Generating Hints for Programming Problems Using Intermediate Output

Barry Peddycord III
Andrew Hicks
Tiffany Barnes

North Carolina State University
Center for Educational Informatics

@isharacomix at #EDM_2014

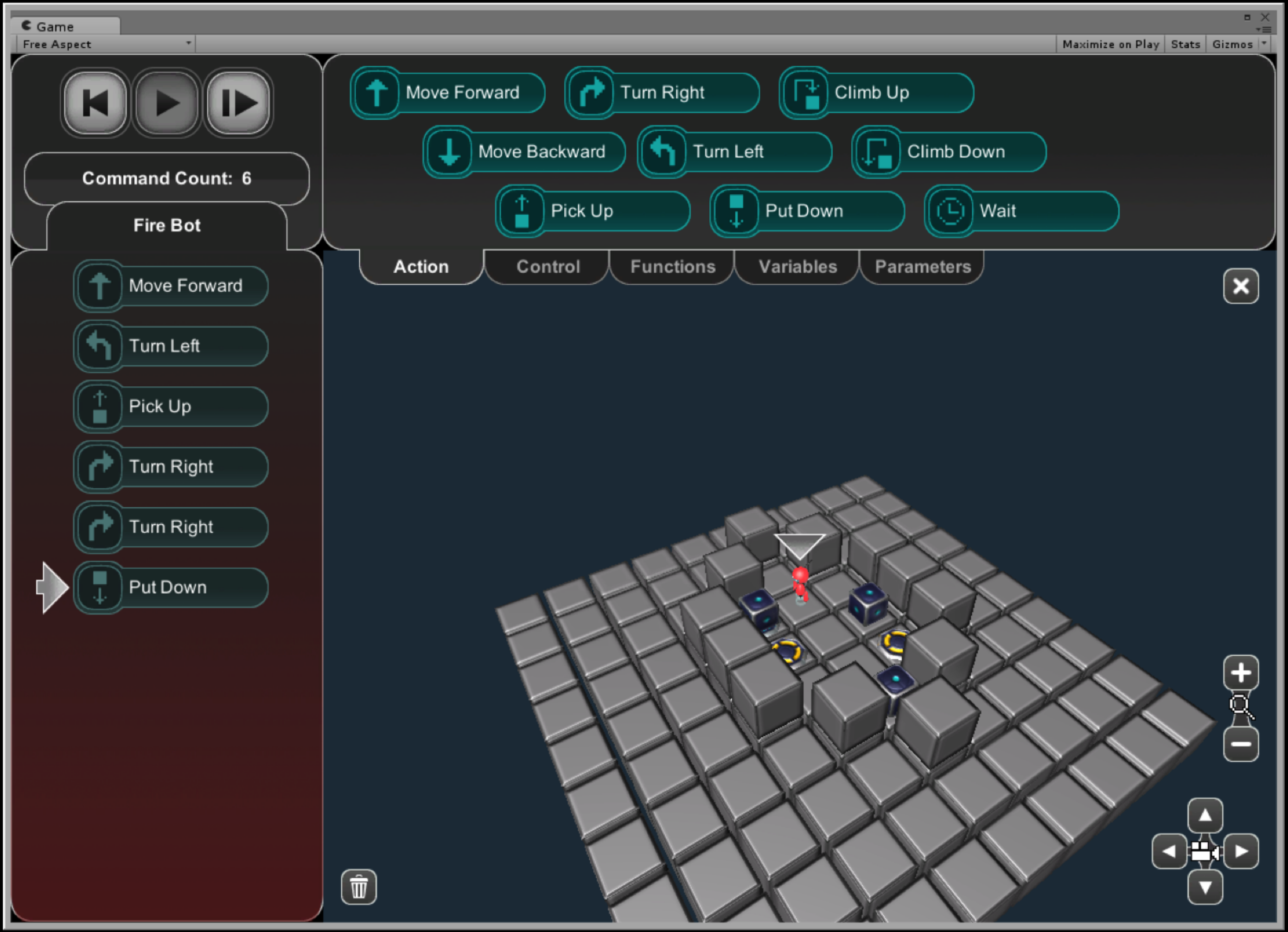
Today’s Menu

1. Motivation and Challenges
2. The big idea: World States
3. Setting up research questions
4. The study
5. Discussion and Future Work

