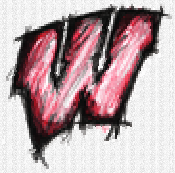
Animation by Example
Lecture 2:
Motion Signal Processing



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Recap: Representation

- Represent human as hierarchical skeleton
- Vector with 1 position, 1 absolute orientation, many relative orientations
- Vector really isn't in R^N
- Many different ways to do this
- Many things to be careful of

How do skeletons differ?

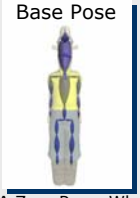
- Obvious ways?
  - Topology
    - number of bones
    - Connectivity of bones
  - Joint Types
  - Bone lengths
  - Anatomical / skin relations
    - Is spine in middle of body, or up the back?

Subtle Skeletal Differences

- What to measure angles with respect to
  - Doesn't matter, as long as we agree
- Poses (design of a skeleton)
  - Zero Pose / Base Pose
  - Dress or Binding pose
  - Frankenstein Pose
  - Da Vinci Pose
  - Rest Pose (real pose of actor)
- Need to figure out how to get between these

Target Poses

Base Pose



AKA Zero Pose. What happens when all joints are set to zero

Bind Pose

AKA Dress Pose. What is required to fit in the skin

- Poses specified by technical needs
- May look different for each setup

Reference Poses

Frankenstein

All limbs vertical (AKA Zombie)

Da Vinci

Arms Horizontal, Legs Spread

Rest

How the actor stands at rest

- Defined by how pose looks
- Not the same values

Why do we care?

- Motion data is relative to base pose
  - Tells us how to interpret data
- Need binding pose to skin character
- Need reference poses for calibration

- Try to unify poses
  - Base pose = Frankenstein?
  - Base pose = Bind pose?
  - Base pose = Rest pose?
  - Animator's T-Pose vs. Anatomical T-Pose?

Recap: Representation

- Represent human as hierarchical skeleton
- Vector with 1 position, 1 absolute orientation, many relative orientations
- Vector really isn't in R^N
  - $R^3 \times SO(3) \times SO(3)^{n-2}$

- Many different ways to do this
- Many things to be careful of

Now… on to motion!

- Motion is a function of time
  - Given time, provide a pose

- Often represented as samples
  - Sparse samples + interpolation
  - Dense samples (at frames)

- How to manipulate sets of samples?

Motions

- A motion is a map time->pose
  $m(t)$: R -> R^n

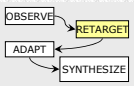
- Not really Rn, but close enough
  - Only matter if we manipulate vector
  - Euler Angles – arithmetic + pray
  - Quaternions
    - Arithmetic + renormalize
    - Log map + arithmetic + Exp map

The General Challenge

- Get a specific motion
  - From capture, keyframe, …
  - Specific character, action, mood, …
- Want something else
- But need to preserve original
  - But we don't know what to preserve
  - Can't characterize motion well enough*

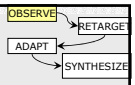
*This is a working assumption of my research. I'd love to be proven wrong.

Three Problems



- Where does X live in the data?
  - Where X ∈ {style, personality, emotion, …}
  - The things to keep or add
- Small artifacts can destroy realism
  - Eye is sensitive to certain details
  - Amazing what you can't get away with
    - Kovar, Schreiner and Gleicher, SCA '02
- How to *specify* what you want

Why Edit Motion?



- What you get is not what you want!
- You get observations of the performance
  - A specific performer
  - A real human
  - Doing whatever they did
  - With the noise and "realism" of real sensors
- You want animation
  - A character
  - Doing something
  - And maybe doing something else…

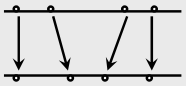
Manipulating motion

- Manipulate time
  $m(t) = m_0(f(t))$
  - F : R- >R "time warp"
- Manipulate value
  $m(t) = f(m_0(t))$
  - F : R^n- >R^n
  - F : R,R^n- >R^n

Time Manipulations

$m(t) = m_0(f(t))$

- Time scaling
  $f(t) = k\,t$
- Time shifting
  $f(t) = t + k$
- Time warping
  - Interpolate a table
  - Align events



Value Manipulations

- Scale?
- Shift?
- Convole (linear filter)
- "Add" to another motion
  $m(t) = m_0(t) + a(t)$

Signal Processing Example: Noise Removal

- Noise comes from errors in process
- Sensor errors
- Fitting errors
- Bad movements
- Nose is "data" that we don't want

Where's the Noise?

