Affordances

15-494 Cognitive Robotics
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Carnegie Mellon
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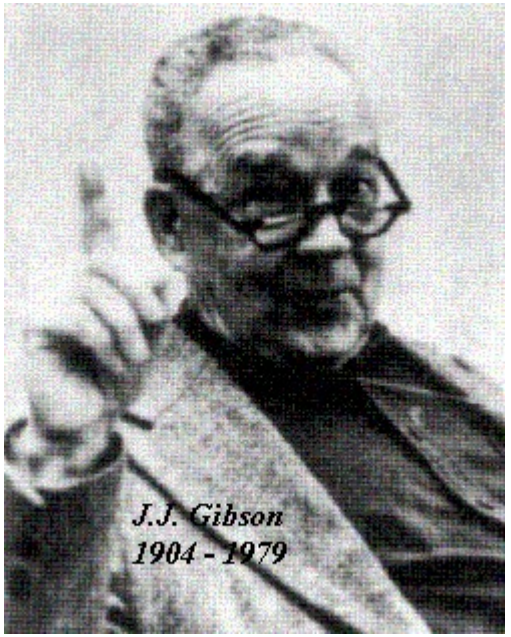
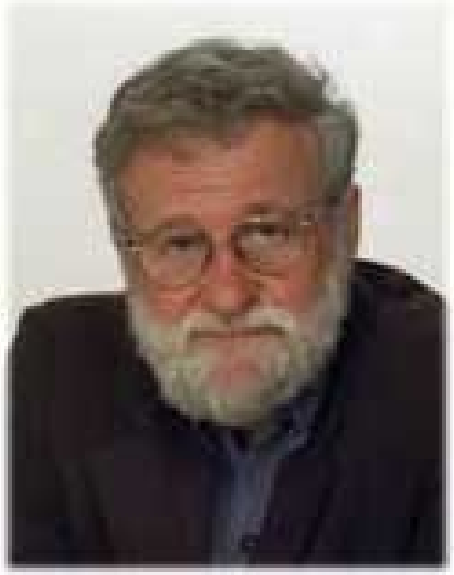
J J Gibson



- American psychologist (1904-1979) who worked in the area of visual perception.
- Coined the term “affordance”.
- “The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill.”
- In Gibson's formulation, affordances are properties of the environment, independent of the animal's perception.

Don Norman



- Cognitive scientist at UC San Diego who studied under Gibson.
- Replaced Gibson's objective affordances with the notion of perceived affordances.
- "... the term *affordance* refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used... Affordances provide strong cues to the operation of things."

The Design of Everyday Things

- Norman's book “The Psychology of Everyday Things” helped popularize the notion of affordances.
- Later reissued with updated frontmatter as “The Design of Everyday Things”.
- Looked at examples of physical objects such as door handles and light switches.

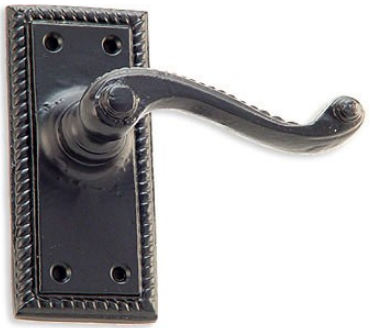
Affordance Examples from Norman

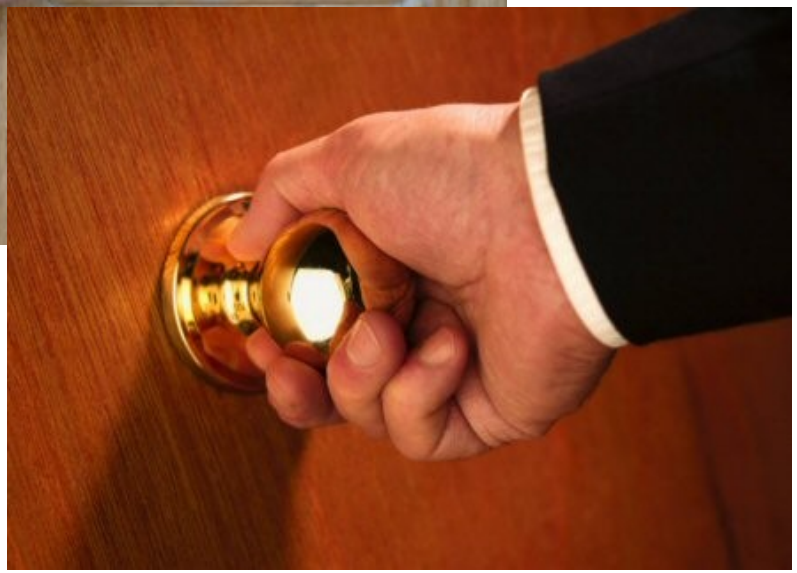
- Plates (on doors) are for pushing.
- Knobs are for turning.
- Slots are for inserting things into.
- Balls are for throwing or bouncing.

