Agenda

• Intro to H-Anim Concepts
• H-Anim Nodes
• Demos: Authoring and Applications for H-Anim Characters
• Future Directions and Issues
Introduction to H-Anim Concepts

• Purpose
• Goals
• Hierarchy
• Levels of Articulation (LoA)
• Modeling
Purpose

- Support the Creation of Interchangeable Humanoids, Behaviors, and Animations
- Support the Development of Authoring Tools for Modeling and Animating Humanoids
- Examples of Applications
  - Games & Entertainment
  - Ergonomic Studies
  - Education and Training
Virtual Humans in Learning, Education, and Training

- Demonstration of procedures
- Presentations
- Role-playing actors
- Interpreters
Goals

• **Compatibility**: Humanoids should work in any compliant browser.

• **Flexibility**: No assumptions are made about the types of applications that will use humanoids.

• **Simplicity**: When in doubt, leave it out. The specification can always be extended later.
Hierarchy of Joints and Segments

• Implicit assumptions & approximations:
  – Joints approximated by rotations about points.
  – Major deformations of body surface are caused by rotations about these joints.
Hierarchy (LOA 1)

HumanoidRoot : sacrum
  sacroiliac : pelvis
    l_hip : l_thigh
      l_knee : l_calf
      l_ankle : l_hindfoot
      l_midtarsal : l_middistal
    r_hip : r_thigh
      r_knee : r_calf
      r_ankle : r_hindfoot
      r_midtarsal : r_middistal
  vl5 : 15
    skullbase : skull
      l_shoulder : l_upperarm
        l_elbow : l_forearm
        l_wrist : l_hand
      r_shoulder : r_upperarm
      r_elbow : r_forearm
      r_wrist : r_hand

"vee-el-5", not "vee-15"

joint : segment
# Levels of Articulation

<table>
<thead>
<tr>
<th>Description</th>
<th>LoA 0</th>
<th>LoA 1</th>
<th>LoA 2</th>
<th>LoA 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Humanoid Root Only</td>
<td>Typical Simple Model w/ Fixed Hands</td>
<td>Typical Complex Model w/ Articulated Hands</td>
<td>Complex Model with Articulated Hands &amp; Spine (24 Vertebrae)</td>
<td></td>
</tr>
<tr>
<td>Joints</td>
<td>1</td>
<td>18</td>
<td>71</td>
<td>89</td>
</tr>
</tbody>
</table>
Complete H-Anim Hierarchy of Joints

r_eyebrow
r_eyeball  temporomandibular  l_eyebrow
r_eyelid  skullbase  l_eyelid
vc_1
...
vc_7
r_sternoclavicular  vt_1  l_sternoclavicular
r_acromioclavicular  ...  l_acromioclavicular
r-shoulder  vt_11  l-shoulder
r-elbow  vl_1  l-elbow
r_wrist  ...  l_wrist
vl_5
r-hip
r-knee
r-ankle
r-subtalar
r-midtarsal
r-metatarsal

Total of 23 Vertebrae

l_eyebrow
l_eyeball
l_eyelid
l_sternoclavicular
l_acromioclavicular
l-shoulder
l-elbow
l_wrist
l-hip
l-knee
l-ankle
l-subtalar
l-midtarsal
l-metatarsal

Vertebrae
Modeling

- **Rest Position**
  - Standing
  - Arms at side
  - Fingers down
  - Thumbs at 45 deg.
  - Eyes Ahead and Open
  - Eyebrows neutral
  - Mouth Closed
H-Anim Nodes

• Basic Nodes
  – Humanoid
  – Joint
  – Segment

• Advanced Nodes
  – Sites
  – Displacers

interface Humanoid {
    float[3] bboxCenter
    float[3] bboxSize
    float[3] center
    sequence<string> info
    sequence<Object> joints
    string name
    float[4] rotation
    float[3] scale
    float[4] scaleOrientation
    sequence<Object> segments
    sequence<Object> sites
    sequence<Object> skeleton
    sequence<Object> skin
    sequence<float[3]> skinCoord
    sequence<float[3]> skinNormal
    float[3] translation
    string version
    sequence<Object> viewpoints
}
Humanoid Node (VRML Syntax)

