Activity 1.1.2

Lightbot: Input, Output, State

Introduction

The various senses we have as people, like sight or hearing, are our inputs. Human muscles provide outputs in such a system. A given input (like a bright light in one eye) will produce a particular output (like both pupils contracting). Many times a particular output is determined by our state and memory.

Does your output depend on what you sense?

Does your behavior depend on your state?

Does what you do depend on anything else?

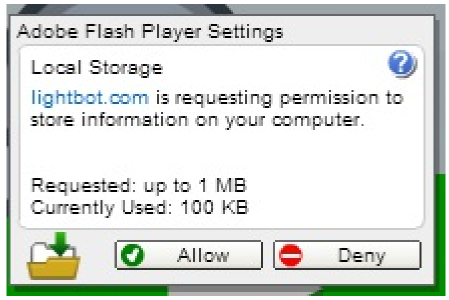
Materials

- Computer with Adobe Flash and Lightbot from http://lightbot.com/hocflash.html.

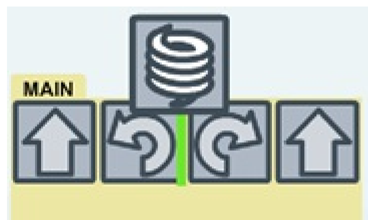
Procedure

> Refer to your downloadable resources for this material. Interactive content may not be available in the PDF edition of this course.

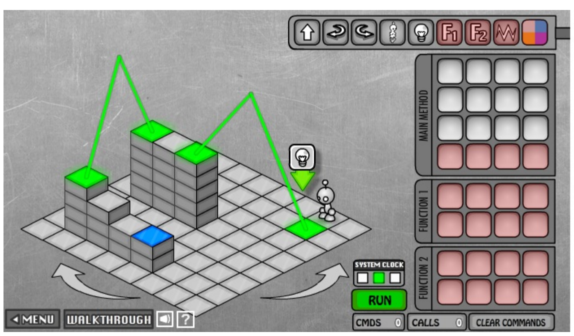
1. Play Lightbot from http://lightbot.com/hocflash.html.
    - Allow the allocation of local storage to the Flash game.

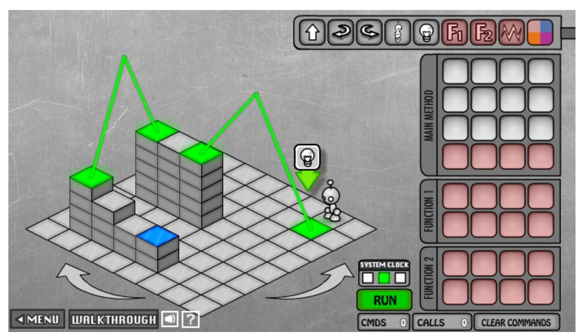


- Play for 10-15 minutes as directed by your teacher. Note that you can drag commands around to change their order; the green line in the image below shows where the jump command will be inserted.



2. Just as Lightbot processes one instruction at a time, a computer processor core handles one instruction at a time. The output of the computer is determined entirely from its input and its state, which includes its memory. For Lightbot the state is described by which square the Lightbot is standing on and which direction it is facing.