"When affordances are taken advantage of, the user knows what to do just by looking; no picture, label, or instruction needed."

How To Open a Door

Shape determines grasp strategy:



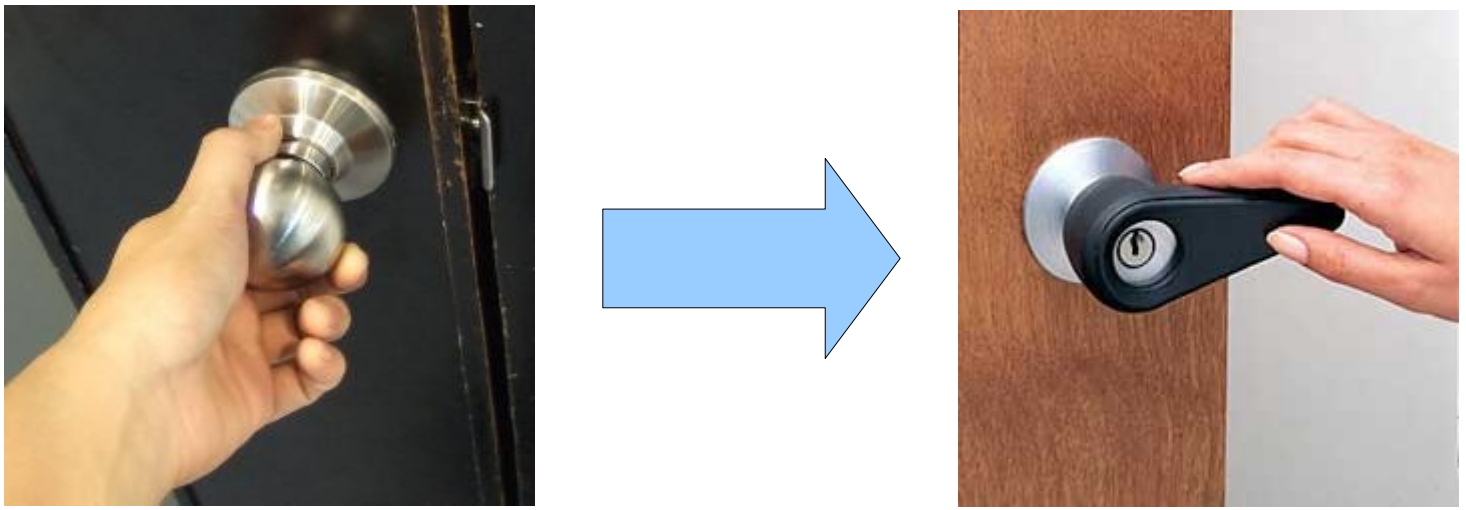


How (Not) To Open a Door

"Emergency Exit Only Push Until Alarm Sounds Door Can Be Opened In 15 Seconds

Furniture illegally blocking exit

Changing An Affordance



Rubber handle fits on doorknob to allow easier opening by people with gripping difficulties.

Learning by Observation?

Is This Really Necessary?

Kodak DC-290 Camera

Example from Joel Spolsky's “User Interface Design for Programmers”, ch. 4.

