Natural Programming

NATURAL PROGRAMMING

- Want to find out how people "naturally" specify software.

EXAMPLE

- Suppose we want to design a system that allows users to create and participate in lotteries. The rules of the lottery are as follows:
- Someone creates a lottery with a secret "winning number" between 0 and 100.
- Anyone can purchase a lottery ticket for a set amount of money. A lottery ticket also has a number (picked by the buyer) between 0 and 100. If the lottery ticket's number is equal to the lottery's number, that is a winning ticket.
- The buyer of a ticket can check whether a ticket is the winning ticket and redeem a winning lottery ticket for a set amount of money. The buyer of a ticket can redeem the ticket at any point after they buy it.
- It is only possible to redeem a lottery ticket from the lottery where the ticket was purchased. For instance, if you buy a lottery ticket from lottery1, you cannot redeem your ticket from lottery2, even if that ticket's number matches the winning number of lottery2.

EXAMPLE (CONT.)

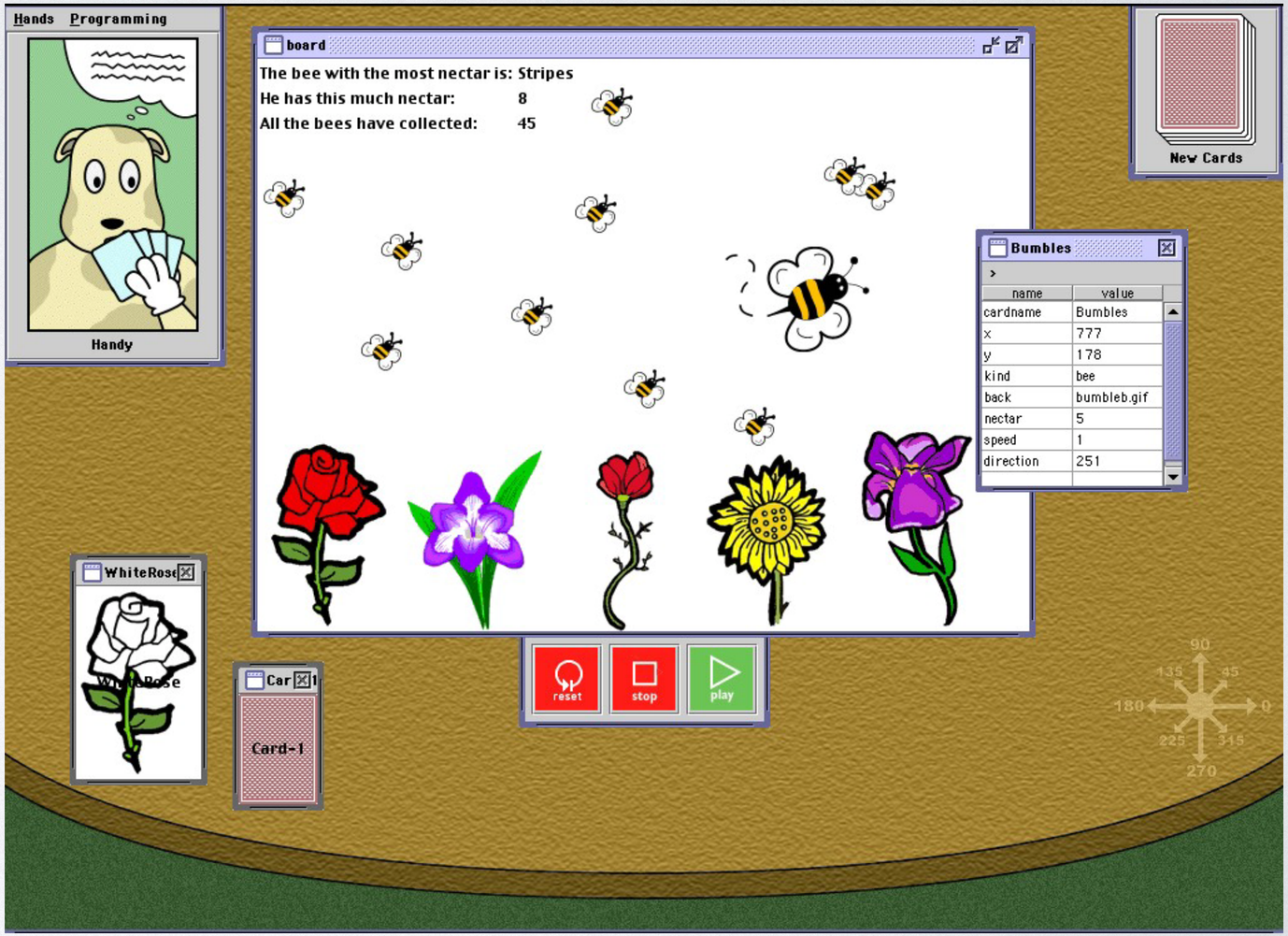
- Design, using pseudocode, a program to handle this lottery system. Do not worry about writing code that resembles any particular language, and feel free to make up any language features you may want. We want to see the kind of code you would want to be able to write. The goal here is to see how people naturally go about solving a problem like this.