PROTO Humanoid [
  field SFVec3F bboxCenter 0 0
  field SFVec3F bboxSize -1 -1 -1
  exposedField SFVec3F center 0 0
  exposedField MFString info []
  exposedField MFNode joints []
  exposedField SFString name ""
  exposedField SFRotation orientation 0 0 1 0
  exposedField SFVec3f scale 1 1 1
  exposedField SFRotation scaleOrientation 0 0 1 0
  exposedField SFRotation scaleOrientation 0 0 1 0
  exposedField MFNode segments []
  exposedField MFNode sites []
  exposedField MFNode skeleton []
  exposedField MFNode skin []
  exposedField SFNode skinCoord NULL
  exposedField SFNode skinNormal NULL
  exposedField SFVec3f translation 0 0 0
  exposedField SFString version "2.0"
]
# Humanoid Node (X3D Bindings)

**HAnimHumanoid**

- **SFFvec3f** [in,out] `center` 0 0 0 \((-\infty, \infty)\)
- **MFString** [in,out] `info` [ ]
- **MFNode** [in,out] `joints` [ ] [HAnimJoint]
- **SFNode** [in,out] `metadata` NULL [X3DMetadataObject]
- **SFString** [in,out] `name` ""
- **SFRotation** [in,out] `rotation` 0 0 1 0 \((-\infty, \infty)][-1,1]\)
- **SFFvec3f** [in,out] `scale` 1 1 1 \((0, \infty)\)
- **SFRotation** [in,out] `scaleOrientation` 0 0 1 0 \((-\infty, \infty)][-1,1]\)
- **MFNode** [in,out] `segments` [ ] [HAnimSegment]
- **MFNode** [in,out] `sites` [ ] [HAnimSite]
- **MFNode** [in,out] `skeleton` [ ] [HAnimJoint]
- **MFNode** [in,out] `skin` [ ] [X3DChildNode]
- **SFNode** [in,out] `skinCoord` NULL [X3DCoordinateNode]
- **SFNode** [in,out] `skinNormal` NULL [X3DNormalNode]
- **SFFvec3f** [in,out] `translation` 0 0 0 \((-\infty, \infty)\)
- **SFString** [in,out] `version` ""
- **MFNode** [in,out] `viewpoints` [ ] [Viewpoint]
- **SFFvec3f** [] `bboxCenter` 0 0 0 \((-\infty, \infty)\)
- **SFFvec3f** [] `bboxSize` -1 -1 -1 \([0, \infty)\) or \(-1\, -1\, -1\)
Humanoid Node (XML Syntax)

```xml
<HumanoidNode

DEF="" ID=""
USE="" IDREF=""
age="" SFString
authorEmail="" SFString
authorName="" SFString
center="" SFVec3f [in, out]
copyright="" SFString
creationDate="" SFString
gender="" SFString
height="" SFString [init]
humanoidVersion="" MFString [in, out]
info="" SFString [in, out]
name="" SFString [in, out]
rotation="" SFRotation [in, out]
scale="" SFVec3f [in, out]
scaleOrientation="" SFRotation [in, out]
translation="" SFVec3f [in, out]
usageRestrictions="" SFString [in, out]
version="" SFString [in, out]
weight="" SFString [in, out]
containerField=""children"" NM_TOKEN
class="" string

/>
Stickboy Demo
Joint Node

PROTO Joint [

exposedField SFVec3F center 0 0 0
exposedField MFNode children []
exposedField MFFloat llimit []
exposedField SFRotation llimitOrientation 0 0 1 0
exposedField SFString name ""
exposedField SFRotation rotation 0 0 1 0
exposedField SFVec3f scale 1 1 1
exposedField SFRotation scaleOrientation 0 0 1 0
exposedField SFNode skinCoordIndex []
exposedField MFNode skinCoordWeight []
exposedField MFFloat stiffness [0 0 0]
exposedField SFVec3f translation 0 0 0
exposedField MFNode ulimit []
]

new!
Segment Node

PROTO Segment [
  field SFVec3F bboxCenter 0 0
  field SFVec3F bboxSize -1 -1 -1
  exposedField SFVec3F centerOfMass 0 0
  0 exposedField MFNode children []
  exposedField SFNode coord NULL
  exposedField MFNode displacers []
  exposedField SFFloat mass 0
  0 0 0 0 0 exposedField MFFloat momentsOfInertia [0 0 0 0 0 0 0 0 0]
  exposedField SFString name “ ”
  exposedIn MFNode addChildren
  exposedIn MFNode removeChildren
]

Seamless Character Demo

• Skin deformation new with H-Anim 200x.
• Each joint influences subset of skin vertices.
  – Approach commonly used in real-time gaming.
  – Can exhibit foreshortening (“sausage link”, “soda straw” effects for large motions)
Overcoming Limitations of Blending Method: “Mini-Bones”

Three “mini-bones” with vertex interpolation.

Standard bones with vertex interpolation.
Site Node

- **Purpose**
  - “end effector” for Inverse Kinematics
  - attachment point for clothing, jewelry, etc.
  - location for a virtual camera in the reference frame of a Segment object (e.g., eyepoint of humanoid)

**PROTO Site**