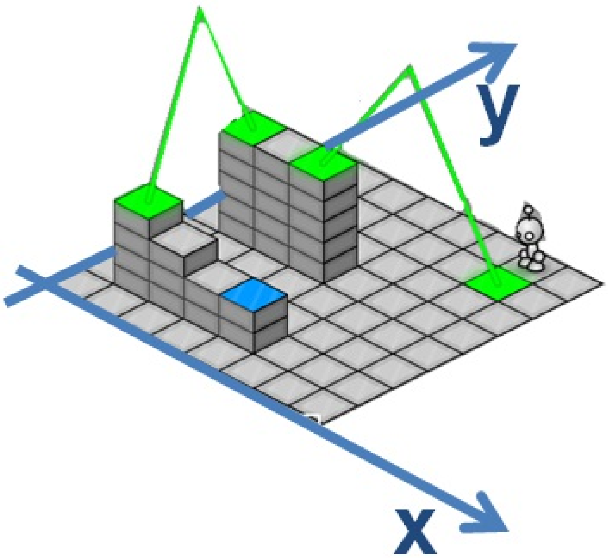


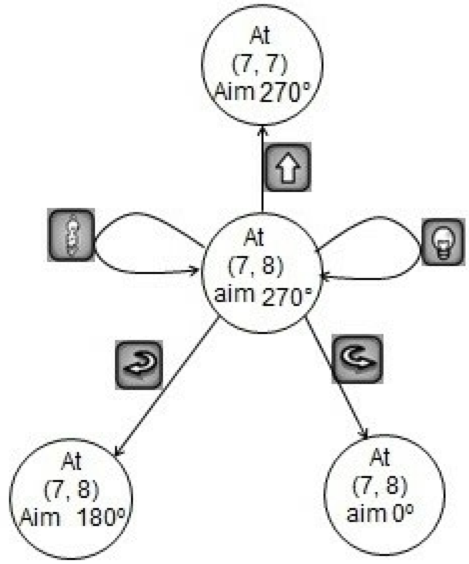


- In the picture above at left, how many spaces are available for Lightbot to stand on?
- In the picture above, how many directions can Lightbot face?

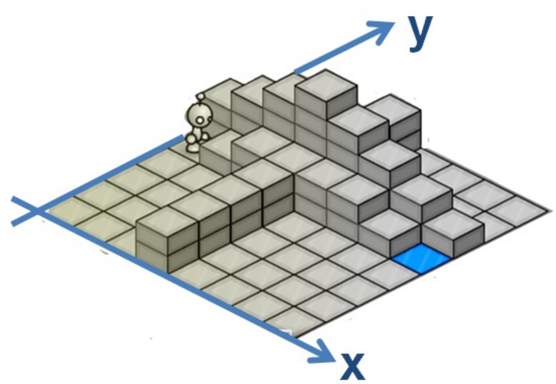
3. (Enrichment. Complete if desired or as directed by teacher.) To describe the Lightbot robot's state, we just need toidentify the square it is on and the direction it is aiming. In the picture at the left, Lightbot is at location (7, 8)and is aimingin the direction 270°. Together the location and direction of Lightbot say everything there is to know about Lightbot's **state**. The figure below on the right is a **state diagram**.

   Circles show the states thatLightbot can be in. The arrows show the actionsLightbotcould take on the next move, and the arrows point toward the state that Lightbot would move to as a result. To complete the state diagram, we would also have to show the moves Lightbot could take on the next turn. The full state diagram would show every possible location and heading and show what moves Lightbot could make from each state.

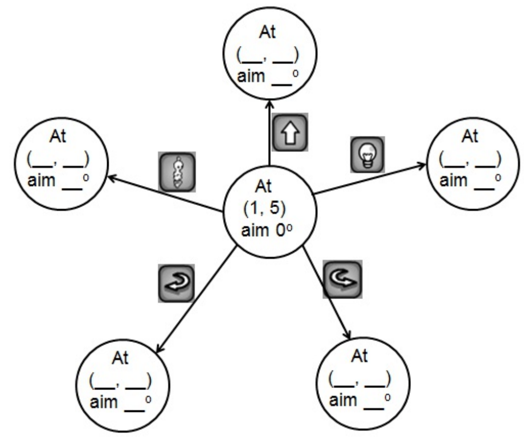




- What is Lightbot's state in the picture below?



- After one of the instructions is executed, Lightbot is again in a state described by its position and the direction it is facing. Fill in the remaining states in the state diagram below.



Conclusion

1. How is Lightbot like a computer?

2. How is Lightbot different than a computer?

3. One aim of this course is to consider the relationship between humans and computers. Read the following background and write a journal style response to one of the two sets of questions below.

   Lightbot has only a few instructions and only three variables to describe its state. Alan Turing proved that simple computers like this can do all the computation that a modern computer can do. A small set of simple instructions can produce intelligence, or at least the appearance of it.

   A human brain contains roughly one hundred billion neurons: 10^{11} neurons. The state of the neurons' connections and chemistry in one human brain at any one instant could be represented by 10^{16} to 10^{19} zeros and ones.

   In his controversial book, *The Singularity Is Near*, Ray Kurzweil projects that computers will be exceed the computational power and memory of a human brain around year 2035. He predicts a “singularity” in 2045 in which machines quickly design smarter machines on their own.

   - When computers become smart enough that we cannot tell humans and computers apart (the Turing test), do you think that computers will experience consciousness the way we do? Should they have rights?

   - Someday the technology might exist to create an artificial neuron that is able to connect to and communicate with human neurons. Suppose one human neuron in a person's brain were replaced by one artificial neuron. Suppose the artificial neuron behaved the same as the human neuron in terms of inputs, states, and outputs. Would the person still be the same person or even still a human? What if a second neuron were replaced? What if all of the neurons in the brain were replaced, one by one? At what point do you call this a computer instead of a human? Why?