Deformable Body Analysis through Gauge Kinematics

Landsberger, Huws

A cat released in mid-air devoid of angular momentum or anything to push off easily maneuvers to land on its feet. Similarly, a diver can leave a diving board with no angular momentum and yet perform several twists. Classically, it is quite difficult to analyze the motion of deformable bodies such as cats and humans. A method called gauge kinematics that has its origins in particle physics provides a tool for assigning a natural coordinate frame to deformable bodies simplifies the mechanics. This methodology provides a basis for analysis of deformations and the rotations they induce. The Mathematica symbolic computation program was used to create a simulation of the deforming body. A body comprising moving point masses was represented by a natural coordinate frame in which their motions were simply described. Inertia tensors and apparent angular momenta arising in the body were calculated at each timestep. Infinitesimal net rotation matrices were then found for any arbitrary change of shape at each time. By taking the product of all infinitesimals, a final rotation matrix transforming from body to space frames was found. The method of using gauge kinematics worked successfully and efficiently to describe the motion of any body undergoing deformations in the absence of a net angular momentum. The simulations demonstrate the usefulness of the gauge kinematics method for analyzing the spatial motion of deformable bodies. This would simplify calculations for the movements of self-deforming robots, spacecraft, and even microorganisms in low Reynolds number fluids.

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