Education and Outreach

ExCAPE Year 1 Review Meeting
Tuesday June 11, 1:00-2:15pm

Leads: Stéphane Lafortune and Steve Zdancewic
Education and Outreach: Year 1 Highlights

• 2013 Summer School
• Training of graduate students and post-docs
• Online Education Technology
• Knowledge Transfer
• K-12 Outreach
2013 Summer School

• Proposal: Summer Schools in 2013, 2015, 2017

• 2013: Here, June 12-15: 3.5 days + excursion

• Local organizer: Ras Bodik et al.

• Exceptional interest: 100+ registrants!
  – Mix of graduate students (72), post-docs (13), researchers (10), and faculty (8), from 17 different countries
2013 Summer School: Schedule

• 3 main tutorials with “hands-on” sessions (over 3 days):
  – Reactive Synthesis: Vardi and Ehlers
  – Synthesizing Programs with Constraint Solvers: Bodik and Torlak
  – Synthesis for Cyber-Physical Systems: Tabuada and Rungger

• Supporting lectures by ExCAPE PIs:
  – Tripakis, Seshia, Lafortune, Solar-Lezama
2013 Summer School: Schedule

• Invited Speakers:
  – Sumit Gulwani (Microsoft Research): Synthesis for computer-aided education
  – Richard Murray (Caltech): Synthesis for embedded control software
  – Alexandre Donzé (UC Berkeley): Requirement Synthesis for Industrial-Scale Control Systems
Training of Graduate Students and Post-Docs

• More than 26 graduate students involved in ExCAPE-related work at 6 institutions
  – Database under construction; we need your feedback!
• Several REUs as well (please tell us)
• Post-Doctoral Researchers:
  – One in Year 1, continuing in Year 2 (R. Ehlers; Cornell and Berkeley)
  – Four more to join in September: I. Saha (Penn, Berkeley); C. Stergiou (Berkeley, Penn); X. Qiu (Maryland, MIT); D. Zufferey (Penn, UIUC)
Online Education Technology

• Autograder at MIT: A. Solar-Lezama, R. Singh
  – Highlighted yesterday morning
  – Deployed with impressive success

• AutomataTutor at UPenn: R. Alur
  – Classroom use in fall at UPenn and UIUC
  – Demo by Loris D’Antoni (slides on pages 8 to 15)

• Cyber-Physical Systems course at UC Berkeley: S. Seshia
  (slides appended at the end)
Automated Grading and Feedback for DFA constructions

Experiments and Evaluation

Rajeev Alur (Penn), Loris D’Antoni (Penn), Sumit Gulwani (MSR), Bjoern Hartmann (Berkeley), Dileep Kini (UIUC), Mahesh Viswanathan (UIUC)
Twice ab

Draw a DFA that accepts the following language over the alphabet \{a, b\}: all strings in which \textit{ab} appears exactly twice as a substring.

Answer:

![DFA Diagram]

automatatutor.com
Tool Evaluation

- **Grade:** 4/10
- **Feedback:** You are computing the language
  \[ \{ s \mid \text{‘ab’ appears in } s\text{ at least 2 times}\} \]

How do we check whether the grade is “correct”?

What is a good/bad feedback?
Evaluating the grades – part 1.1 - [IJCAI13]

• Experiment setup:
  – We collected 800 UIUC student attempts for 6 different assignments
  – We graded each assignment using
    • H1, H2: instructors
    • N: a naïve grader
    • T: our tool

<table>
<thead>
<tr>
<th>Problem</th>
<th>Attempts</th>
<th>Average</th>
<th>Standard Deviation</th>
<th>Pearson Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1 = { s</td>
<td>s starts with a and has odd number of (ab) substrings}</td>
<td>131 108</td>
<td>0.99 0.54 0.22</td>
<td>2.06 1.99 2.62</td>
</tr>
<tr>
<td>L2 = { s</td>
<td>s has more than 2 a’s or more than 2 b’s}</td>
<td>110 100</td>
<td>-0.66 0.85 0.26</td>
<td>1.80 2.44 2.71</td>
</tr>
<tr>
<td>L3 = { s</td>
<td>s where all odd positions contain the symbol a}</td>
<td>96 75</td>
<td>-0.52 0.86 -1.38</td>
<td>1.61 2.67 3.84</td>
</tr>
<tr>
<td>L4 = { s</td>
<td>s begins with (ab) and (</td>
<td>s</td>
<td>) is not divisible by 3}</td>
<td>92 68</td>
</tr>
<tr>
<td>L5 = { s</td>
<td>s contains the substring (ab) exactly twice}</td>
<td>52 46</td>
<td>0.02 0.19 0.29</td>
<td>2.01 1.88 3.23</td>
</tr>
<tr>
<td>L6 = { s</td>
<td>s contains the substring (aa) and ends with (ab)}</td>
<td>38 31</td>
<td>-0.50 -1.34 -1.5</td>
<td>2.42 2.90 3.70</td>
</tr>
</tbody>
</table>
Evaluating the grades – part 1.2 - [IJCAI13]

- Experiment setup:
  - We collected 800 UIUC student attempts for 6 different assignments
  - We graded each assignment using
    - H1, H2: instructors
    - N: a naïve grader
    - T: our tool

<table>
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<tr>
<th>Average</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>H1-H2</td>
</tr>
<tr>
<td></td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>-0.66</td>
</tr>
<tr>
<td></td>
<td>-0.52</td>
</tr>
<tr>
<td></td>
<td>0.40</td>
</tr>
<tr>
<td></td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>-0.50</td>
</tr>
</tbody>
</table>

Average not informative (N better than H2)