- It is critical to the system that a lottery ticket can be redeemed only from the lottery where it was purchased. You can assume that creator and players of the lottery have accounts of some sort from which money can be withdrawn and deposited.

HANDS

- The HANDS system portrays the components of a program on a round table. All data is stored on cards, which can be drawn from the pile at the top right and dragged into position. At the lower left, two cards are shown face-down on the table. One has a generic card back and the other has been given a picture by the programmer. In the center of the table is a board, where the cards are displayed in a special way where only the contents of the back are displayed. Each picture, string, and number on the board is a card. At the right, one of the cards has been flipped face-up, where its properties can be viewed and edited. The programmer inserts code into Handy's thought bubble, by clicking on Handy's picture in the upper left corner. When the play button is pressed, Handy begins responding to events by manipulating cards according to the instructions in the thought bubble. The stop button halts the program, and the reset button will restore all cards to their state at the time the play button was last pressed. For reference, a compass is embossed on the table at the lower right.

- Credit: J.F. Pane, B.A. Myers, and L.B. Miller, "Using HCI Techniques to Design a More Usable Programming System," Proceedings of IEEE 2002 Symposia on Human Centric Computing Languages and Environments (HCC 2002), Arlington, VA, September 3-6, 2002, pp. 198-206.



HANDS

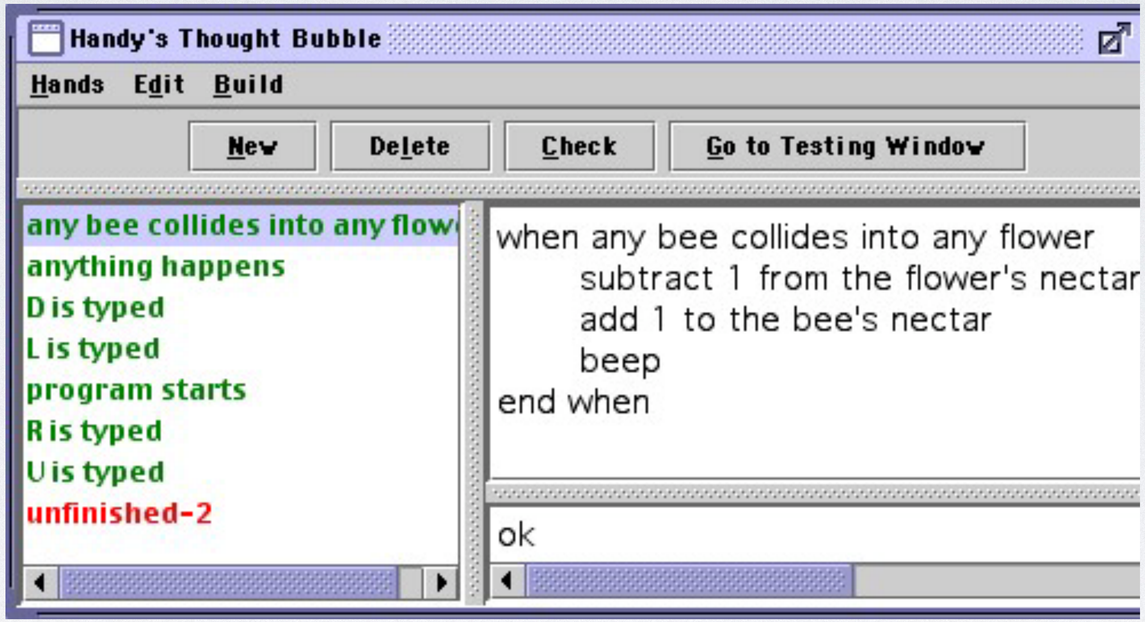


Figure 2. HANDS is an event-based system. The left pane lists seven complete (syntactically correct) event handlers, and one that is marked in red because it is not finished (unfinished-2). The upper right pane shows the code for *when any bee collides into any flower*. The lower right pane displays any error messages for the selected event handler.

