored, it might result in estimation errors of TTC for maneuvers with non-zero relative accelerations. In order to improve the accuracy of TTC estimation, we consider the relative acceleration and extend the region of interest for FCWS from the main lane to adjacent lanes. According to the measured relative distance and relative orientation, a multi-object tracking algorithm is also developed in this research. If we assume constant relative acceleration within the sample time, the relative distance can be approximated using a second order polynomial. Recursive least square technique is employed to estimate coefficients of the polynomial. The variable forgetting factor, which is adjusted with respect to the relative acceleration, is proposed to enhance the estimation performance. Similar process is applied to estimate the coefficients of a second order polynomial for the relative orientation. The estimated coefficients of the second order polynomial of the relative distance can be transformed into the relative distance, relative velocity, and relative acceleration for calculating TTC. When the TTC is below the threshold value, relative velocity vector is used to determine if there is an impending threat for collision. If the relative velocity vector is pointing toward the host vehicle, different levels of collision warning are issued to the driver according to the TTC values. If the relative velocity vector is not pointing toward the host vehicle, it is determined to be a safe condition even with TTC below the threshold value. A prototype vehicle

equipped with a laser radar and necessary sensors is used to collect the field data on the road. Experimental results show that the proposed algorithm can pass all 3 tests of ISO 15623 and issue valid warnings to the driver without false alarms for the expressway tests.