Realistic Characters in Interactive Virtual Environments

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Overview

- **Introduction**
  - GATE project
  - Challenges in Animation
- **Body animation**
  - Example-based motion synthesis
  - Path following (navigation)
  - Ongoing: Combining navigation with manipulation tasks
- **Facial animation**
  - Simulating crying motions
- **Conclusions**

My background

- **UD at Universiteit Utrecht**
  - "Games and Virtual Worlds" research group
  - Master courses: Game Programming in C++, Seminar Animation
- **PhD (2006) in MIRALab – University of Geneva on interactive characters**
- **Studied computer science at Universiteit Twente**
- **Current research focused on character animation**
  - Realistic body motion
  - Facial expressions
  - Combining navigation and manipulation motions
- **Mainly work in the GATE project**

The GATE project

- **GATE Project funded by Dutch government**
- **10 million euro funding, total size 19 million euro**
- **Collaboration with TU Delft, UT, Waag, Thales, NBL, many SMEs**
- **Structure**
  - Research
  - Knowledge Transfer Projects
  - Pilots in domains Education, Health, Safety

http://gate.gameresearch.nl

Research in GATE

- **Modeling the World**
- **Simulating the World**
- **Virtual Characters**
- **Interacting with the World**
- **Affective Appraisal**
- **Adaptive Game Play**
- **Learning with Simulated Worlds**
- **The X-factor**

Introduction

Characters in games and simulations

- **Computer games contain a lot of animated characters**

Introduction

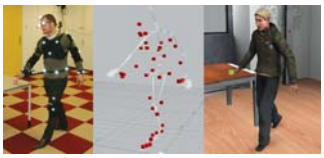
Animation challenges

- **Body motion**
  - Natural motion
  - Smooth animations
  - Lots of possible actions
  - Physical simulation
- **Facial motion**
  - Facial expressions
  - Speech animation
  - Other facial motions, such as crying, blushing, laughing…
- **Other animation challenges**
  - Hair and clothing simulation
  - Deformable objects
  - …

Introduction

Body animation

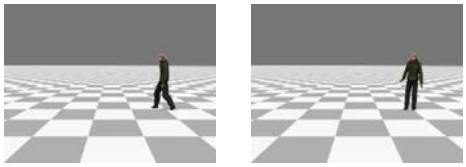
- **Games mostly use motion capture → natural motions**
  - Need resources (actors, directors, engineers)
  - Noise, occlusion, post processing
  - Data hard to modify afterwards
  - Still not natural!
- **Algorithms have been developed to re-use motions**



Problem

Blending

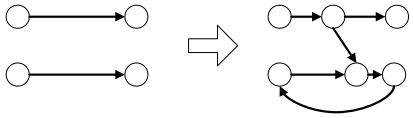
- **Concatenate two motions by blending from one motion to the other using interpolation**
  - might introduce artifacts (foot skating)
- **Blending introduces the least artifacts when the start and end point of the transition "resemble" each other**



Problem

Motion graphs

- **An automatically generated graph that captures natural transitions between motions (Kovar et al. 2002)**
- **Originally created manually**
- **Edge is a motion, node is a frame**
- **Create new edges between similar nodes using blending**

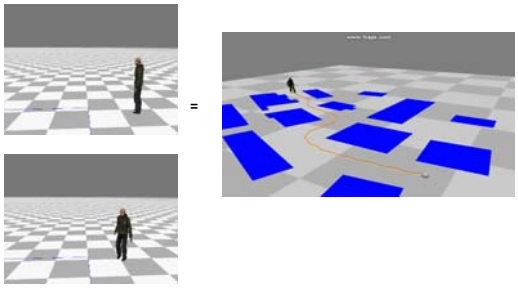


What are good transition points?
We need a notion of resemblance!

Problem

Motion graphs

- **Generate a constrained motion by graph search**



Distance metrics

Posture distance metrics

- **Crucial in motion blending, time warping, motion retrieval and performance analysis**
- **Many different distance metrics:**
  - Joint angles
  - Point cloud (geometrical)
  - PCA (motion heuristic)
- **The choice of distance metric is never really motivated**
- **We have compared these 3 different metrics in a motion graph**

