Preventing Error

SWE 632, Spring 2018

GEORGE MASON UNIVERSITY

Today

- What causes errors?
- What design choices can help reduce the frequency of errors?
- What design choices can help users resolve errors more effectively?

Human Error

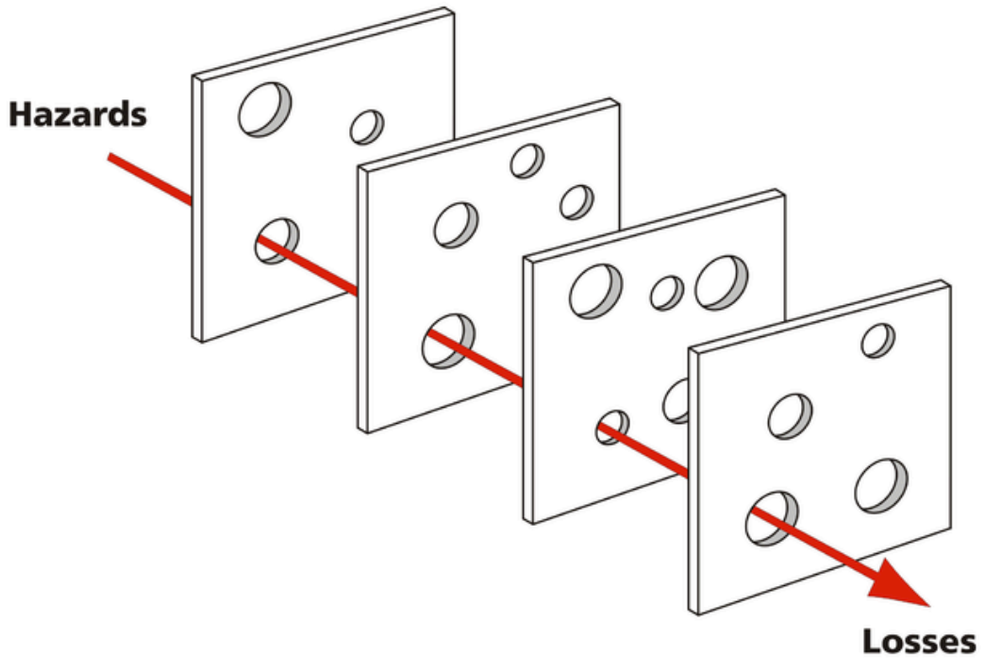
Root cause analysis

- Keep asking **why** to determine causes for erroneous actions, and the causes of these causes
- Example
  - 2010 F-22 crash that killed pilot
  - Official cause: pilot error - pilot failed to take corrective action
  - Why did the pilot not take the action?
    - Pilot was not receiving oxygen and was probably unconscious.

What causes disasters?

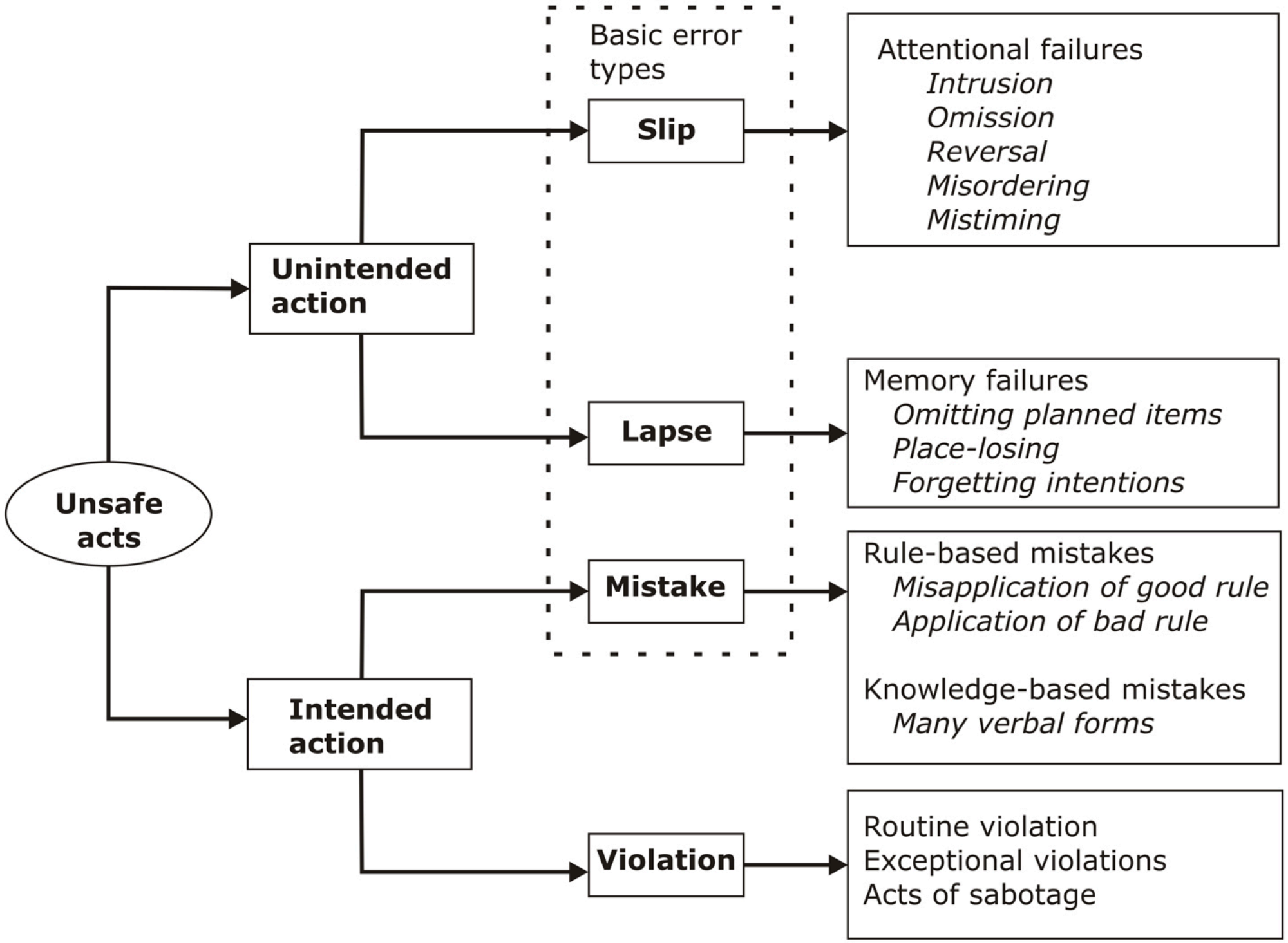
- Mechanical malfunction?
- Poor design?
- Human error?

