

Tipsy Turvy

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Summary

This animation is a result of a research effort at IBM to apply physical simulation in making more realistic computer animations. The star of the show is the "Utah teapot", a computer graphics teapot, designed by Martin Newell in 1971, that has come to symbolize the modern computer graphics achievement of making realistic pictures of real objects.

At the start of the animation, the teapot is apparently suffering from a hangover. It hiccups twice, bouncing its lid into the air, startling the nearby glassware that rocks back and forth. Then the teapot sneezes violently, propelling itself and the lid into the air. When the teapot returns to the table it lands on the spout, smashing the teapot into thousands of pieces. Teapot fragments ricochet off the other occupants of the table, knocking vases and bottles aside. By the time the teapot lid lands, the table has been cleared by the teapot's crash.

Modeling of flexible and brittle objects

All of the behaviors displayed in the animation are the consequence of computer simulation. The teapot "hiccups" were obtained by altering the force of gravity applied to the teapot. The teapot was made to "sneeze" by briefly softening the ceramic material, then stiffening it again abruptly. The wobbling of vases and glassware was caused by colliding these objects with invisible spheres.

All objects that were simulated in the animation were constructed from a mathematical model that simulates networks of masses and springs. The internal dynamics of the various objects results from the contraction and expansion of damped springs. Interaction between objects results from response forces being applied after collision detection. The table was modelled as a rigid object that applies friction and repulsion to intruding flexible objects. The physical simulation is performed by applying Eulerian integration to Newtonian dynamics. The stiffness of the teapot was limited by the computation required for such a stiff system of differential equations.

Breakage is modeled by introducing a threshold value to the springs that hold the teapot together. When the force applied to a spring exceeds that threshold, the spring breaks. The teapot was seeded with random variations in the breakage threshold to create the effect of random defects in the material. Small particles of the teapot material are rendered as tetrahedra after they have been liberated from the ceramic.

Technical details

The teapot scene was simulated as a mesh of more than 20000 nodes, requiring about 1/2 hour of 3090 CPU time per animation frame. The resulting images were then ray traced to exhibit shadows and reflections. During the course of the production more than 2000 hours of 3090 CPU time was used. The software for simulation and rendering was written in C. Simulation was performed in the AIX/370 system. Rendering was done under AIX/370 and MVS.