HANDS Design

- Based on natural programming studies
- Principle: *speak the user's language*
- x = x + 10 doesn't make sense in math
- instead: `add 100 to score`
- Allow "the" anywhere
- See also HyperTalk / AppleScript

MORE SYNTAX

Is there empirical data on this? If not, do we need some?

```
if (...) ...

if (...) ...

else ...
```

which `if` does this `else` go with?

```
if (...) ... end if

if (...) ...

else ... end if
```

Now it's clear.

PROPERTIES

- `nectar of flower`
- `flower's nectar`
- `cardname`

OPERATIONS ON CARDS

- `set nectar of flower to 100`
- `set flower’s nectar to flower’s nectar + 25`
- `add 25 to flower’s nectar`

AGGREGATE OPERATIONS

- All operations take lists!
- `1 + (1,2,3)` evaluates to `2,3,4`
- `(1,2,3) + (2,3,4)` evaluates to `3,5,7`

QUERIES

- Users don't maintain and traverse data structures
- Instead they use queries
- `all flowers` evaluates to orchid, rose, tulip
- `all bees` evaluates to bumble
- `all snakes` evaluates to the empty list
- `all (flower and (nectar < 100))` evaluates to orchid

BOOLEANS

- "The common uses of the words AND and OR in natural language lead to errors when these words are used to name the Boolean operators in queries; and the intended scope of the NOT operator is ambiguous."
-

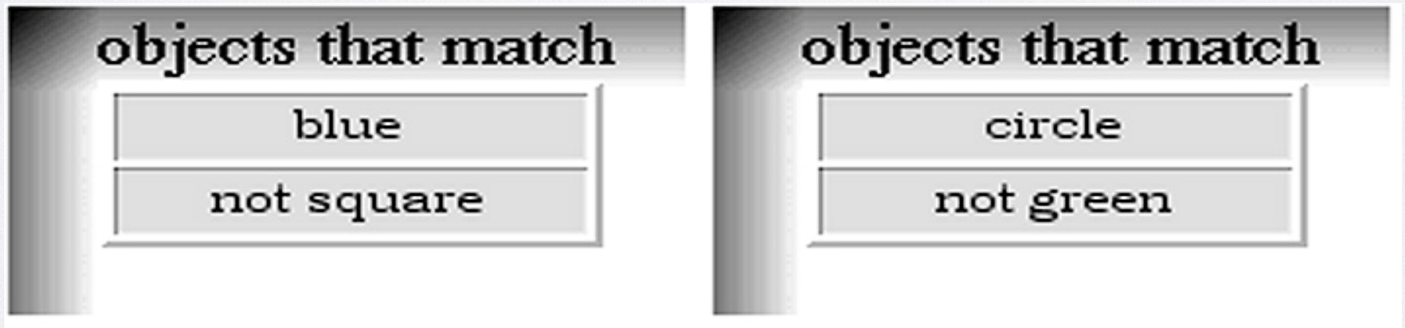


Figure 4. Match forms expressing the query
***(blue and not square) or (circle and not green)*.**

LOOPS AND CONDITIONALS

```
with all flowers calling each the flower
    set the flower’s nectar to random from 50 to 100
end with


if f=tulip then
    set f’s nectar to 0
otherwise set f’s nectar to 100 end if
```

USER STUDY

- 23 fifth graders, no programming experience
- HANDS vs. limited HANDS (no queries/aggregate operations, less data visibility)
- Tutorial; "Those portions utilizing a feature that was missing in the limited system were replaced with material teaching the easiest way to use the system's remaining features to achieve the same result."
- Of children who finished tutorial, HANDS participants performed better than "limited HANDS". $p < .05$
    - But what does "better" mean?

LIMITATIONS OF NATURAL PROGRAMMING

- If you ask a Java programmer, won't they just write Java code?
- Yes, depends on prior experience
  - Find people without experience
  - Put people in a novel situation
- Constrain choices

EXAMPLE

- Gave seven participants a description of a voter registration system.
- "Please implement this system in pseudocode using any language features you want."
  - Two invented syntax denoting states and transitions.
  - Many of the rest were unsafe, e.g. separate lists for unregistered and registered voters.
- "Here's a state diagram that models the system. Modify your pseudocode to use states and transitions."
  - Two participants: explicit state blocks with variables nested inside

```
contract Citizen {

    Citizen() {
       state = Unregistered;
    }

    state Unregistered {
      transaction submitApplication

            …
      }
    }
}
```

```
var states = {
  (0, “Processing”),
  (1, “CanVote”),
  (2, “CannotVote”)}
var state = states[0]

function processed(a):
   # run this once “a” has been processed
   if a.accepted:
     state = states[1]
   else:
     state = states[2]
```