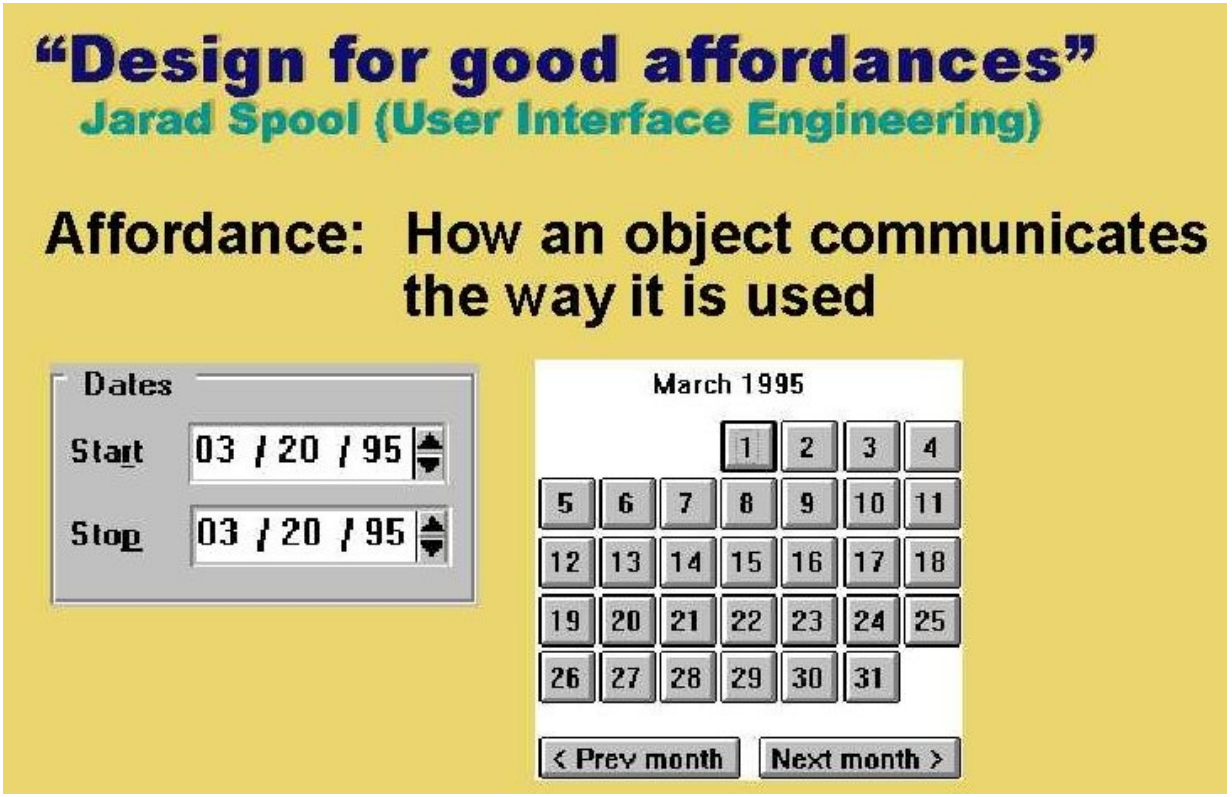
- Encourages users to hold camera with both hands.
- Keeps fingers away from the lens and viewfinder.

Right hand fingers curl around grip

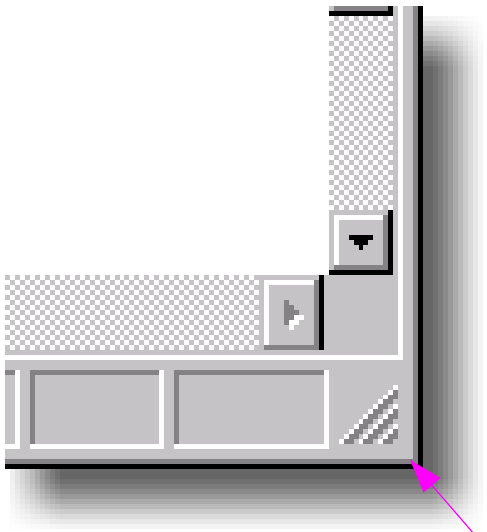
Left thumb goes here

Affordances Are An Important Concept in GUI Design

- Buttons drawn as 3D shapes appear to “stick out” and hence afford pushing.
- Sliders and scroll bars afford dragging.

