1

Notes

- Questions?
- Assignment 1 should be ready soon (will post to newsgroup as soon as it's out)

2

Gauss-Newton

- Idea: nonlinear least-squares is hard, but linear least-squares is easy
- So replace the nonlinear function

  $x(\theta)-x_{target}$

  with a linear approximation:

  $J(\theta-\theta_k) + x(\theta_k)-x_{target}$

- ♣ Then solve the linear least-squares problem to get the "Gauss-Newton" direction:

  $d_k=(J^TJ)^{-1}J^T(x_{target}-x(\theta_k))$

- ♣ This avoids the scaling problem of Steepest Descent, and is much more efficient
- ♣ Problem: need to solve a linear system

3

Scaled Steepest Descent (SSD)

- Replace the matrix J^TJ we need to invert with something simpler: $\text{diag}(J^TJ)$
- Diagonal matrices are trivial to invert
  - But guard against zero entries!

4

Evaluating Jacobians

- Simplest approach in code: numerical approximate with a finite difference

$$J_{ij} = \frac{\partial x_i}{\partial \theta_j} \approx \frac{x_i(\theta_1,\ldots,\theta_j+\varepsilon,\ldots,\theta_n) - x_i(\theta_1,\ldots,\theta_j,\ldots,\theta_n)}{\varepsilon}$$

- Can also work out derivative analytically by hand (a little painful)

5

When to stop

- In our case, absolute minimum of f(.) is zero: stop when it's smaller than some tolerance
- It might be impossible to get to zero, but at the minimum $\nabla f=0$: stop when $|\nabla f|$ is small enough
- ♣ Or give up when maximum number of iterations reached

6

Character Rigging

- A "rig" is a model together with a UI for posing it
- At its simplest, a skeleton with joint angles available for motion curves
- May simplify DOF by enforcing relationships between joints
  - E.g. hand and fingers
- May define standard poses (especially for facial expressions!) that can be mixed together
  - Then can set sliders to, say, 70% happy, 20% surprised, …
  - Take weighted linear combination of pose angles

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Breaking Rigs

- Who said animated figures had to have rigid parts?
  - Remember animation principles: stretch & squash, exaggeration, etc.
- Often attractive to break up a rigid skeleton into separate parts (e.g. torso, arms, legs, head)
  - Allow connecting links to change dimension as needed
  - Kinematics only done on a small part - artist doesn't need to worry about effect on whole (local vs. global control)
- "If it ain't broken, then fix it"

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What's left?

- We now have the basics of animation
- Plan for next while:
  - Rendering animations
  - (Semi-)automatic animation
    - Dynamics for rigid bodies
    - Particle systems
    - Skinning, morphing, blending
    - Motion capture
    - Motion control

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Rendering for Film

10

Compositing

- The action of combining multiple "layers" -- parts of each frame -- into the final shot
  - E.g. background + actors + vfx
  - For vfx-intensive shots, there could be dozens of separate layers
- Handling each layer separately
  - makes the problem simpler,
  - allows better division of labour,
  - and gives flexibility in putting the elements together at the end
    (often the majority of CPU time is spent in compositing!)

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Atop

- The simplest (useful) and most common form of compositing: put one image "atop" another
  - Image 1 (RGB) on top of image 2 (RGB)
- For each pixel in the final composite, need to know what RGB value to take
  - Where image 1 is opaque, choose RGB_1
  - Where image 1 is "empty", choose RGB_2
  - Where image 1 is partly transparent, or where image 1 only covers part of the pixel?