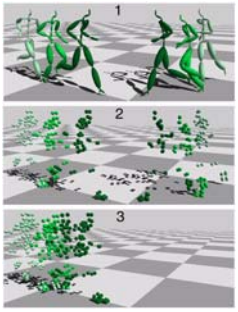
Distance metrics

Point-cloud metric

- Construct a point-cloud over window of frames
- Registration of cloud *a* and *b*

$$d(a,b) = \min_{\theta,x_0,z_0} \sum_i w_i (a_i - T_{\theta,x_0,z_0} b_i)^2$$

- Weighted distance over points



M. Gleicher, *Snap-Together Motion: Assembling Run-Time Animations, I3D '03*

Distance metrics

Joint-angle metric

- Determine differences between joint angles of skeleton

$$d(a,b) = \sum_{k \in J} w_k \left\| \log(q_{b,k}^{-1} \cdot q_{a,k}) \right\|^2$$

PCA metric

- Principal component analysis on linear representation of joint angles
- Weighted Euclidean distance in PC representation, weights are Eigen values

$$d(a,b) = \sum_{i=0}^{N} w_i \cdot (a_i - b_i)^2$$

Experiment

Quantitative evaluation

- 4 motion graphs per metric
- Graph sizes are equal for all metrics
- Generate 20 animations on a long zigzag path
- Database of 5 clips of locomotion with different curvatures
- Applied standard B&B search algorithm
- Metrics evaluated over window of 10 frames
- Measured foot skating, path deviation, computation time

Experiment

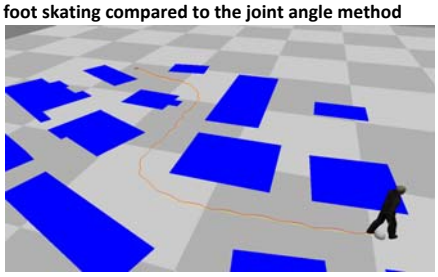
Qualitative analysis

- Does a distance metric correspond to the human perception?
- User test, 251 participants
- 40 out of 50 motions of 5s in random order
- 45 blends occurring at various times corresponding to various distances:
  15 per metric + 5 mocap

Results

Quantitative evaluation

- Point cloud metric results in path deviation, yet less foot skating compared to the joint angle method



Results

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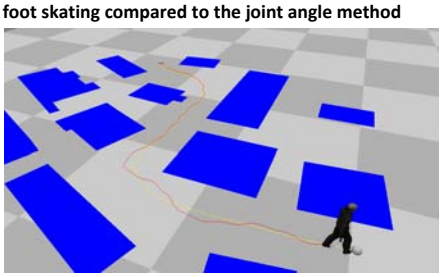
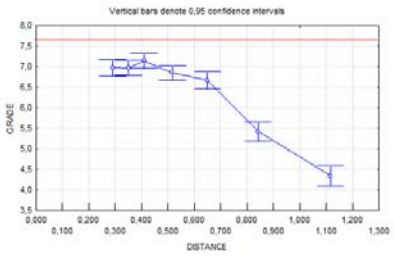


Results

Qualitative analysis

- Does a distance metric correspond to the human perception?
- PCA metric:



Conclusion

Quantitative

- Use joint angle based metric for path planning in highly constrained environment
- Use joint angle based metric for fast synthesis
- Use point cloud based metric for the least foot skating
- PCA based metric provides trade-off, no need to set weights

Qualitative

- Threshold can be safely increased on the plateau without sacrificing perceived blend quality
- This allows for more transitions in the graph, leading to more flexibility

Combining Navigation and Manipulation

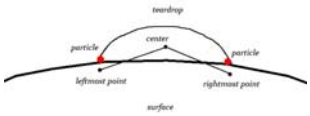
How to combine navigation and manipulation tasks?

- Adapting path to allow for manipulation
- But path representation is no longer sufficient/logical
  - Currently investigating step-based approach
- How to combine the upper and lower body motions?
  - Sometimes straightforward → use IK
  - Often more difficult → planning required
- Still ongoing work

Facial animation

Simulating crying

- Phenomena of crying:
  - Tears
  - Facial expressions
  - Red/glassy eyes
  - Red skin around tears



- How to simulate it
  - Standard MPEG4 facial animation is not sufficient
  - Introduce fluid simulation on top of the face (particle-based)
  - Simulate tear-skin interaction by tear trail synthesis
- How to control it
  - Extension of FAP parameters to control number of particles

Facial animation

Discussion and future work

Conclusions

- Body animation
  - We can generate locomotion for any given path
  - Challenge: combining with other actions
- Facial animation
  - More complex facial animation (crying) is now possible
  - More research into muscle models, other facial motions is needed
- These are but small steps toward a more natural, interactive and affective virtual human

Questions

Questions?

This research has been supported by the GATE project, funded by the Netherlands Organization for Scientific Research (NWO) and the Netherlands ICT Research and Innovation Authority (ICT Regie).

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