Abstract

The aim of this dissertation was to design and compare various controllers in the control of three separate high-speed, supertall/ultratall elevators. The three models differed in building height, nonlinear cable dynamics, override height and the motor used for actuation. Following verification of the models in an uncontrolled state, seven different control architectures were developed – a conventional proportional-integral-derivative (CPID) controller, a conventional pseudo-derivative feedback (CPDF) controller, a nonlinear proportional-integral-derivative (NPID) controller, a nonlinear pseudo-derivative feedback (NPDF) controller, a full sliding mode control (FSMC) system, a simplified sliding mode control (SSMC) system and a direct adaptive neural network-based sliding mode control (RBFNN-SMC) system. The parameters of each of the controllers were tuned using genetic algorithm (GA) optimisation. The control systems were evaluated on the ability to efficiently track the setpoint signal, ensure prompt arrival of the cabins, maintain ride comfort by limiting the experienced acceleration and jerk, and reduce the power consumption of the system. Following extensive simulations, it was observed that the NPDF controller exhibited the best all-round performance, being the only control system to obtain at least acceptable performance (i.e., arrival accuracy $\leq$ 0.3 m, experienced jerk $\leq$ 1.7 m/s^3, etc.) for each of the cabin masses, travel distances and travel directions considered throughout this dissertation. In addition to superior robustness in operation, the NPDF controller displayed a high level of flexibility in design; being the most effective control scheme at prioritising comfort and energy efficiency, while effectively re-levelling the cabin to within 1 mm of the target floor when performance was given precedence. Notable improvements were observed in the NPID controller responses, compared with those of the CPID control architecture, particularly in terms of sensitivity to parameter variations. The implementation of a simplified mathematical model in the SSMC control law resulted in noticeable reductions in run time, compared with the FSMC. The drawbacks associated with the need to explicitly define the model in the SMC control laws were overcome following the introduction of the RBFNN-SMC, with comparable control recorded despite the system dynamics being approximated. Although the RBFNN-SMC was able to suitably account for external disturbances, with the connection weights of the hidden layer neurons being adapted online in order to maintain control; problematic chattering was observed following rapid changes to the system states due to sensor noise. It was concluded that in order to be viable in practice, the RBFNN-SMC must be coupled with a noise-attenuating filter.