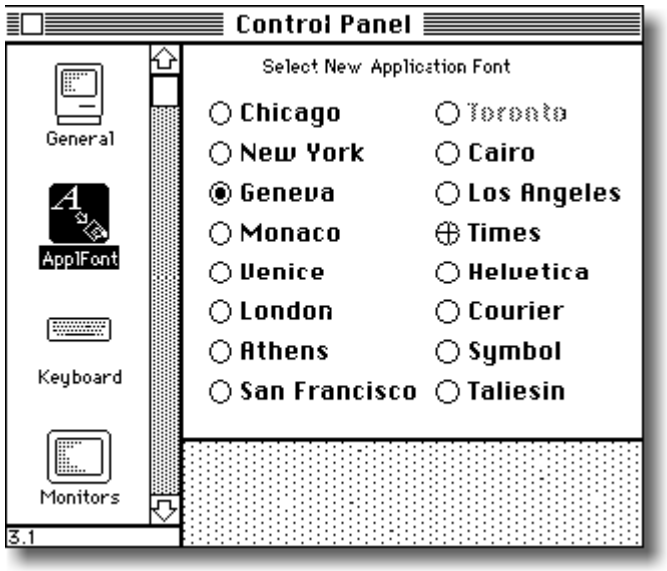


Window Controls: Resize Tab

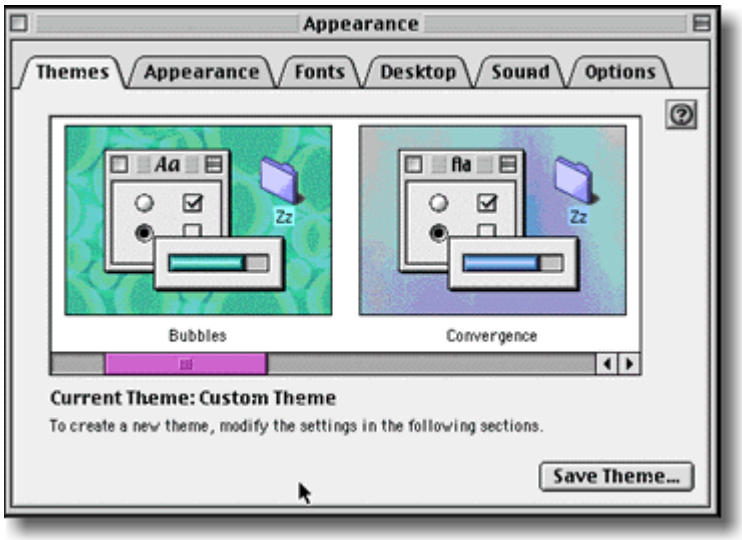


Lines look like the ridges on a slider switch that increase friction (Spolsky)

Tabbed Dialogs



1980s-style Mac control panel: major mode shown by icon on left. That mode's choices appear on the right.

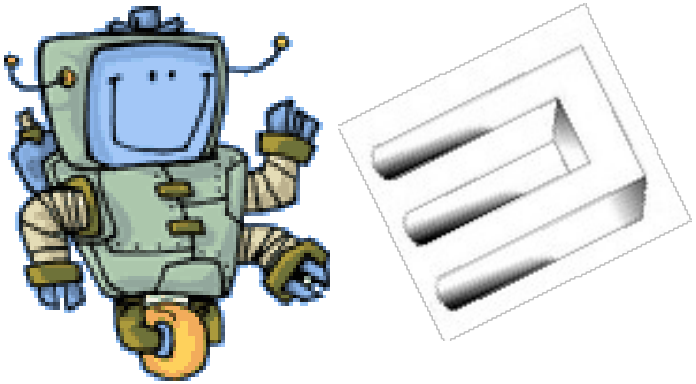


1990s-style Mac control panel using tabbed dialogs was much easier for users to understand.

Tabs are affordances.

What Does This Have To Do with Robotics?

