Vibration Control of Time-Varying Nonlinear Systems

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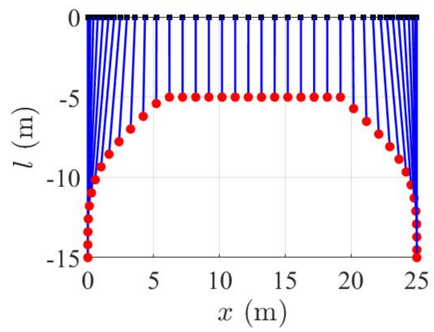
Abstract. The induced vibration from a commanded time-varying nonlinear systems is controlled by using a pre-designed shaped input command. The changes of the system parameters during the motion of the system as well as the input and system constraints are accounted when designing the shaped commands. The proposed controlling techniques are tested by suppressing the residual vibration of an overhead crane with simultaneous traveling and hoisting maneuvers. The hoisting and lowering operations when traveling a payload in an overhead crane induce a nonlinear system with time-dependent natural frequency and positive-negative damping-like behavior. The numerical results demonstrate the performance of the proposed shaped commands in suppressing the residual vibration of the suspended payload regardless the hoisting and lowering profiles used during the maneuver.

Introduction

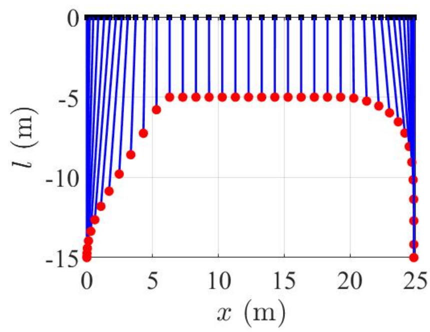
The application of a control input into a time-varying system, e.g., flexible link manipulators [1], crane operation with hoisting/lowering maneuver [2], or pouring and filling operation [3], results in unwanted transient and residual vibrations. The complexity of the dynamical models complicate the controlling procedure of the system's input. The open-loop control, especially the command shaping approach, is commonly used for vibration control with precise and accurate positioning and fast and safe operation. The principle of the command shaping control is to design based on on either optimal control approach or input shaper [4] a special input that commands the mechanical system without inducing residual vibration. Unlike the input shaper scheme where the rise time of the generated impulses depends on the system parameters, the optimal control approach has the freedom of selecting the maneuver time to compensate between the move time and required vibration reduction in the transient stage. The objective here is to extend the command shaping approach to control a time-varying nonlinear system while accommodating the changes of the system parameters and satisfying the input and system constraints.

Results and Discussion

The proposed controlling techniques is tested by controlling the induced vibrations of payloads traveled and hoisted by an overhead crane. The input shaped command consists of equidistant steps. The residual pendulum oscillations were suppressed at the end of the command when using linear and quadratic hoisting/lowering profiles, Figure 1. The transient pendulum oscillations can be further reduced by increasing the command time length unlike the classical input shapers that have a fixed command length. Without basing the controlling design on the average system parameters, the time-nature of the system parameters during the motion was considered when designing the shaped command.



(a)



(b)

Figure 1: Motion profiles for (a) linear and (b) quadratic hoisting and lowering operations.

References

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