Lecture 8:
Kinesthetic haptic devices: multi-DOF rendering

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rendering
algorithms
Coordinate Systems

\[ \vec{p}_{\text{user}} = [x_{\text{user}}, y_{\text{user}}, z_{\text{user}}] \]
Wall aligned with axis

If $x_{user} > x_{wall}$, $F = k(x_{wall} - x_{user})$

stiffness $k > 0$
Non-aligned wall

\[
\vec{r} = \begin{bmatrix}
x_u - x_w \\
y_u - y_w \\
z_u - z_w 
\end{bmatrix}
\]

if \((\vec{r} \cdot \vec{n}) > 0 \rightarrow \text{no collision,}

if \((\vec{r} \cdot \vec{n}) < 0 \rightarrow \text{collision}

\[d = |(\vec{r} \cdot \vec{n}) \cdot \vec{n}|\]

\[F = kd\vec{n}\]

*(does this work? Check yourself)*
Outside a sphere

\[ r = \sqrt{(x_u - x_s)^2 + (y_u - y_s)^2 + (z_u - z_s)^2} \]

\[ \hat{r} = \frac{1}{r} \begin{bmatrix} x_u - x_s \\ y_u - y_s \\ z_u - z_s \end{bmatrix} \]

if \( r < R \), \( F = k(R - r)\hat{r} \)
Inside a box

\[ F_x = 0 \]
\[ F_y = 0 \]
if \( x_{user} > x_{wall-max} \)
\[ F_x = F_x + k(x_{wall-max} - x_{user}) \]
if \( x_{user} < x_{wall-min} \)
\[ F_x = F_x + k(x_{wall-min} - x_{user}) \]
if \( y_{user} > y_{wall-max} \)
\[ F_y = F_y + k(y_{wall-max} - y_{user}) \]
if \( y_{user} < y_{wall-min} \)
\[ F_y = F_y + k(y_{wall-min} - y_{user}) \]
Outside a box

\[ F = 0 \]

if \[ ((x_{\text{user}} < x_{\text{wall-max}}) \& (x_{\text{user}} > x_{\text{wall-min}})) \]
\[ \& (y_{\text{user}} < y_{\text{wall-max}}) \& (y_{\text{user}} > y_{\text{wall-min}}) \]

Then… what force should be displayed??
Limitations of “penalty-based” methods

(a) Lack of locality

(b) Force discontinuities

(c) “Pop-thru” of thin objects

The proxy object

- Keep track of virtual object on the surface

- A related concept is the “God Object” (Zilles & Salisbury 1997)
What you feel

Object has limited stiffness, but it is not “deformable” in a global sense
Assignment 4 due 5/2
done in teams of two!

Suggested (optional) readings
A. Render a horizontal plane
B. Render an oriented plane
C. Render inside a box
D. Render outside a sphere
E. Sphere in a box (dynamic simulation)
Things to know

- Passcode to room 550-108
- Login and password for computers
- There are 5 stations
- How to compile and run your code
- Start early, finish early
- What you don’t need to know: graphics!
Walk through code and demo (led by Julie)
How would you render…

Being stuck “inside” a sphere