Swiss cheese model



- Accidents must penetrate levels of system defenses
- Reduce accidents by
  - Adding more layers
  - Reduce the size and number of holes
  - Alert users when holes line up

Psychological types of unsafe acts



Violation

- Error occurred because user **intended** the erroneous output
- Routine violation - user always intends to do it
  - Noncompliance is so frequent it is ignored
  - E.g., running a red light
- Exceptional - only in some cases
- Sabotage - intended destruction

Mistakes

- User **formulated** the wrong goal or plan
  - Executing action will not achieve goal
- Rule based: appropriately diagnosed situation, but chose erroneous course of action
  - Example: Night club attendees blocked from leaving during fire because bouncers thought they
- Knowledge based: does not have correct information
  - Example: Skidding driver feels brake vibrations, believes indicates malfunctioning breaks and takes foot off break, stopping ABS

Memory Lapse

- Failing to do all steps of a procedure, repeating steps, forgetting the outcome of an action, forgetting the goal or plan
- Often caused by interruption
  - Time between when plan was formulated and plan was executed leads to forgetting plan
  - Take a pen out to sign form, get interrupted talking to someone, leave it on desk rather than put it back in bag

Slips

- Attentional failure - user **intended** to do correct action, but did not actually execute action
- Example: forgot to turn off the gas burner on the stove after cooking

Strong habit intrusion

- Performance of some well-practiced activity in familiar surroundings
- Intention to depart from custom
- Failure to make an appropriate check
- Example: start trip to frequent destination, forget going somewhere else

Omissions

- May be interrupted, forgetting intention to act
- “I picked up my coat to go out when the phone rang. I answered it and then went out of the front door without my coat.”

Perceptual confusions

- Take frequent action very often, leading to high System 1 automation
- Don’t perform perceptual check to verify that System 1 action is the correct one to take
- Example: “I began to pour coffee into the sugar bowl”

Mistimed checks

- Highly automated System 1 activity that is interrupted
- Error in resuming activity because usually unconscious.
- Example - interrupted in the middle of tying shoes

Activity

- Think of the last unsafe act you performed.
- What was the underlying cause?