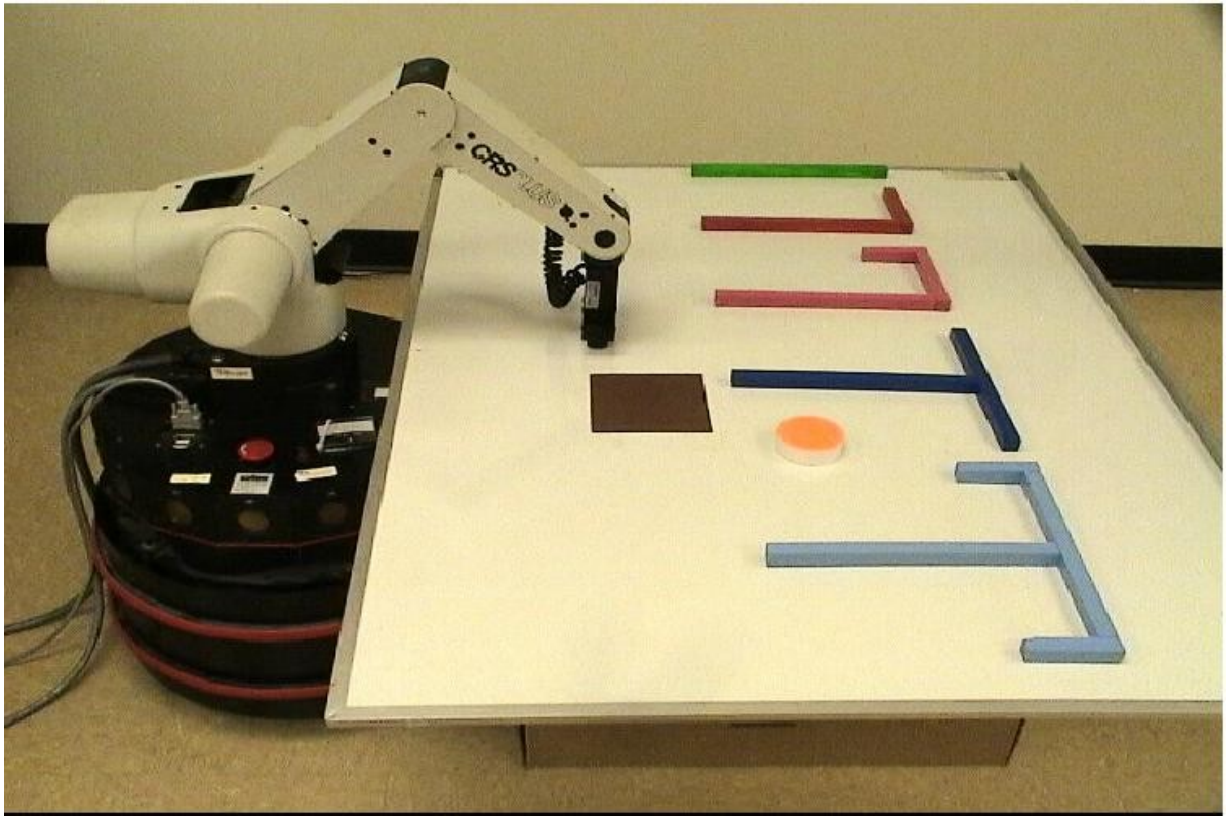
1. Robots must be able to deal with unfamiliar objects.
   - Recognizing affordances can lead them to effective strategies for interacting with objects.



- 2. Humans needs ways of instructing robots.
  - Language for describing object interactions would be helpful.
  - This is the language in which affordances are described.

Stoytchev (2005): Recognizing Tool Affordances

- Robot experiments randomly to learn the effect of actions using various tool shapes to move an orange puck.



Robert St. Amant: Tool Use With the AIBO

- "Some tools seem to have the property that one can tell how they should be used just by looking and experimenting – no instruction or specialized knowledge is needed. Affordances are part of the explanation why, as is general tool-using ability."

