Building Lifelike Humanoid (and Non-Humanoid) Characters

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Physical Characters in Theme Parks

Meet and greet

Queue line

Attraction

Show

Interactive/close

Scripted/remote
Building “Useless” Robots

Difficult to quantify the goal
Technology must be transparent to users
Technology must be used to tell stories
Requires human (anthropomorphemic) form
Less environmental constraints
Lifelike Characters

Motion
- Style and personality

Interaction
- Reactive and safe

Design
- Size and shape
Talk Outline

1. **Motion**
   - Style and personality

2. **Interaction**
   - Reactive and safe

3. **Design**
   - Size and shape
Talk Outline

- **Motion**
  - Style and personality

- **Interaction**
  - Reactive and safe

- **Design**
  - Size and shape
Motion

Style and personality

Motion
Style and personality

Interaction
Reactive and safe

Design
Size and shape
Motion
Style and personality

Created by animators (expensive)
No real locomotion/manipulation
Human to Humanoid Motion Retargeting

Already have style and personality but …

- Different kinematics and dynamics
- Different actuators
- Different constraints
  - Joint motion range
  - Joint velocity/acceleration limits
  - Joint torque limits
- Contacts
Human to Humanoid Motion Retargeting

[Mistry, Murai, Yamane, Hodgins 2010]
Human to Humanoid Motion Retargeting

[Yamane, Anderson, Hodgins 2010]
Human to Non-humanoid Motion Retargeting
Human to Non-humanoid Motion Retargeting

[Yamane, Ariki, Hodgins 2010]
Mapping Function

Gaussian process latent variable model (GPLVM) [Lawrence 2003]

- low-dimensional latent space
- high-dimensional observation space

Shared GPLVM [Ek et al. 2007]

- human pose
- common feature
- character pose

GPLVM

GPLVM

GPLVM
Results: Emotional Motions

- anger
- disgust
- sadness
- fear

[Yamane, Ariki, Hodgins 2010]
Design

Size and shape

Size/shape constraints
Untethered
Lots of manual work
Untethered Hopping Robot

Linear Elastic Actuator in Parallel (LEAP)

Voice coil
1D Testbed

Stiffness optimization
Lifelike Characters

Motion
Style and personality

Interaction
Reactive and safe

Design
Size and shape
Interaction
Reactive and safe

Teleoperation (expensive)
No physical interaction
Safe Autonomous Interaction: Playing Catch

[Kober, Glisson, Mistry 2012] [Carter et al. 2014]

Safe physical interaction between guests and robot

Uses existing Audio-Animatronic Figure and controller

Reaction to ball drop with social gestures
Robot
- All gestures are hand-coded and invoked based on ball trajectory
- Lookup table for arm inverse kinematics

Stereo cameras
- Kalman filter to smooth trajectory in flight
- Predict catching location
Reaction to Ball Drop

Untrained Participants
User Study

Questionnaire: more responsive, engaging, and humanlike when the robot displayed gestures

Smile detection: more smiles when the robot displayed gestures

Long-term study necessary to address novelty effect
Juggling with Trained Users

[Kober, Glisson, Mistry 2012]
Lifelike Characters

- **Motion**: Style and personality
- **Interaction**: Reactive and safe
- **Design**: Size and shape
Robot from Animation Character

Maya model → kinematics, shape

Maya animation → number of joints, range of motion and torque
Animation Retargeting

original animation
Animation Retargeting

target motion
Animation Retargeting

optimized motion

[Song, Kim, Yamane 2015]
Animation Retargeting

optimized walking on hardware
Lifelike Characters

Motion
Style and personality

Interaction
Reactive and safe

Design
Size and shape
Human-to-Robot Handover

Quick and natural adaptation to human motion

Learn from human-to-human handover
Human-to-Human Handover

Passer starts moving the object
Receiver recognizes the intention and starts reaching out
Passer and receiver implicitly agree on handover position
Receiver grasps the object
Passer releases the object
Human-to-Robot Handover

Passer starts moving the object

Robot recognizes the intention and starts reaching out

Passer and robot implicitly agree on handover position

Robot grasps the object

Passer releases the object
Observation

Similar motions in similar situations
Relative orientation and distance
Object/grasp type

Predict the receiver’s pose from the passer’s with database
Method Overview

Database of human-to-human handover motions

[Yamane, Revf, Asfour 2013]
Method Overview

Search observed human motion within the passer motion database

Database of human-to-human handover motions
Method Overview

Synthesize robot motion based on the corresponding receiver motion

Search observed human motion within the passer motion database

Database of human-to-human handover motions
Sample Data

“Face-to-face” dataset (3 objects, 1686 frames, 10 layers)

“Side-by-side” dataset (2 objects, 863 frames, 9 layers)
Simulation: Synthesis from Test Data

[Yamane, Revfi, Asfour 2013]
Simulation: Detailed View

Tape

Bottle

[Yamane, Revfi, Asfour 2013]
Hardware Implementation

[Yamane, Revfi, Asfour 2013]
Lifelike Characters

Motion
Style and personality

Interaction
Reactive and safe

Design
Size and shape
Intimate Physical Interaction

Bearbot

- Soft body for impact reduction and force sensing
- 3D printed air-filled modules with pressure sensor
- Fits an animation character’s shape
3D-Printed Air-Filled Module

[Kim, Alspach, Yamane 2015]
Future Direction

- Motion: Style and personality
- Interaction: Reactive and safe
- Design: Size and shape

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Questions?  
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