Designing for error

Designing for error

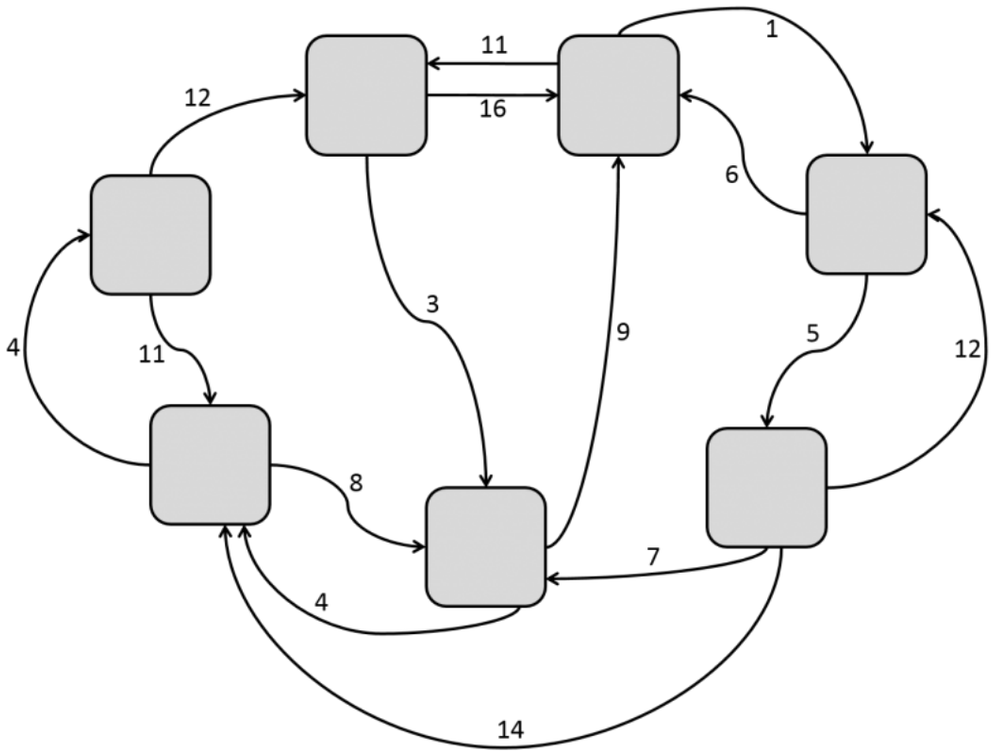
- Humans are not automatons and will never behave like automatons

- Easy to design for the situation in which everything goes well

- But important to think about what might go wrong and how the interaction design can ameliorate issues

IFT perspective

- IFT perspective
  - User exploring patches topology in search of prey
  - Always making a decision about whether a patch is the right place to hunt and changing as new information arrives



- Breaks down when user actions transform the state of the application
  - Patches and topology no longer fixed
  - Visiting a configuration of the system by clicking "Send" on the email editor is a not an undoable action

Some strategies for designing for errors

- Understand the cause, and fix it
- Make it possible to reverse errors
- Offer feedback that enables users to discover and correct errors
- Don't treat actions as errors, but as manipulations

Understand the causes of errors

- What errors occur? What type are they? How can they be prevented?
- Frequent contributing factors
  - Ambiguous or unclear information about the state of the system
  - Lack of an effective conceptual model
  - Inappropriate procedures
- Must design for users as they exist, rather than users as you'd like them to behave

Interruptions

- Interruptions are a frequent cause of error
- User may be using your interface perfectly, with the correct plan to get to their goal
  - What happens if, in the middle of the task, they answer a phone call?
  - Or if they run out of time, and come back the next day?

Designing for interruptions

- Help user resume task, by remembering where they were in task, what steps have been completed, and what steps remain
- Reduce the number of steps
- Use forcing functions to force users to do forgettable action (e.g., take card from **before** picking up cash)

Example: interruptions

- In groups of two or three

- Imagine a user was interrupted while using one of your project apps
- What errors might this create?
- What challenges might users experience when resuming?

- How could you change your design to address these issues?

Offer feedback for user actions

- Feedback helps keep users on track in accomplishing goals
  - Provide feedback early
  - Provide feedback consistently
- Make feedback visible, noticeable, legible, located w/ in users focus of attention

- Requesting confirmation can be used to prevent costly errors (but use sparingly)

Tone of feedback

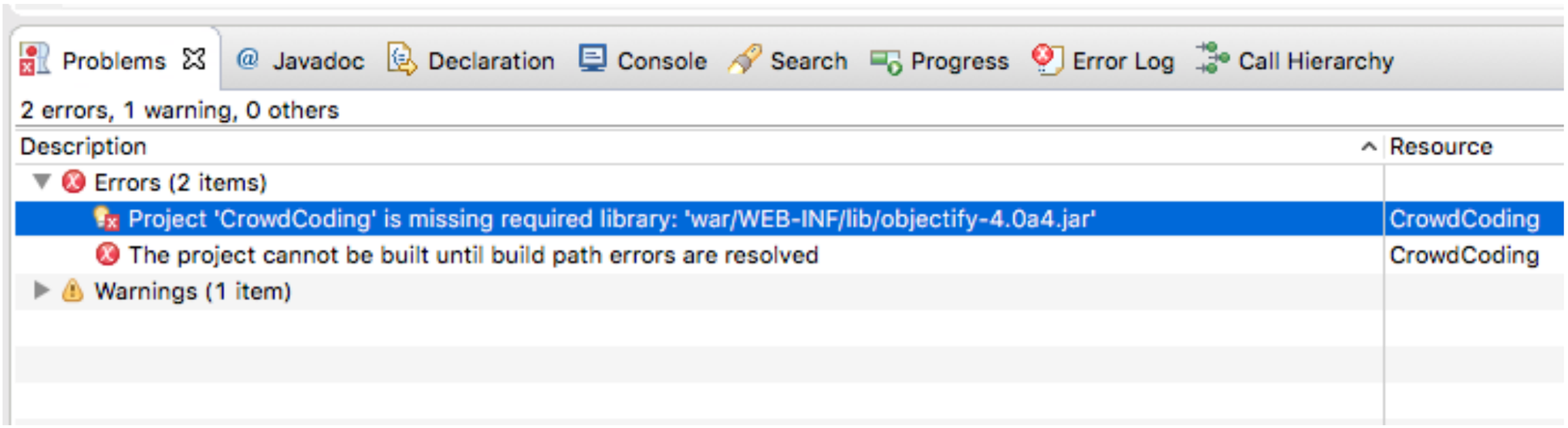
- Establishes relationship with user
- Important not to take user feel “stupid”
- Make the system take blame for errors
- Be positive, to encourage
- Provide helpful messages, not cute messages
- Avoid violent, negative, demeaning, threatening terms (e.g., illegal, invalid)