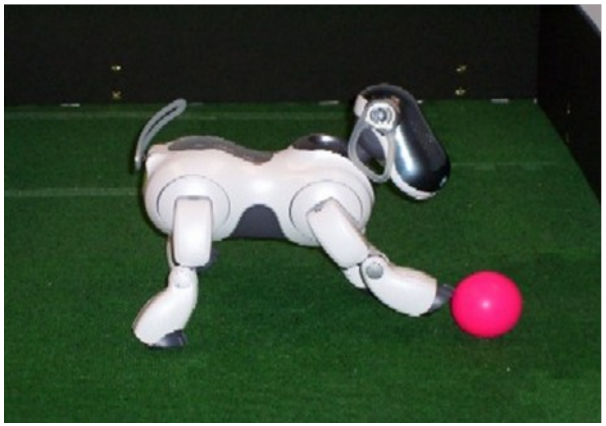
(movie)

Recognizing Affordances

- Physical properties of the object

PLUS

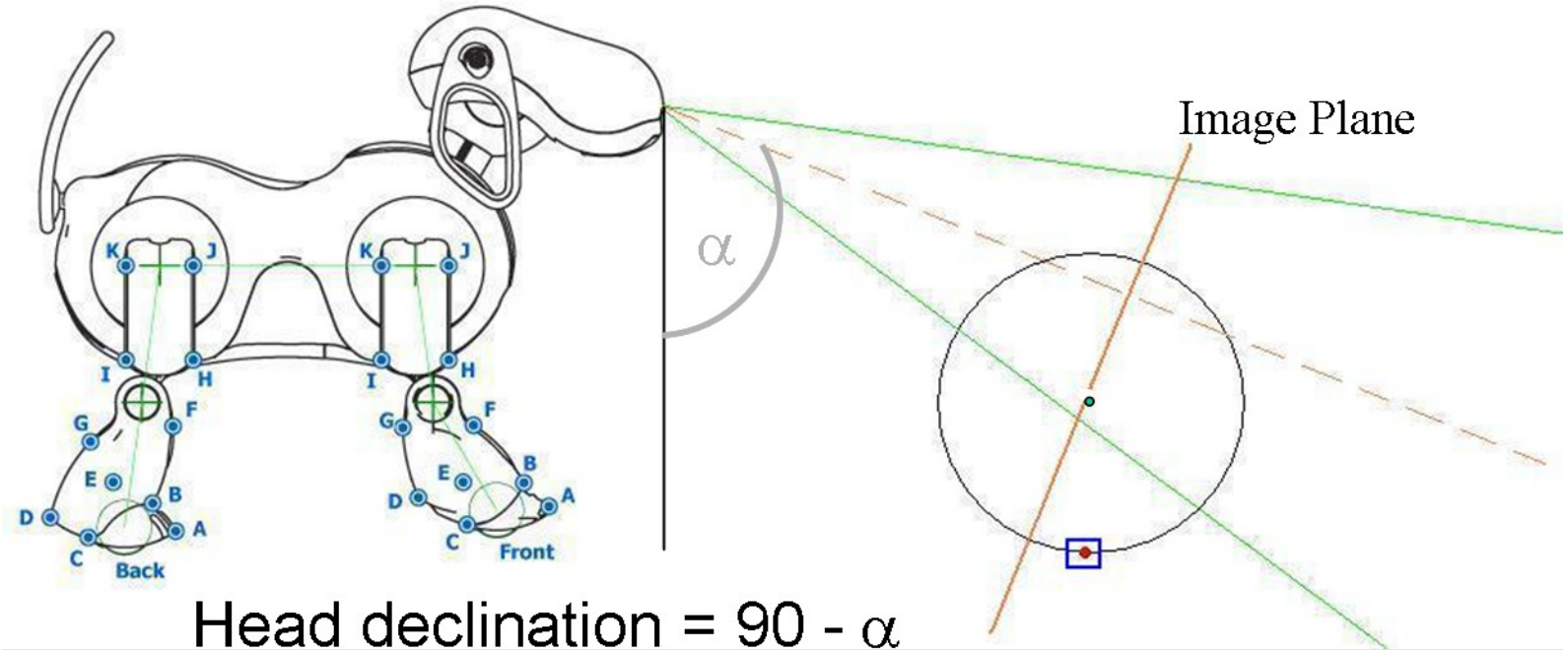
- Understanding how the robot's body could interface with that object.



