

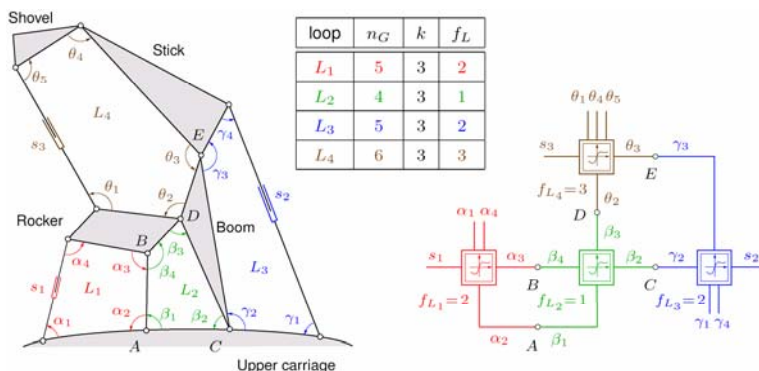
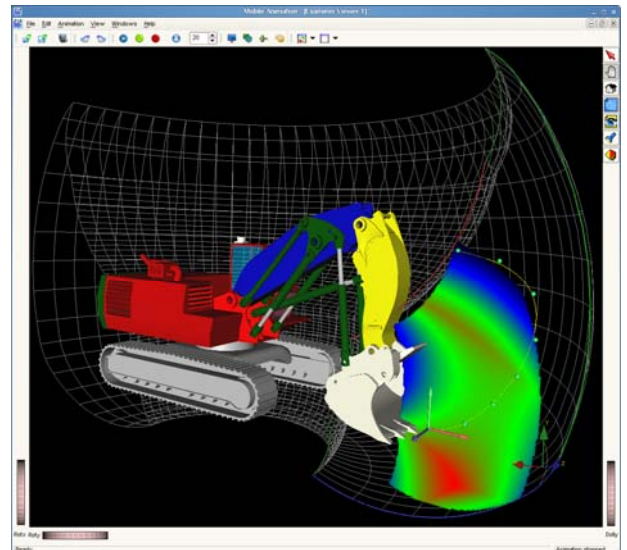
## Object Oriented Modeling of the Kinematics and Dynamics of Mining Excavators



The goal of this industry-funded project is to reproduce the physical behavior of heavy-load mining excavators on the computer for design and control purposes. To this end, the kinematics of the boom are solved using highly-efficient closed-form solutions based on the method of kinematical transformers. Based on these solutions, the dynamics and further evaluation procedures, such as force-based workspace analysis, minimal cycle times, optimal trajectory shaping, and mechanical loads on critical parts are computed. The developed simulation kernel is then

incorporated in a real-time controller as well as in a virtual simulation environment used for operator training. To this end, the inputs of the model can be wired to outputs of MMI devices such as Joysticks or to the outputs of suitable controller blocks in different computation modes, i.e. direct and inverse kinematics as well as direct and inverse dynamics. In order to provide a realistic reproduction of dynamic effects, hydraulic units are included in the model, making it possible to simulate the real-world behavior of the excavator under prescribed operator inputs.

A further feature of the project is that measurements can be directly included in the model simulation, making it possible to reproduce operations or accidental damages of equipment by measurement-driven simulation. Current research involves optimal trajectory planning



based on spline objects capable of transmitting motion and forces. In this way, it is possible to consider the motion of the bucket along a trajectory including the effects of the resulting forces at the tip and the effects of time-derivatives of position change. All dynamical features are included in an application-specific simulation and visualization environment that makes understanding, planning, evaluation and design of excavator components and operations more efficient.

### Funded by

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