System response times

- 0.1second - reacting **instantaneously**
  - requiring no special feedback except displaying result
  - limit for direct manipulation of objects in UI
- 1.0 second - **freely** navigating commands
  - noticeable delay, limit for keeping user's flow of thought uninterrupted
- 10 seconds - keeping users **attention**
  - limit for keeping user's attention focus in UI
  - longer delays create task breaks
- [Nielsen, Usability Engineering, 1993]

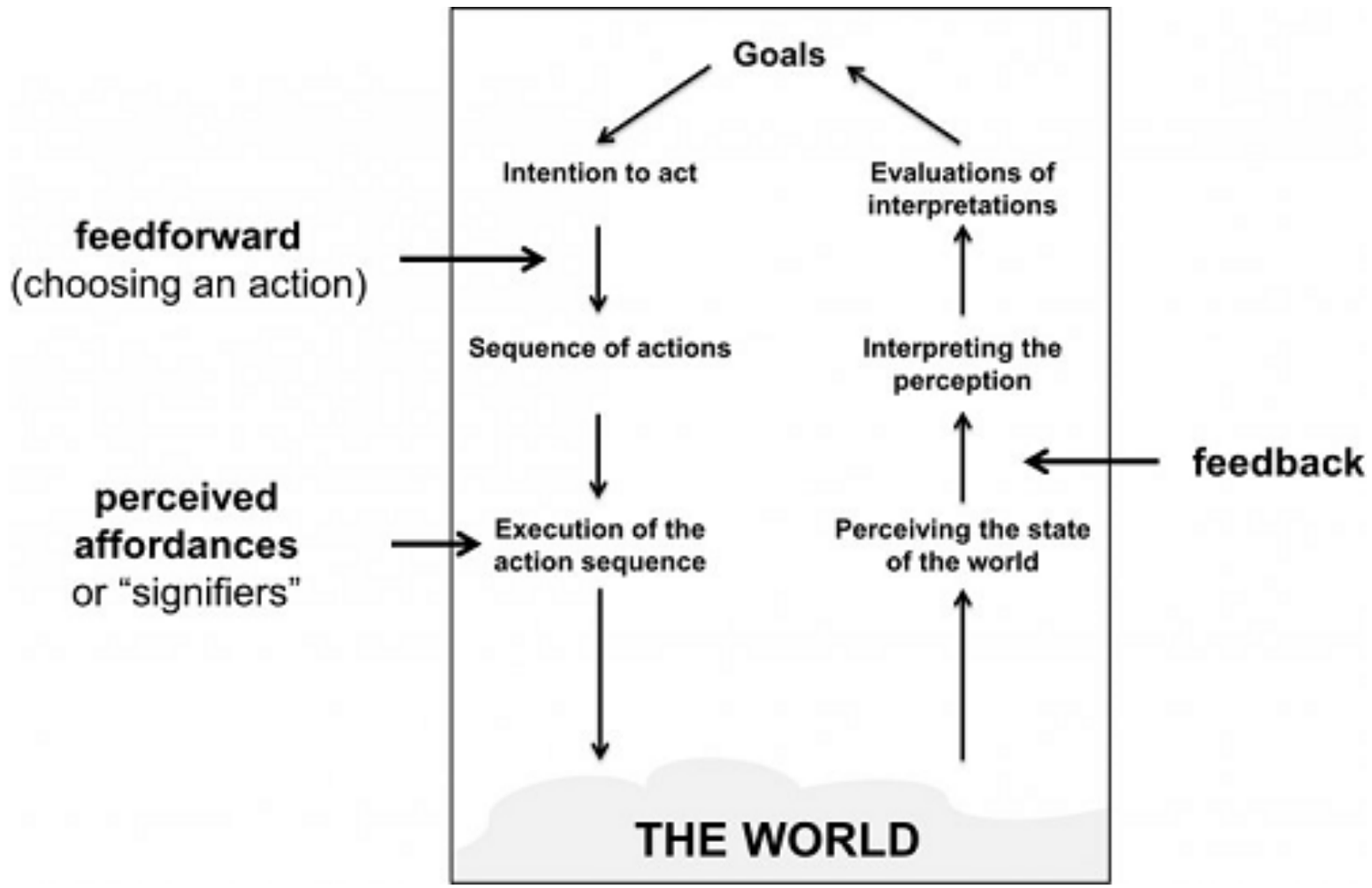
Show users how to fix errors

- Good: detecting user errors
- Better: directly showing how errors can be fixed
- (Best: using constraints to prevent errors from ever occurring)