```plaintext
PROTO Site [
  exposedField  SFVec3F   center        0 0 0
  0 exposedField MFNode  children      []
  exposedField  SFString name         “ ”
  exposedField  SFRotation rotation   0 0 1 0
  exposedField  SFVec3f  scale         1 1 1
  exposedField  SFRotation scaleOrientation 0 0 1 0
  exposedField  SFVec3f  translation   0 0 0
  exposedIn     MFNode   addChildren
  exposedIn     MFNode   removeChildren
]
```
Suggested Feature Point Names - 1

Position index | H-Anim feature point name
---|---
1 | sellion
2 | r_infraorbitale
3 | l_infraorbitale
4 | supramenton
5 | r_tragion
6 | r_gonion
7 | l_tragion
8 | l_gonion
9 | nuchale
10 | r_clavicale
11 | suprasternale
12 | l_clavicale
74 | r_neck_base
75 | l_neck_base

Site Names are adapted from:


http://www.sae.org/technicalcommittees/caesarhome.htm

* - Civilian American and European Surface Anthropometry Resource
Suggested Feature Point Names - 2

<table>
<thead>
<tr>
<th>H-Anim feature point name</th>
<th>H-Anim feature point name</th>
</tr>
</thead>
<tbody>
<tr>
<td>13 r_thelion/bustpoint</td>
<td>29 r_acromion</td>
</tr>
<tr>
<td>14 l_thelion/bustpoint</td>
<td>30 r_axilla_ant</td>
</tr>
<tr>
<td>15 substernale</td>
<td>31 r_radial_styloid</td>
</tr>
<tr>
<td>16 r_rib10</td>
<td>32 r_axilla_post.</td>
</tr>
<tr>
<td>17 r_asis</td>
<td>33 r_olecranon</td>
</tr>
<tr>
<td>18 l_rib10</td>
<td>34 r_humeral_lateral_epicn</td>
</tr>
<tr>
<td>19 l_asis</td>
<td>35 r_humeral_medial_epicn</td>
</tr>
<tr>
<td>20 r_iliocristale</td>
<td>36 r_radiale</td>
</tr>
<tr>
<td>21 r_trochanterion</td>
<td>37 r_metacarpal_pha2</td>
</tr>
<tr>
<td>22 l_iliocristale</td>
<td>38 r_dactylion</td>
</tr>
<tr>
<td>23 l_trochanterion</td>
<td>39 r_ulnar_styloid</td>
</tr>
<tr>
<td>24 cervicale</td>
<td>40 r_metacarpal_pha5</td>
</tr>
<tr>
<td>25 rib10_midspine</td>
<td>41 l_acromion</td>
</tr>
<tr>
<td>26 r_psis</td>
<td>42 l_axilla_ant</td>
</tr>
<tr>
<td>27 l_psis</td>
<td>43 l_radial_styloid</td>
</tr>
<tr>
<td>28 waist_preferred_post</td>
<td>44 l_axilla_post.</td>
</tr>
<tr>
<td></td>
<td>45 l_olecranon</td>
</tr>
<tr>
<td></td>
<td>46 l_humeral_lateral_epicn</td>
</tr>
<tr>
<td></td>
<td>47 l_humeral_medial_epicn</td>
</tr>
<tr>
<td></td>
<td>48 l_radiale</td>
</tr>
<tr>
<td></td>
<td>49 l_metacarpal_pha2</td>
</tr>
<tr>
<td></td>
<td>50 l_dactylion</td>
</tr>
<tr>
<td></td>
<td>51 l_ulnar_styloid</td>
</tr>
<tr>
<td></td>
