Literature Review 2

Primary paper:

Full-Body Animation of Human Locomotion in Reduced Gravity Using Physics-Based Control.

@ARTICLE{8103322,
author={Y. h. Kim and T. Kwon and D. Song and Y. J. Kim},
journal={IEEE Computer Graphics and Applications},
title={Full-Body Animation of Human Locomotion in Reduced Gravity Using Physics-Based Control},
year={2017},
volume={37},
number={6},
pages={28-39},
keywords={computer animation;gait analysis;nonlinear control systems;path planning;pendulums;Froude number;character model;gravitational conditions;human locomotion;motion planner;pendulum trajectory generator;physics-based control;pre-estimation model;reduced gravity;robust full-body animation;stable body animation;stride frequency;tracking;Adaptation models;Biological system modeling;Computational modeling;Gravity;Legged locomotion;Predictive models;Trajectory;3D graphics;animation;computational geometry;computer graphics;object modeling;physics-based modeling},
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Secondary paper:

Control systems for human running using an inverted pendulum model and a reference motion capture sequence

@inproceedings{Kwon:2010:CSH:1921427.1921447,

author = {Kwon, Taesoo and Hodgins, Jessica},

title = {Control Systems for Human Running Using an Inverted Pendulum Model and a Reference Motion Capture Sequence},

booktitle = {Proceedings of the 2010 ACM SIGGRAPH/Eurographics Symposium on Computer Animation},

series = {SCA '10},

year = {2010},

location = {Madrid, Spain},

pages = {129--138},

numpages = {10},

url = {http://dl.acm.org/citation.cfm?id=1921427.1921447},

acmid = {1921447},

publisher = {Eurographics Association},

address = {Aire-la-Ville, Switzerland, Switzerland},

}

Summary:

The primary paper used a pre-estimation model based on the Froude number to predict the desired velocity and stride frequency of a character model in hypogravity, so that they could generate full-body animation using a pendulum trajectory generator, motion planner, and tracking. And the proposed physics-based approach can generate stable and robust full-body animation of various gaits under different gravitational conditions. In the computer graphics field, physics-based locomotion control has been an important problem because of its potential to adapt to unexpected unstable. In early time, controllers often used hand-designed finite-state machines and feedback rules for balance control. Some people have used the preview control of simplified dynamic models abstracting the human body for efficient low-dimensional planning. As results, their simulation can generate stable and robust full-body animation of various gaits under different gravitational conditions. In second paper, they showed a balancing control algorithm based on a simplified dynamic model, an inverted pendulum on a cart. This method is mentioned as before in primary paper. Because of the simplified model lacks the degrees of freedom found in a full human model, they analyzed a captured reference motion in a preprocessing step and used that information about human running patterns to supplement the balance algorithms provided by the inverted pendulum controller. At run-time, the controller plans a desired motion at every frame based on the current estimate of the pendulum state and a predicted pendulum trajectory. By tracking this time-varying trajectory, their controller creates a running character that dynamically balances, changes speed and makes turns. The initial controller can be optimized to further improve the motion quality with an objective function that minimizes the difference between a planned desired motion and a simulated motion. They proved the power of this approach by generating running motions at a variety of speeds (3 m/s to 5 m/s), following a curved path, and in the presence of disturbance forces and a skipping motion. How did they process produces a stable running controller for the speed of the human reference trajectory? Firstly, they built up an off-line analysis step to create a trajectory generator for an inverted pendulum that mimics the trajectory of the center of mass extracted from the human reference motion. And then the pendulum trajectory generator was used as part of an on-line motion planner that takes as input the desired speed and turning rate and produces a trajectory for an inverted pendulum which is then converted into footstep locations and a desired human trajectory. In the end, the human running motion is synthesized by tracking the human trajectory from the motion planner with a full dynamic model of a human.

Relationship:

1. In primary paper, on the Physics-Based character control part, they mentioned a method that control of simplified dynamic models abstracting the human body for efficient low-dimensional planning, which was proposal in second paper dynamitic model and LQR controller, they used a geometric mapping between the pendulum and the character that is intuitive and smooth.
2. In primary paper, they used an approach that optimized reference trajectories to solve locomotion control problems. Often, reference tracking controllers use motion capture data because it can reproduce believable human motion. The method was described on second paper. Firstly, they generated reference coordinates L{t} and W{t} at phase t for foot placements by sampling the pre-dicted pendulum trajectory. And then, an error feedback scheme to convert force F to torque for the full body character.
3. In primary paper, on the Physics-Based Character Control Using Optimization part, they indicated a control algorithm is formulated as an online optimization problem that is solved for each frame. The goal of the online optimization is to find the optimal joint torques and contact forces to control the model. At every frame, their controller adjusted the reference motion using a balance strategy. The good strategy was talked in Tracking part on second paper. They used both hybrid dynamics solver and low-gain PD-servo for tracking. The hybrid dynamics solver computes torques/forces for all joints so that state estimation, motion planning and tracking, the controller can balance a running motion.
4. In primary paper, on the Offline Optimization part, the controller is not optimal in terms of motion quality and cannot generalize for environments

with reduced gravity. To produce controllers that work in such environments, they first modified the character's forward velocity and the gait cycle's duration and then employed a controller optimization technique proposed in earlier work. The technique They used is a randomized optimization algorithm called covariance matrix adaption evolution scheme on second paper. In optimization chapter, they first generated a modified reference human trajectory using the motion planner. Because they used the motion planner to generate a reference trajectory, the optimization can be done at any speed/turning speed profiles. They found optimization in the 24-dimensional space often lead to a local minim. Therefore, they decomposed it into two overlapping sets of variables, and alternate optimization of each subset.

5. In primary paper, on the Qualitative Comparisons against Existing Methods part, they built their controller based on the tracking algorithm. This algorithm presented in tracking chapter on second paper. They used an implementation of the hybrid/forward dynamics solver based on the Lie-group formulation, and verified that our scheme produces visually indistinguishable results on the well-known commercial forward simulator SD/FAST. The state estimation and motion planning step are executed at 120hz while the forward dynamics simulation uses a much higher frame rates. As result, the desired motion is treated as a continuous function using a piecewise linear curve.

The five portions are relationship between these two papers.