Direct manipulation

Motivation



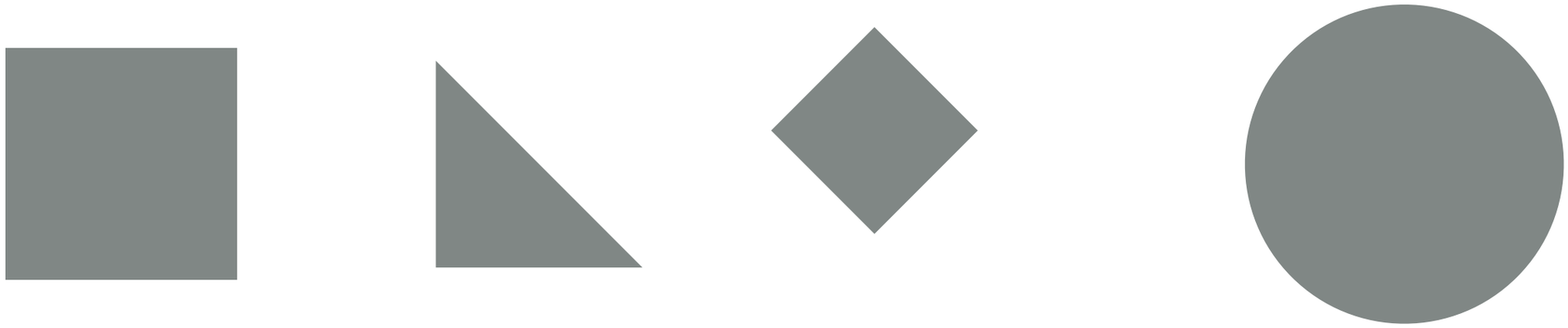
- User is trying to do a task, manipulating a [model] of world
- Hard to plan out long sequence of actions in advance
- Gulf of execution: hard to know if took correct action
- Gulf of evaluation: hard to understand if successfully manipulated world
- Hard to compare hidden world to desired world

Key questions

- What is the cost of an error?
  - Is it low cost or high cost?
  - Is it undoable?
- What feedback is necessary for user to realize the system is not in the desired state?

Direct manipulation

- “Rapid incremental reversible operations whose impact on the objects of interest is immediately visible” (Shneiderman, 1982)



Benefits

- Supports exploration
  - Don’t plan long sequence of actions: pick an action, try it, can change mind if want to do something else instead
- Provides immediate feedback
  - Can quickly see what outcome of actions are in manipulating the world
  - Easy to compare desired state of the world to actual state of the world

Example - Kayak

Advice: BUY Learn more

Create a price alert

Stops Show all

- ✓ nonstop $127
- 1 stop $145
- 2+ stops $303

Times Show all

Take-off Washington (DCA)
Fri 2:41p – 10:30p

Take-off Chicago (CHI)
Mon 5:30a – 10:00p

Show landing times

Airports Show all

- Depart/Return same

Washington

- ✓ DCA: Reagan-Nati… $127
- BWI: Baltimore/Wa… $207

DCA ↔ CHI
108 of 1115 flights

Dec 16 ↔ Dec 19
Friday — Monday

Economy cabin | 1 traveler

Change

Sort by: **Price** Recommended Duration More

Round-trip | Flight-by-flight

$207

View Deal

JustFly, Experience world-class service
Click "View Deal" to find our cheapest flights

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Ad

$227
American Airlines

View Deal

American Airlines
8:12p DCA → **9:26p** ORD 2h 14m nonstop
3:25p ORD → **6:12p** DCA 1h 47m nonstop

