Intelligent Constraints

- Relocation procedure moves selected object along relocation manifold offset from horizontal or vertical surface
- Association procedure (triggered by visibility/contact changes) finds associated objects and modifies position/orientation of selected object and cursor (e.g., pseudo-gravity, on-wall)

1. Selected cup is dragged under a table according to relocation procedure.
2. Visibility information determines when cup "rises" to the tabletop.
3. Association procedure modifies object position and mouse cursor position.
Intelligent Constraints

- R. Bukowski and C. Sequin, "Object Associations," SI3D 95
  - Relocation procedure moves selected object along relocation manifold offset from horizontal or vertical surface
  - Association procedure (triggered by visibility/contact changes) finds associated objects and modifies position/orientation of selected object and cursor (e.g., pseudo-gravity, on-wall)

1. Selected cup is dragged off table’s supporting surface.
2. Cup “falls” onto lower surface.

  - Objects arranged in hierarchy based on one-way constraints
  - Transforming a parent transforms its descendants
Intelligent Constraints


- Objects arranged in hierarchy based on one-way constraints
  - Transforming a parent transforms its descendants

- Objects can have
  - Binding areas: Specify where this object can bind to other objects
  - Offer areas: Specify where other objects can bind to this object

- Binding/offer areas
  - Each defined by polygon and orientation vector
  - Can be independent from object geometry

Intelligent Constraints


- When moving unconstrained object A
  - Pick closest offer area on other objects to binding area of A within limited range
  - Move/orient A to enforce constraint iff binding area can fit within offer area
    - Make object A a child of object B to whose offer area object A was bound

- When moving constrained object A
  - Preserve constraint if binding area of A remains in offer area of B
  - Break constraint if binding area of A pulled away from offer area of B
    - Remove object A from children of object B whose offer area object A left

https://doi.org/10.1109/VR.2002.996529
Intelligent Constraints


- Dual constraints
  - Support limited two-way constraints for nonhierarchical groups (e.g., siblings)
  - Specified by geometry (point, line, or polygon) and normal vector (pointing away from object)
    - E.g., yellow dots at right indicate point dual constraints
**Intelligent Constraints**


**Dual constraints**

- **Build group:** When object \( A \) is moved, if one of its dual constraints is sufficiently close to an appropriately shaped dual constraint of another object \( B \)
  - \( A \) and \( B \) are snapped together such that geometries of the dual constraints are coincident and normal vectors are opposite

- **Maintain group:** When object \( A \) is moved
  - All grouped objects in contact in direction of motion are moved with \( A \)

- **Break group:** When object \( A \) is moved
  - All grouped objects not in contact in direction of motion do not move, are broken off from \( A \), and form new group(s)

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Intelligent Constraints

- Dual constraint graph
  - Specifies direction of connectivity of grouped objects based on normal vectors
  - Supports intuitive splitting of dual groups by generalizing "objects in contact in direction of motion"
  - When selected object A is moved, what happens to objects grouped with A?
    - The only objects that move with A and remain grouped with A are those connected to A in a direction within 90° + tolerance (e.g., 10°) of movement direction, and those that recursively meet that requirement
    - Remaining objects are broken off from A and form new fully connected group(s)

Before

After

(Note need for tolerance angle here)

http://ws.iat.sfu.ca/videos/mive_duals.mpg
Realism

- Necessity of compromise
  - Geometry
  - Texture
  - Illumination
  - Behavior
  - Frame rate

T. Nishita and E. Nakamae, 1985

Realism

- Desirability of compromise
  - Geometry
  - Texture
  - Illumination
  - Behavior
  - Frame rate

A. Frank and Z.B. Simpson, 2003
http://www.adamfrank.com/shadow/shadow.htm
Realism

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A. Frank and Z.B. Simpson, 2003
http://www.adamfrank.com/shadow/shadow.htm

Realism vs. Magic

- Realism isn’t always desirable
- Can violate realistic metaphor to improve functionality
  - E.g., K. Herndon et al., “Interactive Shadows,” UIST 92

Figure 5: Fully-rendered shadows are used to display surfaces of objects that are not directly visible from the user’s point of view. Note that in the mirror view, one can see that the landing gear is aligned with the landing gear bay.

- Shadows are fully rendered (similar to reflections)
- Manipulating shadow manipulates its object