

How Inverse Dynamics Works

The classical equations of motion may be written in the following form:

$$\underbrace{M(\mathbf{q})\ddot{\mathbf{q}} + C(\mathbf{q}, \dot{\mathbf{q}}) + G(\mathbf{q})}_{\text{knowns}} = \underbrace{\boldsymbol{\tau}}_{\text{unknowns}}$$

where N is the number of degrees of freedom;

$\mathbf{q}, \dot{\mathbf{q}}, \ddot{\mathbf{q}} \in \mathbb{R}^N$ are the vectors of generalized positions, velocities, and accelerations, respectively;

$M(\mathbf{q}) \in \mathbb{R}^{N \times N}$ is the system mass matrix;

$C(\mathbf{q}, \dot{\mathbf{q}}) \in \mathbb{R}^N$ is the vector of Coriolis and centrifugal forces;

$G(\mathbf{q}) \in \mathbb{R}^N$ is the vector of gravitational forces;

and $\boldsymbol{\tau} \in \mathbb{R}^N$ is the vector of generalized forces.

The motion of the model is completely defined by the generalized positions, velocities, and accelerations. Consequently, all of the terms on the left-hand side of the equations of motion are known. The remaining term on the right-hand side of the equations of motion is unknown. The inverse dynamics tool uses the known motion of the model to solve the equations of motion for the unknown generalized forces.

Note: Inter-segmental force is the net force acting across a particular joint in a model. This should not be confused with joint bone-on-bone force, which is the force seen across the articulating surfaces of the joint, which includes the effect of active and passive muscle forces. For a thorough discussion on this topic see pp 77-79 in [4].

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