<td>52 l_metacarpal_pha5</td>
</tr>
</tbody>
</table>
Suggested Feature Point Names - 3

Note: Data scanned from 4,400 American, Canadian, Dutch, and Italian subjects is available from the CAESAR project.

Tools for converting to H-Anim are being developed by the U.S. National Institute of Standards and Technologies (NIST).
Displacer Node

• Purpose
  – identify specific groups of vertices within a mesh (either segment or skin field of humanoid node).
  – simulate muscle actions not associated with joints
    – eyebrows, lips, breathing, …
  – provide “hints” as to the direction in which each vertex should move.

PROTO Displacer [
  exposedField MFInt32 coordIndex [ ]
  exposedField MFVec3f displacements [ ]
  exposedField SFString name “ ”
]
Facial Animation

• Basic Facial Expressions can be modeled using H-Anim Face Joints

  skullbase : skull
  l_eyelid_joint : l_eyelid
  r_eyelid_joint : r_eyelid
  l_eyeball_joint : l_eyeball
  r_eyeball_joint : r_eyeball
  l_eyebrow_joint : l_eyebrow
  r_eyebrow_joint : r_eyebrow
  temporomandibular : jaw

• More complex facial animations and lip-synch may use displacers or other approaches to simulate 40+ muscles of the face.
Sites Demo
How do I get/create H-Anim characters?

• X3D / H-Anim Authoring Tools
  – Virtock VizX3D (www.vizx3d.com)
  – Milk Shape (www.smeenk.com)
  – X3D Edit (www.web3d.org)

• CAESAR Data and Conversion Tools
  – NIST (ovrt.nist.gov)

• Conventional 3D Modeling & Animation SW (3D Studio Max, Maya)
  – Export VRML, Convert to H-Anim

• H-Anim Web Site (www.h-anim.org/Models/)
  – Examples for public use
Demonstration: VizX3D
Demonstration: Vcommunicator Studio
References

• X3D & Related Specifications
  • Humanoid Animation (H-Anim) Specification
    – ISO / IEC FCD 19774:200x
    – abstract representation for modeling three dimensional human figures
  • X3D Draft Specifications
    – ISO / IEC FCD 19776:200x (X3D Encodings)
• X3D Schema & DTD
• VRML97 Specification
  – base functionality and text encoding for VRML
  – External Authoring Interface.

All specifications are available at www.web3d.org
Moving Forward: Open Issues

• Library and interchange standard for common animations
• Specification and implementation of higher-level actions
  – Inverse Kinematics: Pointing, Touching, Grasping
  – Facial expression and gaze direction
  – Speech and lip-synch
• Improved seamless mesh algorithms
• Open Discussion