GEOMETRY

LECTURE 6

DESIGN BY SYMMETRY

by

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Design by symmetry

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Gresham lectures so far

- Problems with devices
  — mobile phones, microwaves, ticket machines, aeroplanes, calculators, programming languages, user manuals…
- All problems avoidable

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Weapon salve

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Overview

- Symmetry
- Affordance
- Symmetry + Affordance
  = Successful design

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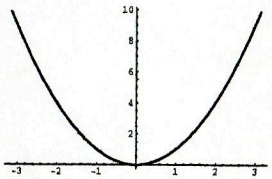
Reflection symmetry



$f(x) = x^2$

$f(x) = f(-x)$

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Rotational symmetry

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Symmetry

Beauty

- Symmetric faces are attractive
- Evolution favours symmetry
- Culturally deep æsthetic significance

Simplicity

- Symmetry is one of the best tools for simplicity
- If $f(x)=f(-x)$, you only need half the information

Definition

- *S–symmetry* occurs when a property of an object remains unchanged through an *S*-transformation of the object.
- Transformation = reflection, rotation, rhythm, period, scaling…

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Notes

- Trivial symmetries arise when the property is a constant or the transformation is an identity.
- Property = invariant, conservation law, permutation…
  e.g., $f(x, y)=f(y, x)$

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Isn't symmetry obvious?

- Translation
- Scale
- Scale symmetry = "zoom in"
- Numerosity

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Science basics

- Chemistry
- Mathematics $x=2$ or x = 2
- Noether's Theorem
- Geometry

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Curie's Principle

- Any symmetry in the cause leads to a symmetry of the effect.
- The symmetry group of the cause is a subgroup of the symmetry group of the effect.

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Natural computation

- Scale symmetry

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Vision & eco'psy

- Objects may *afford* some or several sorts of action
- A set of natural or "easy" relations
- Brain "detects invariants" or "resonates" despite changes in "sensations"

J. J. Gibson, 1979

Marr

- Removes implementation bias
- Detection of invariants *is* information processing

Definitions of Affordance

- "the presentation of a system conveys information about the actions that can be performed by the user of that system"

Amodeus glossary

- "the design of artifacts should naturally invite task-appropriate usage"

  Bill Gaver
- "an object's sensory characteristics intuitively imply its functionality and use"

  Usability First

- "a [Web] page's "link affordance" rate"

  Robert Bailey
- "Design[s] should also suggest (that is, afford) their functionality"

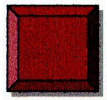
  Jenny Preece

- "what sort of operations and manipulations can be done to a particular object"

  Don Norman
- "Does a calculator afford math?"

  University of Cincinnati, Ecological Discussion Group

Perceived, cultural, or what?



Design

Don Norman,
Psychology of Everyday Things, 1988
Bill Gaver, CHI, 1991
Don Norman, *Interactions*, 1999…

Physical constraints
Perceived affordances
Real affordances

Key concepts

- Symmetry
- Natural computation
- Affordance

A new affordance

The symmetries that apply under the actions relevant to the activities or tasks performed with the object

Affordance is user interface symmetry

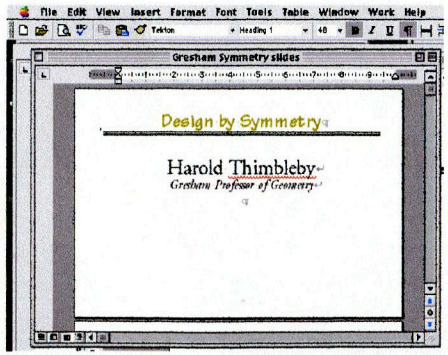
… extends to user manuals

Some examples…

- TV, VCR & remote controls
  - MS Word
    - DM, VR
      - Pencils
        - Digital clocks
          - More!

            WAP, manuals, …

Graphical user interfaces



Direct manipulation

- Familiar Euclidean symmetries
  - (*except* in Word!)
- Reversible and incremental actions

A pencil

- Two main symmetries:

  —Rotational symmetry along long axis

  —Approximate reflectional symmetry about its centre

Other pencil symmetries

- "pencilness"
- colour
- colour of the lead
- cheap ones fail to uphold many symmetries

New design ideas

- indefinitely unchanged

  = inexhaustible lead

  — the propelling pencil

Symmetry & error

- It does not matter what angle a pencil is grabbed at
- It is easy to make end-end errors grabbing a pencil

- S. de Bruxelles, "Kidney Death Surgeon 'Reversed X-ray'," *The Times*, June 14, p13, 2002.

Insights

1. Symmetries provide freedoms the way an object can be used
2. Approximate symmetries provide opportunities for errors
3. Deliberate control of symmetry can train users (kids' pencils)

So...

- Some symmetries are interesting, others not
- Not all symmetries are useful affordances
- Some affordances lead to new designs (e.g., propelling pencil)
- Affordances raise design trade-offs

Programming symmetries

- Large classes of state transformed but behaviour is practically unchanged
- Referential transparency (see last Gresham lecture) is a symmetry

User interfaces

a) Huge number of states for the implementation
b) Small mental models for the user
∴ The user *must* rely on symmetries

- The user interface presents symmetries to the user…

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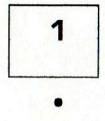
A digital alarm clock



Digit
(e.g., a 7 segment LED)

Pushbutton

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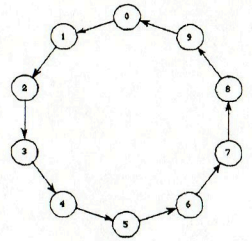
State structure



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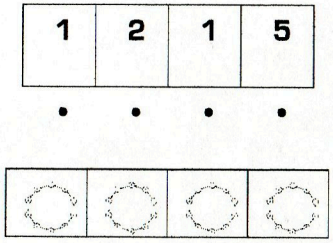
Interface & state structure



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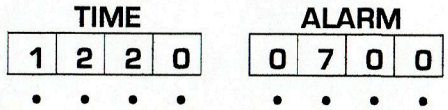
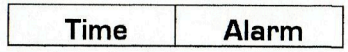
Time & alarm





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Make the clock smaller?

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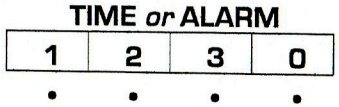
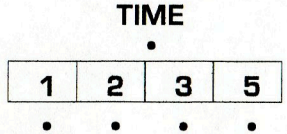
Fix broken symmetry

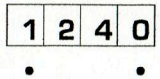


Resolve ambiguity



Replace "or" with a knob

Abandon affordance?



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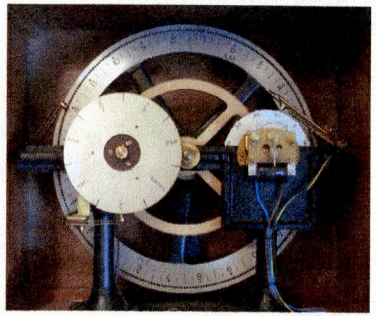
Analogue affordance



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Design principles

- Modeless (temporal symmetry)
- *etc*

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Conclusions

- Almost all design problems are caused by failure to exploit symmetry

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- Affordance was a useful, but vague concept

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- A symmetry-based conception of affordance is constructive

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References

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9) Weyl, H., *Symmetry*, Princeton University Press, 1952.

See also `http://www.uclic.ucl.ac.uk/harold/gresham`