Motivation

- Put the techniques from Intelligent Tutoring Systems into Educational Games
- Improve the state of Intelligent Tutors for programming languages

BOTS



```
Move Forward
Turn Left
Pick Up
Turn Right
Turn Right
Put Down
```

Challenges w/ Programming Tutors

- Hard to break programming down into concrete interactions
  - Granularity of writing code
  - Lots of equivalent representations

```
print 1
print 2
print 3
print 4
print 5
```

```
i = 0
while i < 5:
    i+=1
    print i
```

IDEA: **World States**

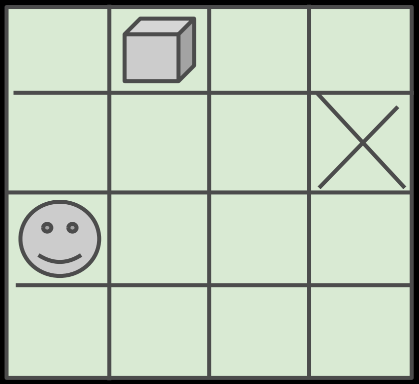
- What if we used the output at each compile as a state?

Let’s Generate Hints

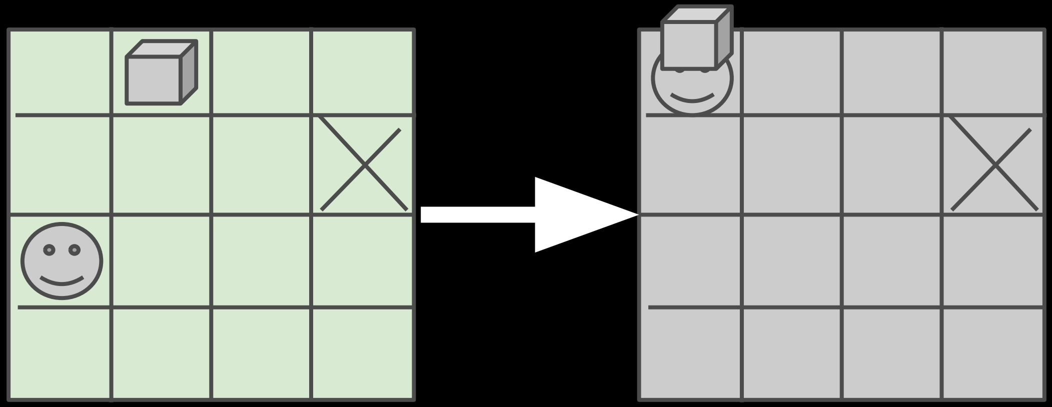
- First, build interaction network for the problem
- Each time a student compiles, a state is added to the network
- To generate a hint, use Hint Factory to pick a state that the student should go to next

Let’s work out an example...

