3D Touch-and-drag: Gesture-free 3D Manipulation with Finger Tracking
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ABSTRACT
We define a new modeling technique called 3D touch-and-drag, wherein users select vertices by simply approaching them with a 3D cursor such as a forefinger. Operations are finished by removing the 3D cursor from a line or plane in 3D space. These lines or planes constrain the modeling operations, as is the case when using 3D widgets.

BACKGROUND
2D:
- Current geometric modeling tools are usually controlled by mouse and keyboard.
  - 2D operations are projected onto 3D planes
  - Modeling tools often use 3D widgets

VR:
- Selection is done by pinch or grasp gestures
  - Gestures slow down operations
  - Gestures reduce precision
- It is difficult to perform interactions in a 3D space
  - Adding constraints can improve usability

Transfer from 2D to VR is complex.

3D TOUCH-AND-DRAg
- Select vertices by approaching them
  - Easy in 3D space
  - (Difficult in 2D since user must hover over mesh)
- Move vertices on planes or lines
  - Constraining planes are determined implicitly
  - 3D distance must remain below threshold
- Finish operation
  - Release vertex by exceeding the threshold
  - Similar to lifting finger from touchscreen (2D)
  - Final position is the projected 3D position onto the plane when the user starts to end operation

ADVANTAGES
- Can be adapted with only moderate effort to modeling systems which use constraints
- Selection gestures can be avoided, which increases performance, especially when starting an operation
- Knowledge can easily be transferred and the learning effort reduced

TRANSFER FROM 2D TO VR
2D touch-and-drag:
1.) User touches vertex on screen → selection by raycasting
2.) User moves vertex in modeling plane (finger on screen)
3.) User lifts finger from screen

3D touch-and-drag:
1.) User approaches vertex in 3D → selection by 3D distance
2.) User moves vertex in modeling plane (in 3D)
3.) User ends operation by removing finger from plane

USER TEST (MOVE A SPHERE ON A LINE)
- We found that the method is as fast as a pinch-gesture-based method while being easier to start.
- The precision of 3D touch-and-drag is even as high as using a button on a controller.

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