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A MULTIBODY DYNAMICS APPROACH FOR THE TRANSIENT SIMULATION OF ROPEWAY SYSTEMS

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From an idealized point of view, a ropeway system can be considered as an assembly of rigid vehicles (gondola cars) that are transported by a moving, flexible cable. The latter is driven and conducted by a number of driving and supporting sheaves. The sheaves are attached to ground via spring-damper elements. For the simulation of moving cables, in which the overall axial velocity is almost constant, such as in belt drives, cranes, or ropeway systems, different models exist. Simple models considering discrete mass-spring-damper systems [1] are highly efficient and can run in real-time. They are, however, not applicable for rope-sheave contact modeling. In contrast, a transient simulation using nonlinear rod elements is possible at high computational costs. Alternatively, thin rod finite elements can be implemented in an Arbitrary Lagrangian-Eulerian (ALE) manner [3]. That is, the deformational motion of the cable corresponds to the motion of the finite element mesh, whereas the overall axial motion is represented by a superimposed Eulerian axial velocity. A similar approach has proven to be appropriate for the simulation of belt drives moving at a constant velocity [2]. This approach is adopted here and extended such that the axial velocity enters the formulation as an additional degree of freedom, which allows the simulation of constant speed, acceleration, and deceleration phases as well as control aspects. Particularly, proper constraint conditions have been derived in order to enforce the synchronized transport of the cars along the ALE rod elements without attaching them to element nodes. If the Eulerian axial velocity is adjusted properly to the overall motion of the rope, non-uniform meshes can be used to refine relevant sections of the ropeway system, e.g. in the vicinity of comparatively small supporting sheave assemblies, avoiding globally fine meshes which would be needed in transient simulations. A numerical example affirms the computational advantages of the proposed method.

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