SD shows H1 is closer to Tool than to H2!!!
Evaluating the grades – part 2 - [IJCAI13]

- Previous slide showed tool is somewhat undistinguishable from human (some sort of Grading Turing Test).
- But there is more!!
- What about the remaining 10%
- We manually checked the cases where T and H were disagreeing by more than 3
  - Most of the times the human wanted to revise his grade!!
  - The tool is still wrong sometimes
Ongoing work – Feedback Evaluation

• We are going to collect student “learning history”
• Every time the student submit a wrong attempt, we either
  – Provide feedback, or
  – Don’t provide feedback
• We compare the two groups of students and check which group will
  – Use less attempts (measures quality of hints)
  – Perform better on following assignments (measure learning)

• Also: when we provide feedback we ask the student to rate it (thumbs up/thumbs down)
Thank you

• lorisdan@cis.upenn.edu

• Questions?
Knowledge Transfer Activities

• Course materials from Summer School
  – Suggestions for continuous updating
• UC Berkeley: Ras Bodik
• Cornell: Hadas Kress-Gazit (see slide next page)
• Rice: Lydia Kavraki
Knowledge Transfer

• Linear Temporal Logic Mission Planner (LTLMoP - Cornell) has been extended to work with Lego mindstorms
  – High school student experimented with the toolbox in the lab (summer 2012)
  – Exploring outreach opportunities
Outreach to High School Students

- Efforts during Year 1
- Anticipated efforts during Year 2

- Discussion and planning
Outreach to High School Students - Cornell

- CURIE academy – week long summer camp about engineering for high school girls
  - Kress-Gazit ran the project component in summer 2012
Outreach to High School Students - Cornell

- Expanding Your Horizons (EYH) – Day of workshops for middle school girls
  - Workshop using the iRobot Create – program the robot using only the bump sensor – offered for the second time.

Cornell University
Saturday, April 20th, 2013
8:45 AM– 5:00 PM

“I liked how it made math and science fun!”

Find out more at: www.eyh.comell.edu
Education and Outreach – Wrap-up

• More to come!
• Suggestions welcome
• Please let Steve and Stéphane know of your relevant activities
Virtualizing Cyber-Physical Systems: Bringing CPS to Online Education

Sanjit A. Seshia
UC Berkeley

Joint work with:
Jeff C. Jensen, Dorsa Sadigh, Edward A. Lee, Mona Gupta
EECS 149: Introduction to Embedded Systems

• Textbook:
  - Lee & Seshia
    *Introduction to Embedded Systems*
  - Jensen, Lee, & Seshia
    *An Introductory Lab in Embedded & Cyber-Physical Systems*

• Laboratory (6 weeks)
• Capstone design (12 weeks)

➢ What would it take to create a MOOC version of EECS 149?
Bringing Automation to Two Course Components

• “Theory” Component: Homeworks and Exams
  – Generating new problems (e.g., “similar” difficulty level to existing problems)
  – Generating solutions
  – Grading / Tutoring
  ➔ Exercise Creation Toolkit

• Lab Component: Structured Labs and Open-Ended Projects
  – Mix of software and hardware design
  – Challenge: how do we give students in an online course offering a similar design experience?
Generalize to template, instantiate the template

- Modify a Model $\langle M \rangle$
  
  | $\langle M \rangle$ | $\langle \psi \rangle$ | Simulation of Model |
  | $\langle M \rangle$ | $\langle \phi \rangle$ | Specification Mining |
  | $\langle M \rangle \& \langle \psi \rangle$ | $\langle \psi \rangle$ | Simulation with Guidance |
  | $\langle M \rangle \& \langle \phi \rangle$ | $\langle \psi \rangle$ | Model Checking |

- Modify a Trace $\langle \psi \rangle$
  
  | $\langle M \rangle \& \langle \psi \rangle$ | $\langle \psi \rangle$ | Simulation with Guidance |

- Modify a Specification $\langle \phi \rangle$
  
  | $\langle \phi \rangle$ | $\langle M \rangle$ | Constrained Synthesis or Repair |
  | $\langle M \rangle \& \langle \phi \rangle$ | $\langle \psi \rangle$ | Model Checking |
More Recent Work (CPS-Ed workshop 2013)

Towards a Virtual Laboratory for EECS 149
  – For a MOOC version of the course

• Cost of Virtualization

• Simulation Environment

• Automatic Grading
Lab: Robot Hill Climb → Virtual World

- Students design Statecharts controller to climb a hill
- ODE simulation of robot, software, & environment
- Statechart deploys to real robot without modification

Simulation of a not-yet-perfected controller.
Virtual Lab in the Cloud

- Amazon EC2 (cloud)
- Estimated $5.44 usage fees for lab sequence
- Minimal end-user requirements (basic PC, good internet)

Simulator running on Amazon EC2 (“the cloud”)
Automatic Grading of Lab Exercises: The How

- Specify desired properties (e.g. end goal for hill climb, waypoints)
  - Temporal logic / monitor automata
- Run-time monitoring
  - Check whether solution is correct / wrong
- Feedback generation
  - Leverage property-based error localization methods [Li & Seshia, RV ’12]
- Possible use of falsification tools for Simulink/LabVIEW/...
  - Tools such as S-Taliro, Breach [HSCC ’13], ...
- Other considerations: Local vs Global, Detecting cheating, etc.
Conclusions

Towards a MOOC version for EECS 149, the Berkeley undergraduate Embedded Systems course

• Automatic Exercise Generation
• Virtual Lab:
  – Cost of Virtualization
  – Simulation Environment
  – Automatic Grading

• Expected deployment in the next 12 months