- Sometimes identification is easy:
  - Clearly wrong (foot through floor)
  - Marked wrong (missing data- gaps)
- More often, need to guess
- Might be a subtle twitch…
- Might be person shaking…
- Might be sensor errors…

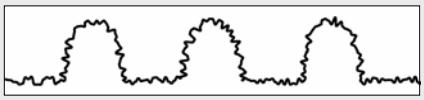
Noise Detection

- Use heuristics and rules of thumb to identify noise
- Use info about which body part as a discriminator
  - Extremities are more likely to have sharp movement
- "Speed" of the movement affects how prevalent noise is
  - Visual signal/noise ratio decreases as movement gets slower

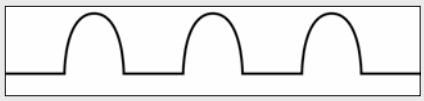
Mocap Noise Misconception

- Things in the world don't change that fast (have high freq)
- If there are high freqs, must be noise
- Get rid of high freqs (quick changes)
- Low-Pass Filter (LPF) easy (weighted average, FIR, ...)

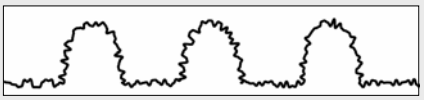
Low-Pass Filters vs. Noise



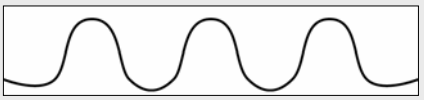
- We want to remove the noise, to get back a signal that looks like



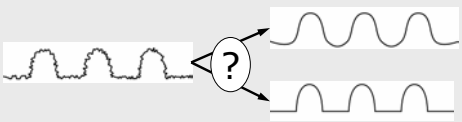
Low-Pass Filters vs. Noise



- Getting Rid of High Frequencies does not eliminate noise
- Leaves a "soggy" look

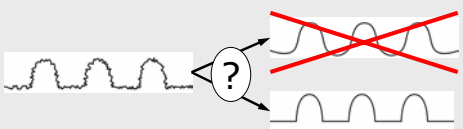


High Frequencies



- PROBLEM: High frequencies can be important!
  - Getting rid of them makes motion look soggy
- ANSWER: Do not over-apply LPF
  - How much is enough?
  - Use a little LPF

Treating Mocap Noise



- Small amounts of Low-Pass Filtering
- Noise modeling
- Adaptive filters
- Non-linear filters
- Hybrid solutions

Important Intuition

- High Frequencies are Important!
- Don't occur often
- Always significant
  - Impact
  - Rapid, sudden movement
  - Emphasis
- Sensitivity of perception

Additive Editing

- "add" two motions together
  - Addition really means combine
  - Interpolate between
  - Compose
- Two common uses
  - Motion displacement maps
  - Motion blending

Changing Motions

- High Frequencies are important
- Can't remove
  - Don't want to take away
- Can't add
  - Don't want to put something in

One way to use this: Motion Displacement Maps

- A.K.A. Motion Warps
- Add in another motion

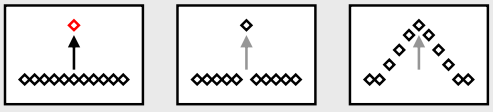
  $m(t) = m_0(t) + d(t)$
- Pick other motion so that it doesn't stick out (no high frequencies)

Band-limited adaptation

- High frequencies are important
  - Eye is sensitive to them
  - Always signifies important events
- Avoid high frequency changes
  - Preserve existing high frequencies
  - Avoid adding new ones
- Band limit the *changes*
  - Not the resulting motions

Band-limited adaptation?

- Can't look at individual frames
- Need to look across space and time



- Popping can be worse than skating

Motion Blending

- "Add" two motions together
  - Really interpolate

    $m(t) = a\ m_0(t) + (1\text{-}a)\ m_1(t)$
- Note: this is a per-frame operation
  - We're really interpolating between poses!

Does interpolation make sense?

- No!
- Yes – but only if poses are similar

How to use blending

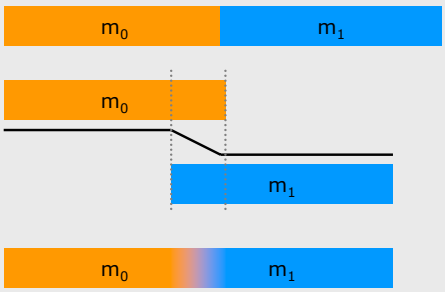
- Interpolate similar motions
  - Be sure to make time correspondence
- Transition between motions
  - Time varying blend (a=0- > 1)
  - Over a short period of time
    - A bad pose isn't such a big deal
  - Avoids discontinuities

    $m(t) = a(t)\ m_0(t) + (1\text{-}a(t))\ m_1(t)$

Transistion

- Very useful!
- Often get small pieces of motion
- Need to connect
- Easy if motions are similar
- Hard if motions are not similar

Transitions



What's next…

- Use Transitions and Blending to synthesize new motions based on a library of examples!

Thanks!

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