Simulation based analysis of open-loop control strategies for cranes in parking systems

A disadvantage of automated parking systems are high investment costs, caused by the conveyor systems. The investment costs can be reduced by the usage of cranes as conveyor system and open-loop control strategies for damping the load sway. Due to this, the main objectives of this dissertation are the investigation of open-loop control strategies and the development of a new device for an exact and fast positioning.

Simulations have been used to determine which control strategy enables the best sway damping in regard to the positioning time and the robustness against tolerances. Therefore, mathematical models of the crane movement have been developed and implemented in the software SIMULINK. The models have been developed for cranes with a parallel and trapezoidal arrangement of the ropes. Furthermore, the models consider a changing rope length during the movement.

The results of the simulations show that the fastest movement is generated by control strategies with a local load sway damping. On the other hand, these control strategies have a low robustness which leads to a high load sway, if kinematic tolerances are present. Especially the variation of the rope length during the movement has a negative influence on the robustness. Different methods are presented in this dissertation, to compensate the effect of the variable rope length. The best method for the compensation of the influence of a variable rope length is the method of Input-shaping. By reason of the low positioning time, this method can only be recommended, if the robustness of the other methods is not satisfying in real applications. The benefits of a trapezoidal arrangement of the ropes are only significant for high rope angles. Hence, a trapezoidal arrangement is not appropriate for the most applications.

To verify the simulation models and results a scaled model has been developed and set up. Experiments with the scaled model have demonstrated the validity of the simulation models and results. Beside the verification an analysis of the influence of geometrical tolerances on the robustness has been done. Based on the results of this investigation the width of the alley between the storage locations has been specified. Finally, in consideration of the results of the simulation a device for damping the remaining load sway has been developed.