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Cable mass model with boundary damping

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This work focused on the analysis of a one-dimensional linear wave equation characterised by two dynamic boundary conditions, incorporating damping and stiffness parameters. The complex process was theoretically represented, and the associated equations were solved using computational methods. To capture the system's behaviour, stiffness parameters, Kelvin-Voigt damping parameter, and viscous damping parameters were introduced into the boundary conditions. An input term was also introduced to the left boundary to control the one-dimensional wave equation. Additionally, the impact of a non-linear term incorporated into the right boundary was closely examined. The balanced truncation method was introduced to generate the non-linear input-output system's reduced-order model (ROM). The objective of the model reduction was to develop a lower-order model that accurately approximates the full-order model's displacement and velocity. It is believed that the non-linear cable-mass model considered here has not been investigated elsewhere. To ensure the reliability of the results, the stability was proved by analysing the system's energy. Numerical experiments were conducted to complement the theoretical work and assess the performance of both linear and non-linear models. These experiments demonstrated that the energy decays exponentially rapidly for the non-linear problem. The numerical experiments showed that the energy was rapidly decreasing, indicating exponential stability in the non-linear case. Consequently, the physical applicability of the model was confirmed. Through comprehensive experimentation and validation, the performance of balanced truncation was evaluated across various scenarios, highlighting its potential to significantly enhance the computational efficiency and applicability of dynamical system modelling. The results concluded that the ROM demonstrated accuracy across multiple combinations of model parameters except when dealing with higher values of the non-linearity term on the right boundary condition.

Keywords: Balanced truncation, Cable mass model, Kelvin-Voigt damping, Stiffness parameters, Viscous damping