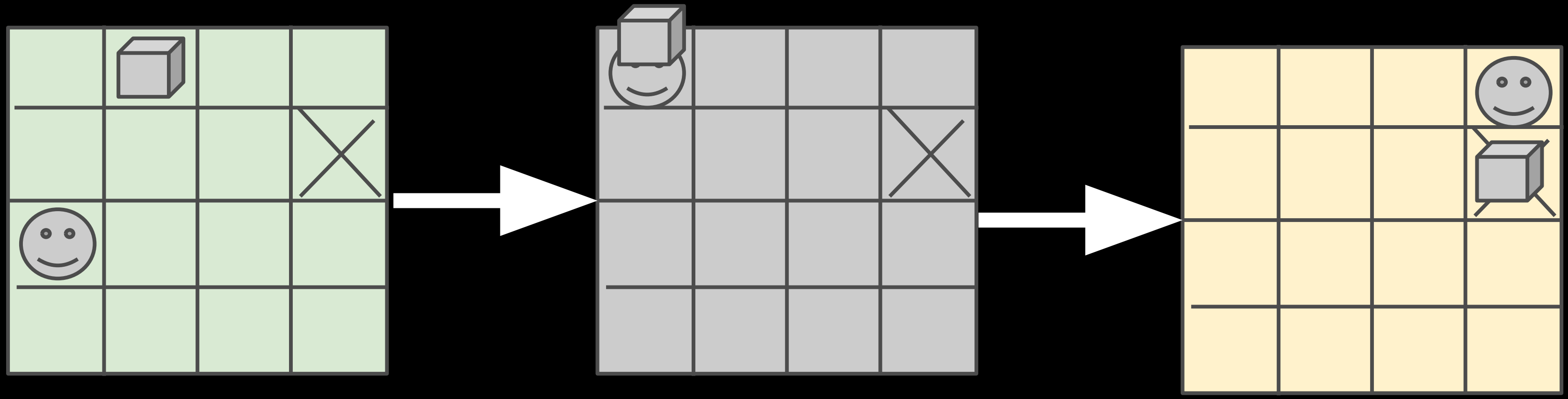
Build the Interaction Network



Build the Interaction Network

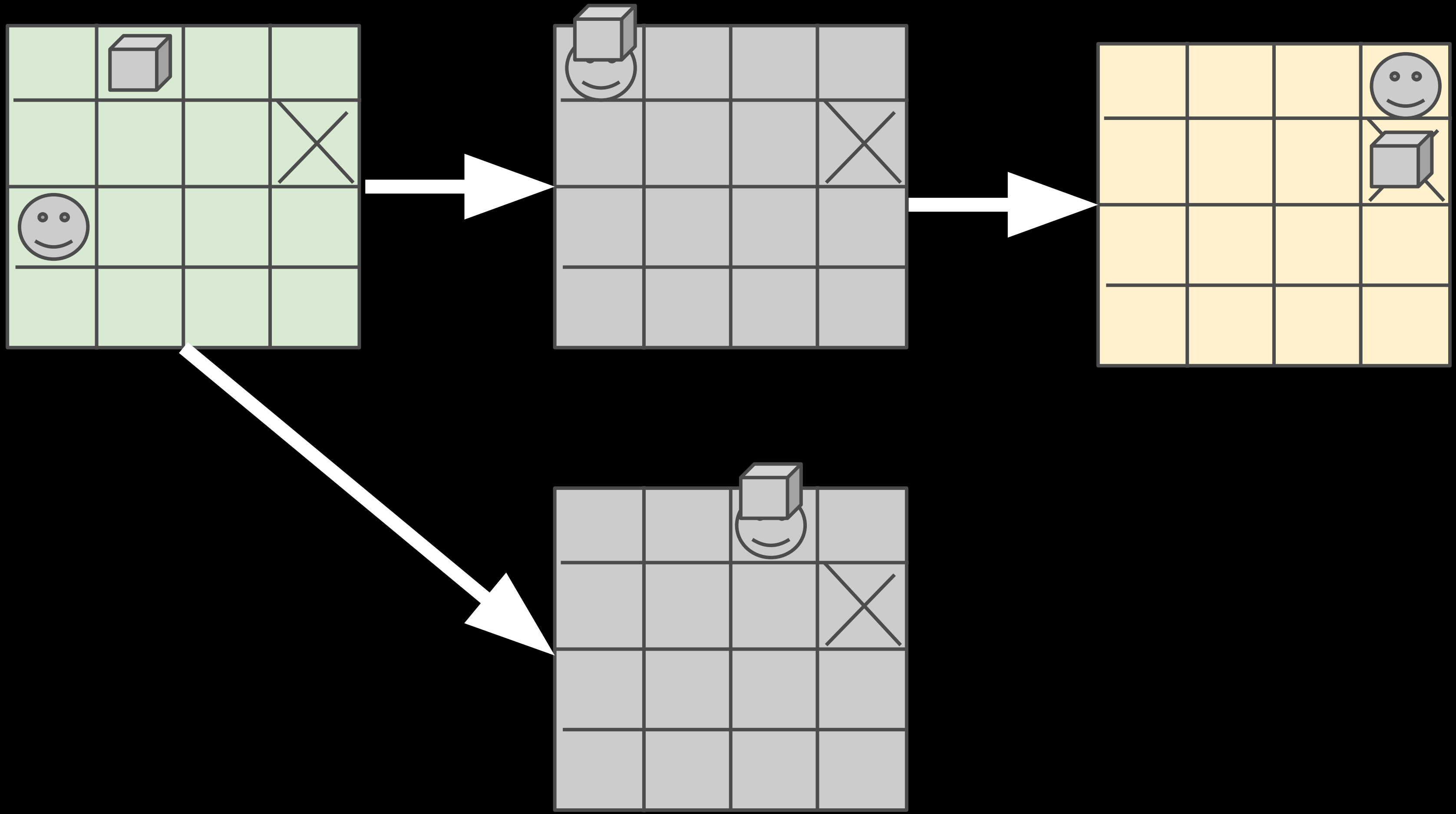


Build the Interaction Network



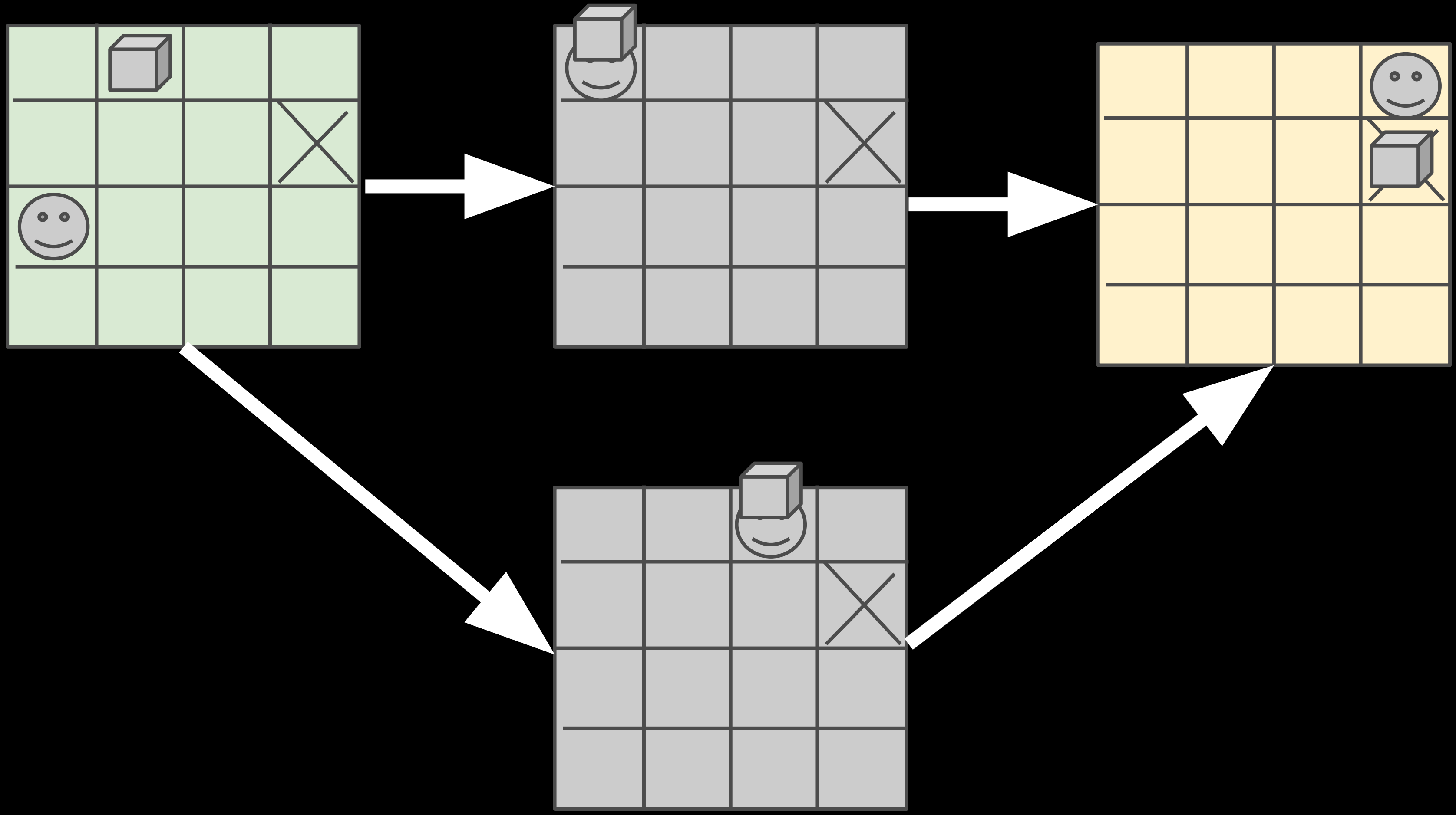
@isharacomix at #EDM_2014

Build the Interaction Network



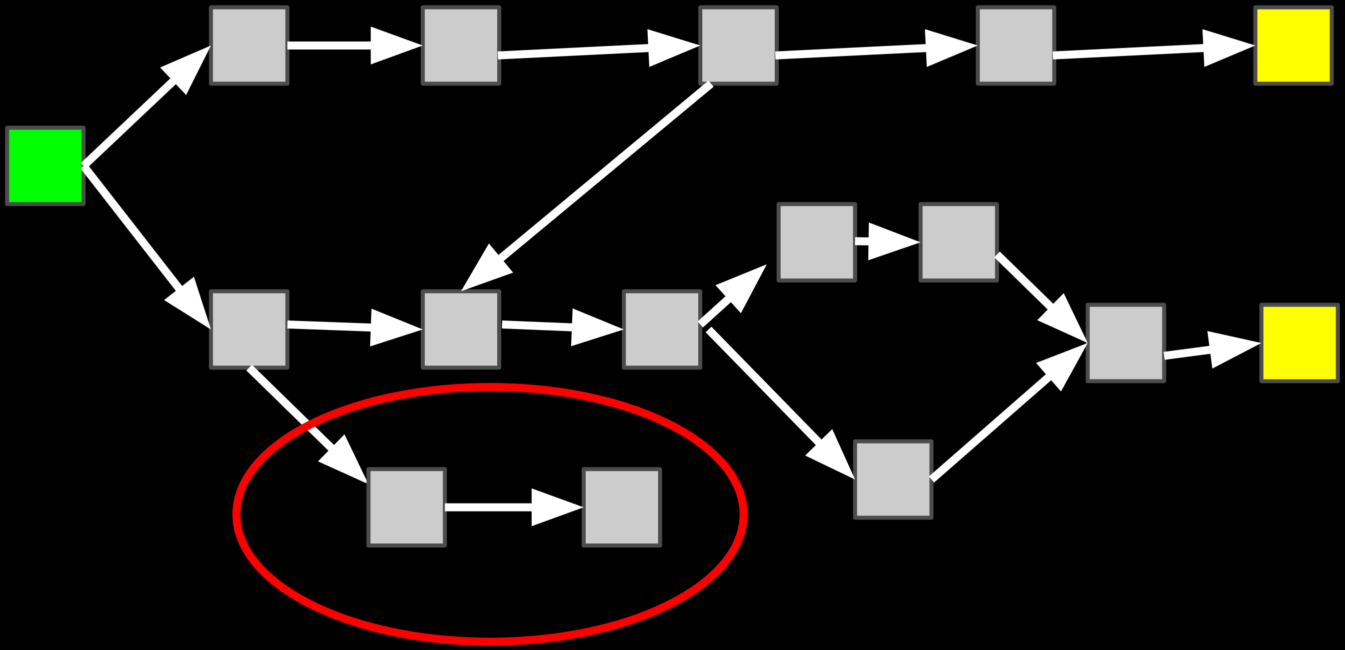