Affordances of Known Objects

- For familiar objects such as balls, we already know a variety of strategies for interacting with them.

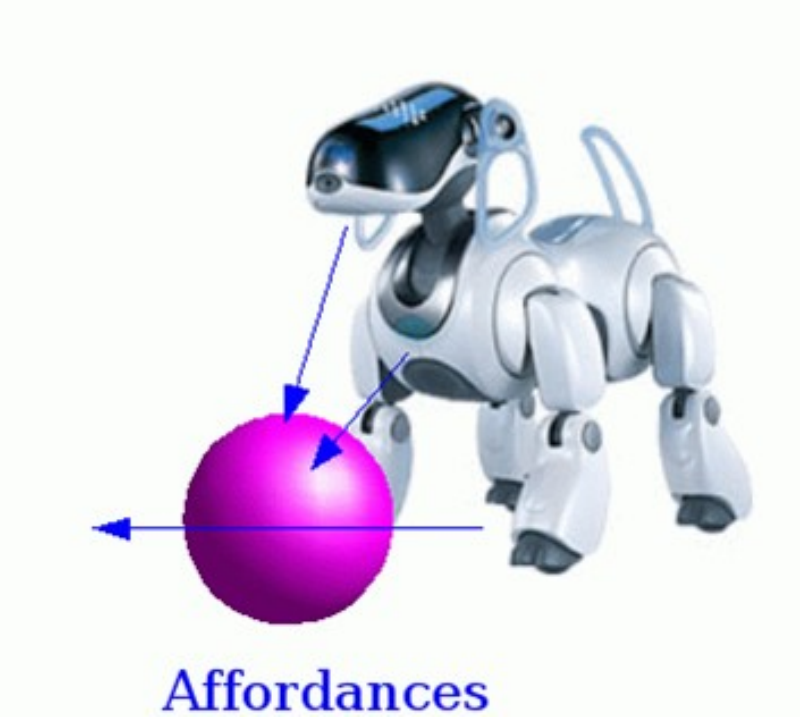
- Which ones are applicable depend on factors such as size and position.



Ball Affordances

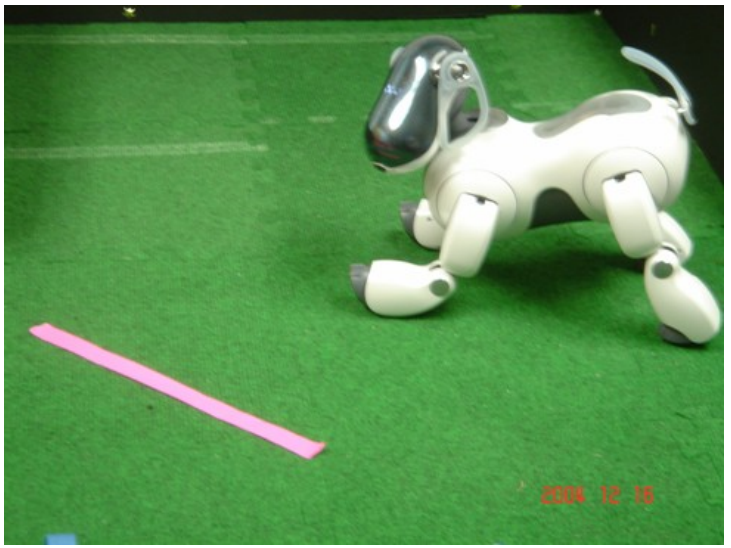
- Can build a library of ball affordances.

- Write code to detect when particular ones are applicable.
  - push with paw
  - push with chest
  - push with head
  - kick ball ...