Show details Economy

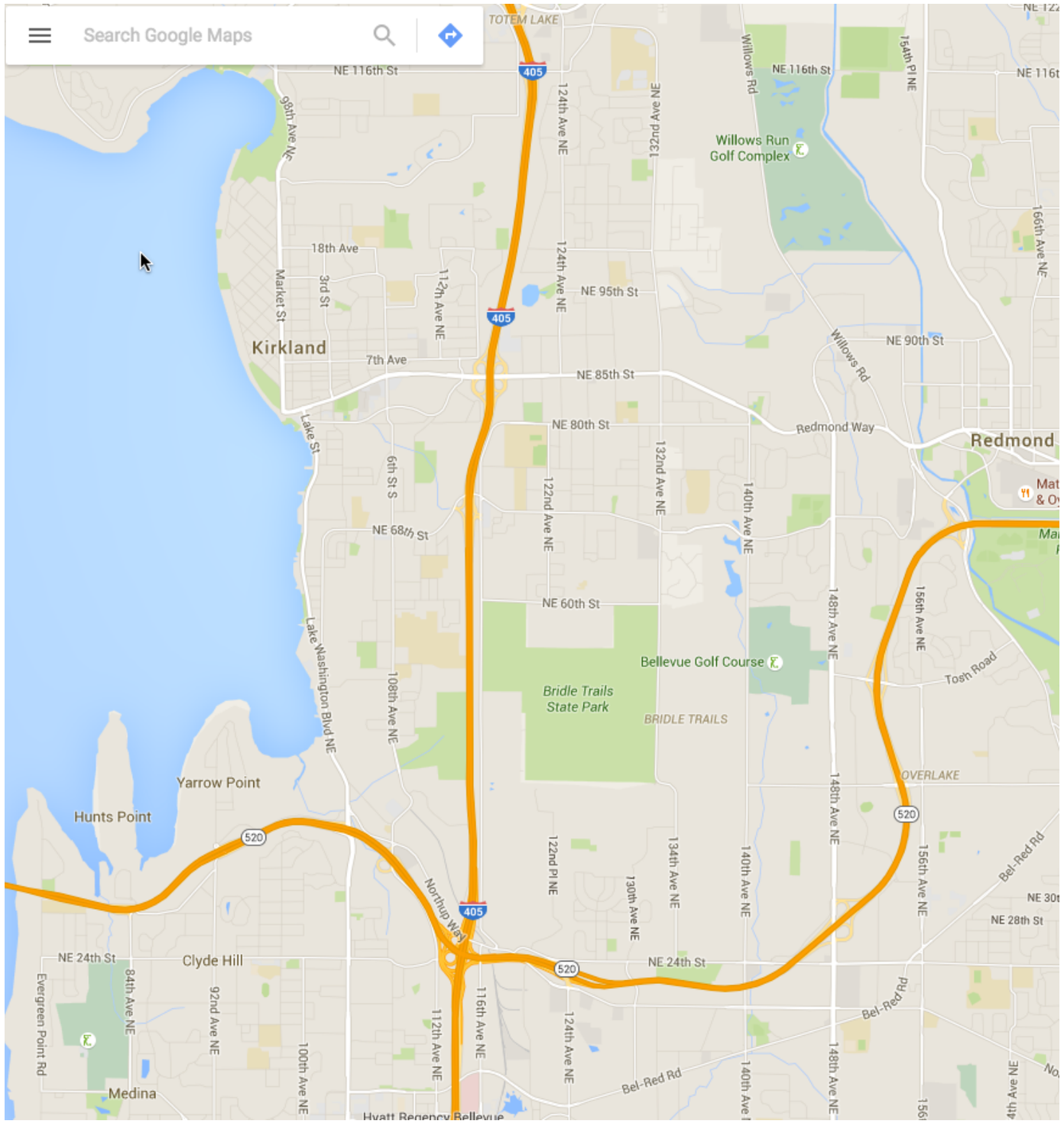
$227
American Airlines

View Deal

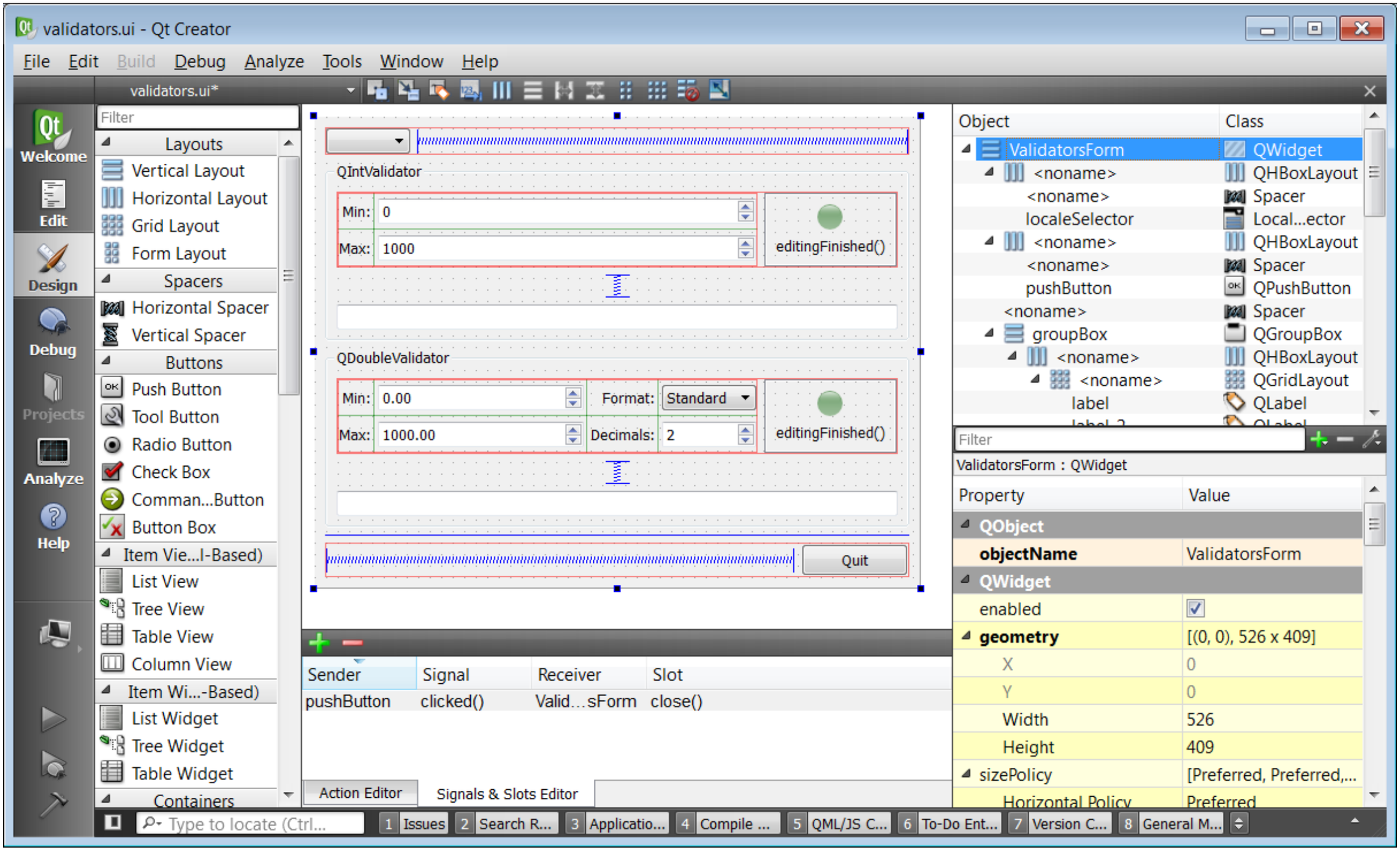
American Airlines
8:12p DCA → **9:26p** ORD 2h 14m nonstop
11:55a ORD → **2:42p** DCA 1h 47m nonstop

