Simulink

The main structure of the proposed dual-loop PID controller is shown in Fig. 1.
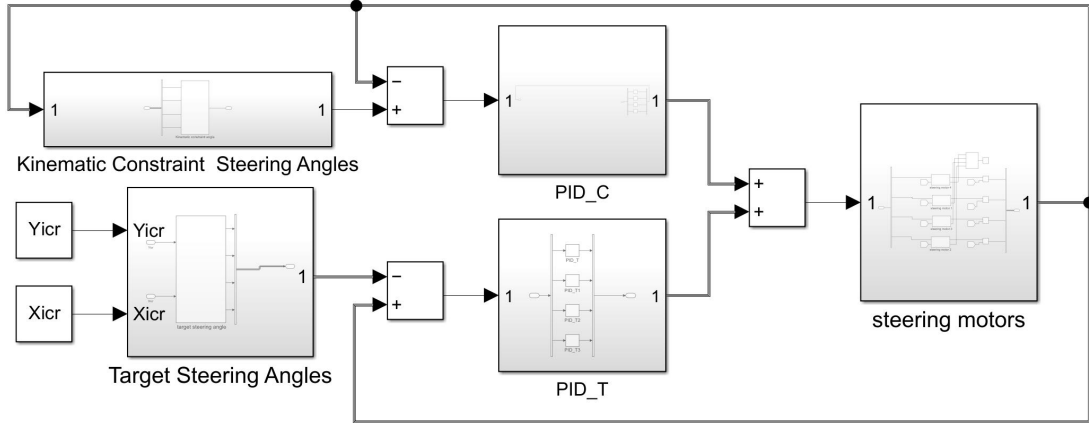

Fig. 2.   Simulation structure diagram of the proposed double closed-loop controller.

The Xicr and Yicr in the Fig. 1 represent the target ICR. The target steering angles are calculated from the target ICR through the Target Steering Angles module. The input of the Kinematic Constraint Steering Angles module is the actual wheel steering angles measured from the steering actuators. Based on the actual steering angles, the approximate instantaneous center of rotation is estimated, and the corresponding kinematic constraint steering angles are then derived. The target steering angles and the kinematic constraint steering angles are respectively subtracted from the actual steering angles to obtain the target tracking error and the kinematic constraint error. These errors are then fed into the PID_T and PID_C controllers, respectively. The outputs of the two PID controllers are summed and sent to the steering motor module as the control input, resulting in the actual wheel steering angles.