Line Affordances

- Lines afford a variety of actions.
  - Visually trace line
  - Walk to line
  - Cross line
  - Touch point on line



Brick Affordances

- Brick affordances include:
  - Push brick to location x
  - Rotate brick to orientation θ
  - Flip brick over
  - Stand on brick

Problems of Action Representation

- Preconditions for feasibility: is this action possible?
- Parameterization: How far? What direction?
- Interactions between affordances
- Recognizing failures

Preconditions for Actions

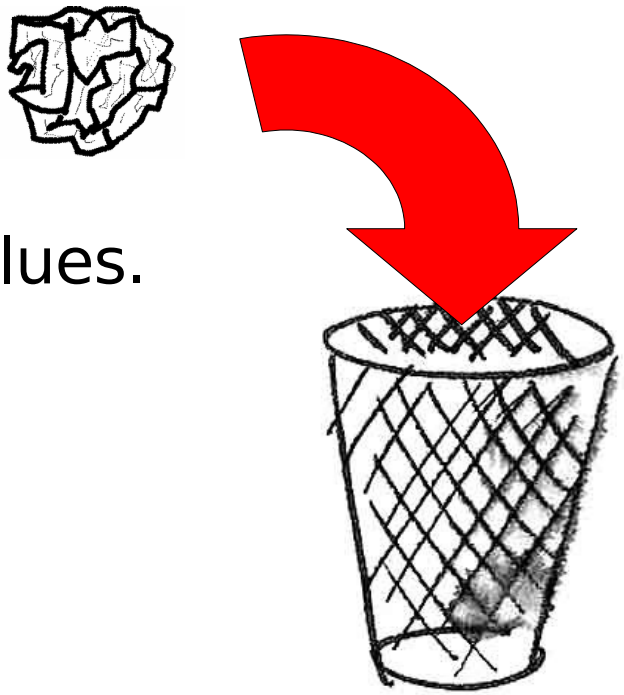
- When is an action feasible?
- Example: when can we push a ball?
  - Must be close enough to touch the ball
  - Must be oriented properly to push in desired direction
  - Must have freedom of motion
  - Ball must not be obstructed
- What if we're not close enough to push?
  - Balls could afford “moving into position to push” actions.

Parameterized Actions

- We don't usually want to just push at random.
  - “Push ball in direction θ”
- Do we recognize an infinite number of affordances?
- Special cases?
  - Push ball toward object/landmark x

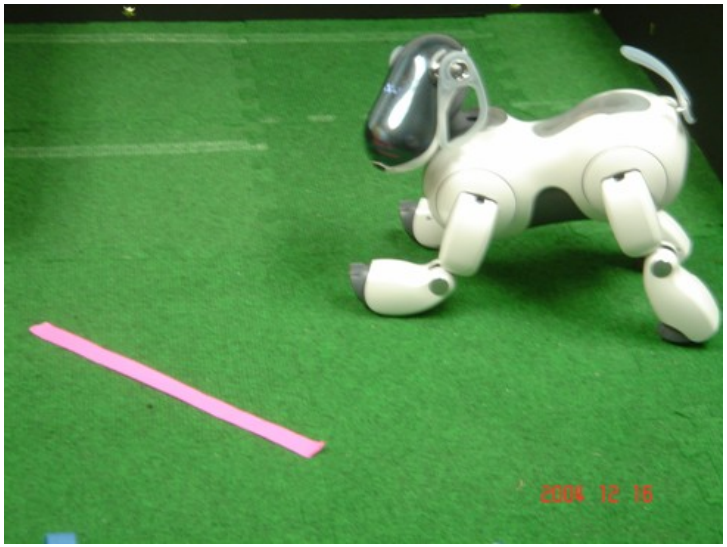
Interactions Among Affordances

- A wad of paper affords tossing.
- A wastebasket affords receiving tossed objects.
  - Potential for combinatorial explosion?
- Interactions can supply parameter values.
  - Where to push



Recognizing Failures

- Trace line affordance fails:
  - Neck pan limits exceeded.
- Need to understand why the action failed.
- Failure explanations:
  - positioning problem
  - lost sight of object
  - lost contact with object (dropped it)
  - etc.



Dealing with Novel Objects

How do you turn on the shower?

How Can Robots Handle Novel Objects?

- Perceive the object in terms of its parts.
  - Surfaces, protuberances, axes of symmetry.
    (Well beyond what Tekkotsu can do right now.)
- Part geometry suggests possible actions.
  - Knobs are for pulling or twisting.
  - Plates are for pressing.
  - etc.
- Robot must be able to perceive and evaluate the effects of its actions.