Show details Economy

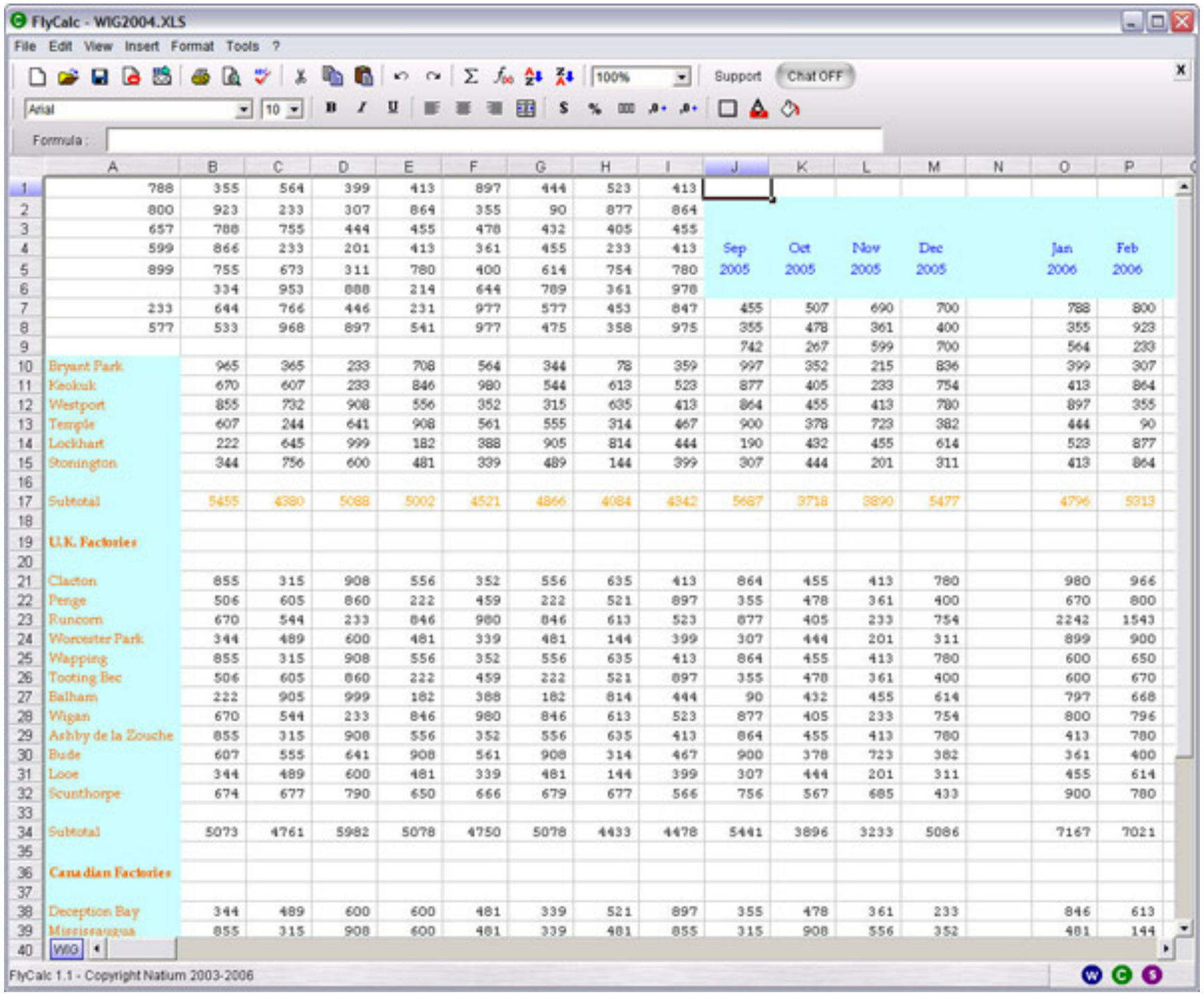
Example - Google Maps



Example - GUI builder

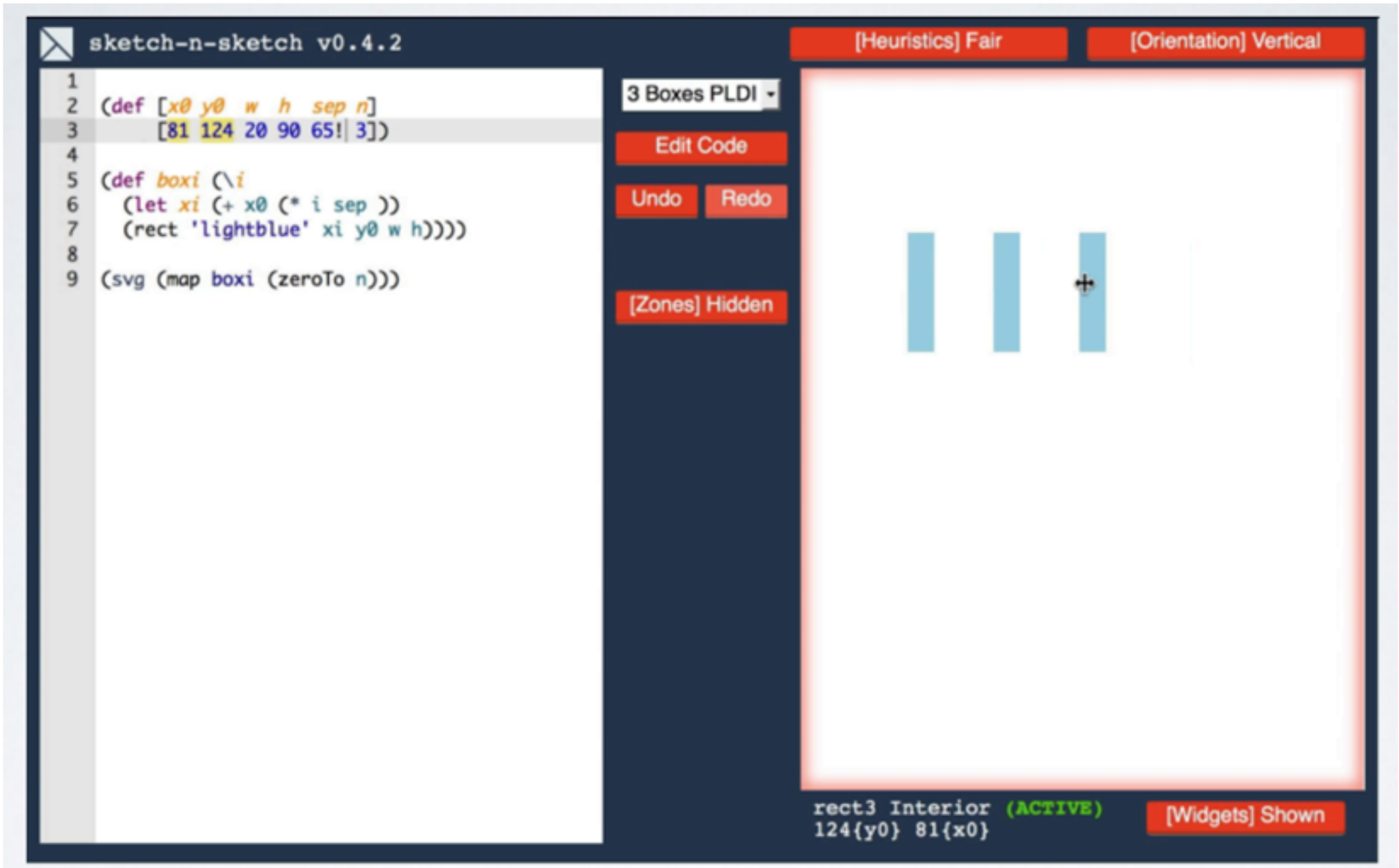


Example - Spreadsheets



Example: live programming

Example: edit constants by editing output



Chugh et al. [PLDI '16]

In-class activity

In Class Activity: Direct Manipulation Programming Interactions

- In groups of 2
  - Design a system for writing code through direct manipulation
    - Create sketches showing key screens
    - Should support
      - Standard programming language features (variables, conditionals, loops, functions)
      - Should make it faster and easier to make code changes
      - Should make it easier to get feedback on if program exhibits intended behavior