Composable Controllers for Humanoid Motion

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Motivation

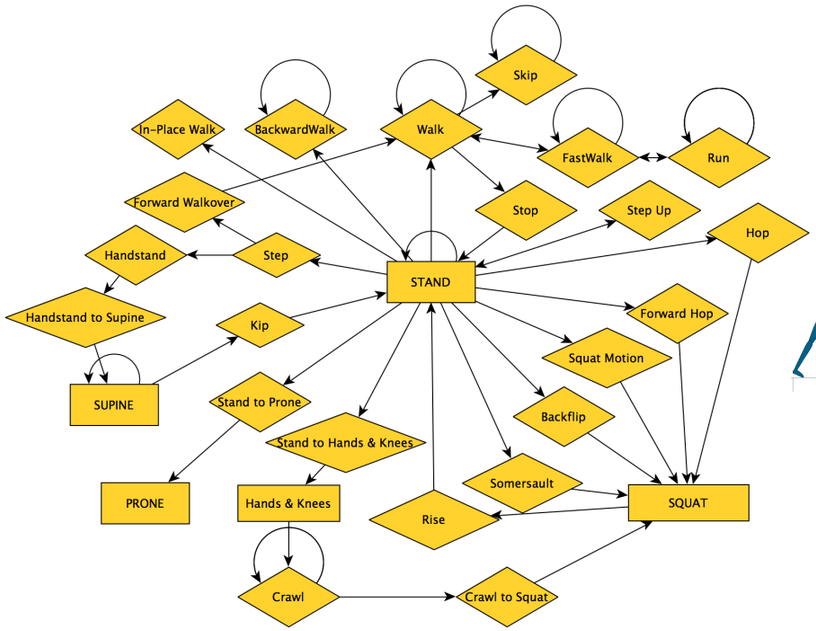
While many methods exist for the development of motions for physically simulated humanoids, they are rarely reimplemented or reused by others. The predominant focus of papers remains in algorithmic novelty, due to the difficulty to more fully explore what can be accomplished within the scope of existing methodologies. This is the case despite various methods having many features in common.

Domain specific languages such as PostScript or Renderman have made significant advancements in their field. We propose a rich, detailed language that can be used to develop a wide variety of controllers.

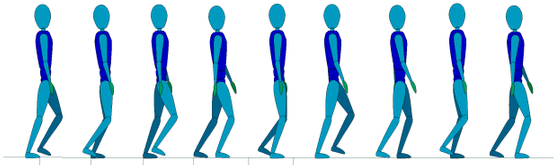
Challenges

- Lack of authoring tools available to novice and expert users alike
- Lack of a general controller representation
- Lack of existing methods for finding viable transitions.

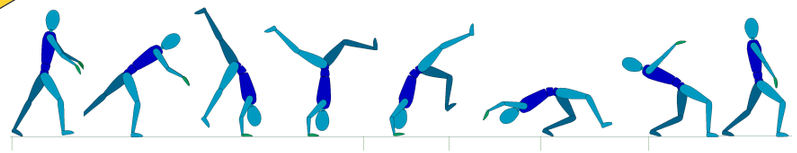
Controllers



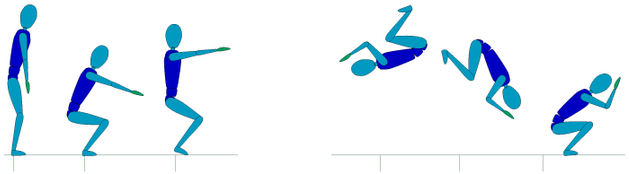
Implemented controllers and transitions



Walking



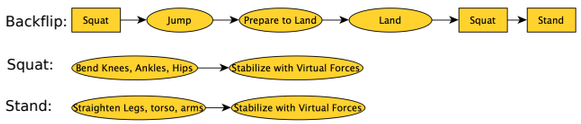
Forward Walkover



Backflip

Language

Hierarchical Phase-Based Structure



Stair-Climbing script

```
BEGINSCRIPT step_up(x, y)

# Phase Based Structure
PHASE 0
> standVFFB.t(.1);
TRANSITION to(1).after(complete);
ENDPHASE

PHASE 1
ACTIONS
        # Inverse Kinematics
        IK rFoot.targetlocal(0.1, -.6, 0).base(rHip);
        # Virtual Force Feedback
        VFFB uTorso(3000., 250.).by([Ankle).over(cop);
ENDACTIONS
TRANSITION to(2).after(time .2);
ENDPHASE

PHASE 2
ACTIONS
        IK rFoot.targetglobal(x, y, -10).base(rHip).tolerance(0.001);
        VPD rFoot(0.0, -300, -30).joint(rAnkle);
        VFFB uTorso(3000., 250.).by([Ankle).over(lFoot);
ENDACTIONS
TRANSITION to(3).after(time .3);
ENDPHASE

PHASE 3
ACTIONS
        # PD-Controller
        LIPOSE rHip(0.0).time(5);
        VPD rFoot(0.0, -1000, -100).joint(rAnkle);
        VFFB uTorso(3000, 250.).by([Ankle).over(lFoot);
ENDACTIONS
TRANSITION to(4).after(contact rFoot);
ENDPHASE

PHASE 4
ACTIONS
        VFFB uTorso(3000, 400.).by([Ankle).over(rFoot);
        VPD uTorso(0.0, 100, 10).joint(rHip);
        POSE rAnkle(0., 0., 100);
ENDACTIONS
TRANSITION to(5).after(time 1);
ENDPHASE
```

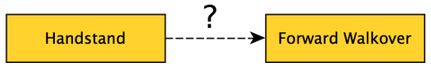
Control Primitives

- Proportional Derivative
- Virtual Forces
- Inverse Kinematics
- External Force
- Gravity Compensation
- Balance Feedback
- Speed Feedback

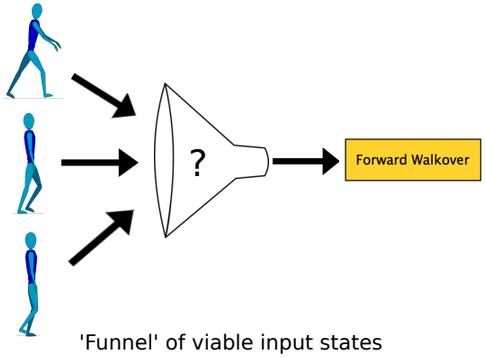
Desired Features

Virtual Forces

Transitions



Optimizing for New Transitions



'Funnel' of viable input states

Future Work

- Extension to 3D
- Model of all possible transitions
- Crowd sourcing controller development
- Web interface for submitting new controllers
- Learning new transitions upon submitting a controller

Previous Work

- Faloutsos, P. , van de Panne, M., and Terzopoulos. D. Composable controllers for physics-based character animation. (SIGGRAPH '01).