@isharacomix at #EDM_2014

Build the Interaction Network



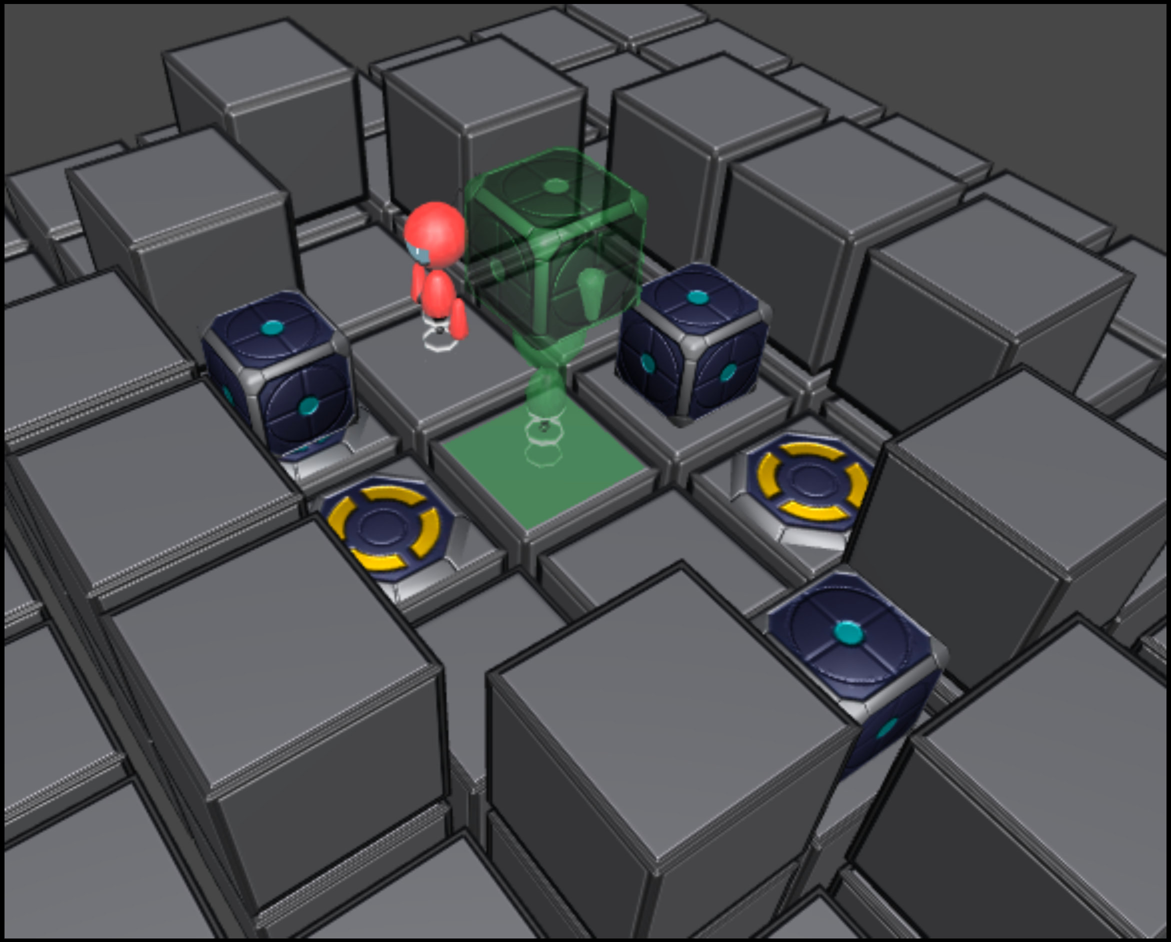
@isharacomix at #EDM_2014

Getting a Hint



@isharacomix at #EDM_2014

What a hint might look like



Our Requirements

- We need a state model where student behavior produces
  - Enough states to meaningfully differentiate between students
  - Few enough states where students fall into groups
- We believe World States meet these conditions
  - Code is usually very diverse, but many programs share the same output
    - Huang et al, EDM 2013

Research Question

How well do world states represent the actions of students in the game BOTS?

- How much do world states reduce the state space?
- How many states only occur once in the model?
- How much student data is needed to generate hints?

NOT Research Question

- How effective are programming hints?
- How hard is articulating programming hints?

We are assessing the suitability of this domain for hint generation before going forward with generating hints.

