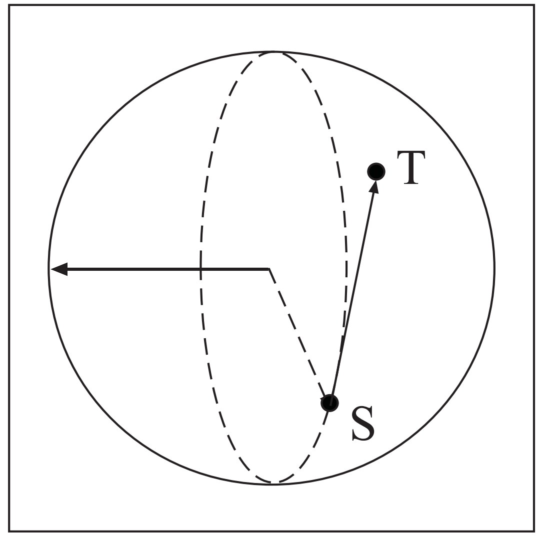
3D Rotation User Interfaces and Specifying 3D Orientations

Goal: Use of a 2-button or 3-button MOUSE to orient a model/camera in 3D world coordinates

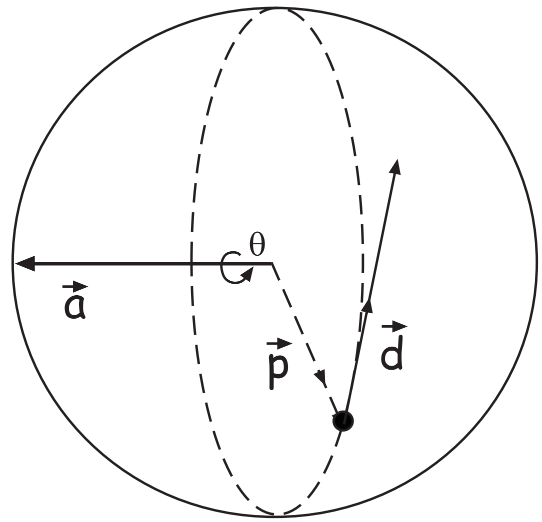
Solutions:

- Virtual Sphere or Arcball
- Rotations easier to specify as a vector (axis) in 3D and angle
- Composing Rotations about any vector in 3D,
- Quaternions as alternative to Euler Angles

The Virtual Sphere

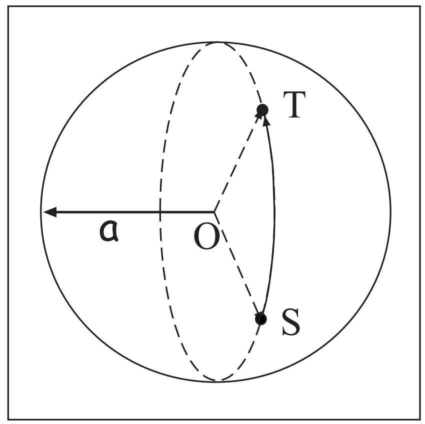


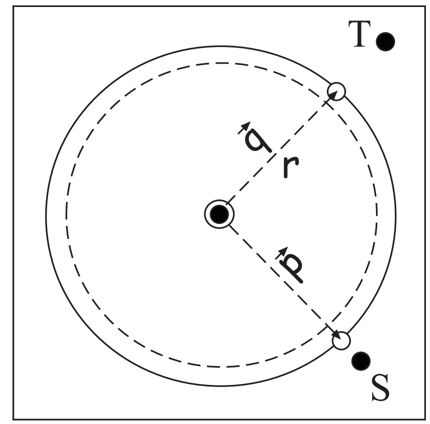
1. Define portion of screen to be projection of virtual sphere.
2. Get two sequential samples of mouse position, S and T.
3. Map 2D point S to 3D unit vector $\vec{p}$ on sphere.



4. Map 2D vector $\overrightarrow{ST}$ to 3D tangential velocity $\vec{d}$.
5. Normalize $\vec{d}$.
6. Axis: $\vec{a} = \vec{p} \times \vec{d}$.
7. Angle: $\theta = \alpha|\overrightarrow{ST}|$.
   (Choose α so a 180° rotation can be obtained.)
8. Save T to use as S for next time.

The Arcball





1. Choose region of screen as projection of sphere: 2D point O center, radius ρ.
2. Get initial 2D point S on button-down.
3. Compute $\vec{s} = (s_x, s_y)$.
4. Compute 2D radius: $r^2 = s_x^2 + s_y^2$.
5. Map 2D vector $\vec{s}$ to 3D unit vector $\vec{p}$ as before:

If $r^2 > \rho^2$, map to silhouette of unit sphere:

$$
\begin{aligned}
p_x &\leftarrow s_x/r \\
p_y &\leftarrow s_y/r \\
p_z &\leftarrow 0.
\end{aligned}
$$

Else,

$$
\begin{aligned}
p_x &\leftarrow s_x/\rho \\
p_y &\leftarrow s_y/\rho \\
p_z &\leftarrow \sqrt{1 - p_x^2 - p_y^2}.
\end{aligned}
$$

6. For each new mouse position T, map to unit 3D vector $\vec{q}$ as above.
7. Axis: $\vec{a} = \vec{p} \times \vec{q}$.
8. Angle: $\theta = 2\cos^{-1}(\vec{p} \cdot \vec{q})$.
9. Notes:
   - Rotation given by *twice* the angle of the great arc between $\vec{p}$ and $\vec{q}$.

- Doubling the angle matches orientation's mathematical structure better.
- Points on opposite sides of the sphere silhouette allow a rotation by 360°.

JUMP to Quaternions!

Reading Assignment and News

Chapter 4 pages 202 - 215, of Recommended Text.

Please also track the News section of the Course Web Pages for the most recent Announcements related to this course.

(http://www.cs.utexas.edu/users/bajaj/graphics24/cs354/)