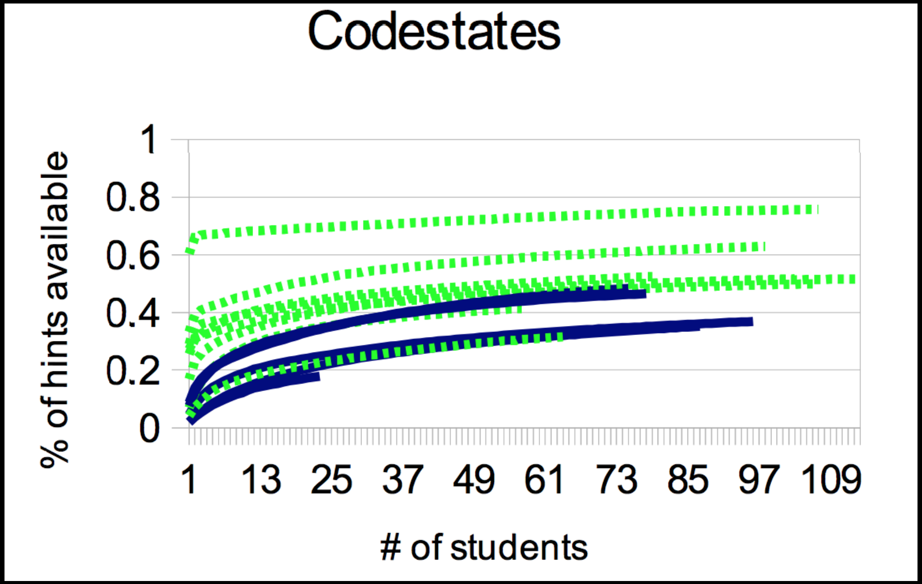
Theory to Practice

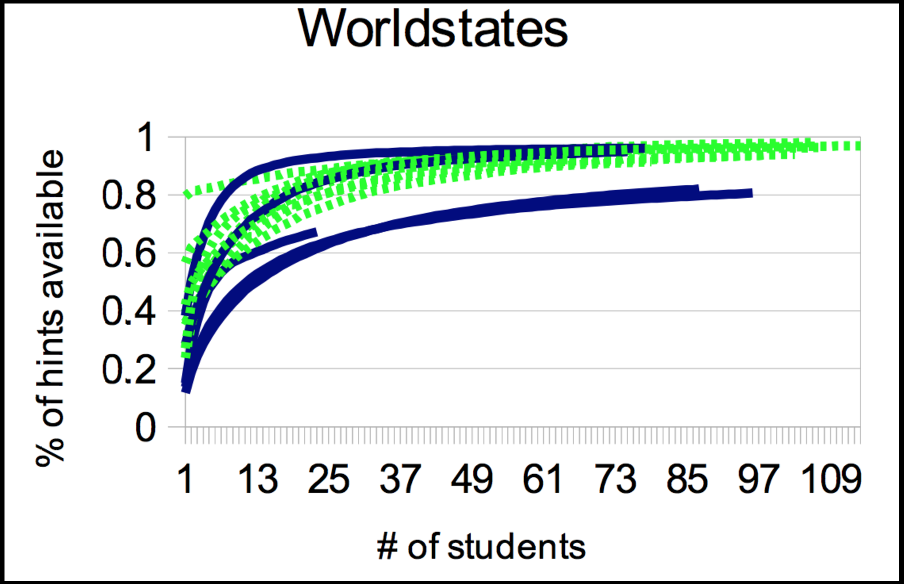
- We have data from about 120 students who have played BOTS
  - First, we present what the interaction networks look like
  - We also simulate what it would be like if they tried to get hints

Size of Interaction Networks

Name	# Students	Code States (All, Freq1, Hint)			World States (All, Freq1, Hint)		
Tutorial1	125	162		89	25		22
Tutorial2	118	50		36	14		12
Tutorial3	117	210		130	24		22
Tutorial4	114	225		137	41		33
Tutorial5	109	106		75	29		25
Chlnge1	107	560	146	348	191	112	143
Chlnge2	98	431	127	201	133	84	86
Tutorial6	90	143		107	36		33
Chlnge3	89	278	91	192	30	22	28
Chlnge4	86	208	65	137	45	36	40
Tutorial7	76	383		206	57		43
Tutorial8	68	134		112	30		29
Chlnge5	34	27		17	17		13

Cold Start Problem (simulated students)





Conclusions

- Enough overlap to justify generating hints
- Still several complications
  - Open ended problems still have large state spaces
  - Programming is usually open-ended
  - Need more studies on how problem design affects state space
- World state space may be interesting way to model programming solutions

Q&A

We do have a replication package. Please contact the authors for more details.

{bwpeddyc, aghicks3, tmbarnes}@ncsu.edu

This material is based upon work supported by the National Science Foundation Graduate Research Fellowship under Grant Nos. 0900860 and 1252376.