

Formal Methods for Personalized (Lab-Based) Education

Sanjit A. Seshia

UC Berkeley

Joint work with

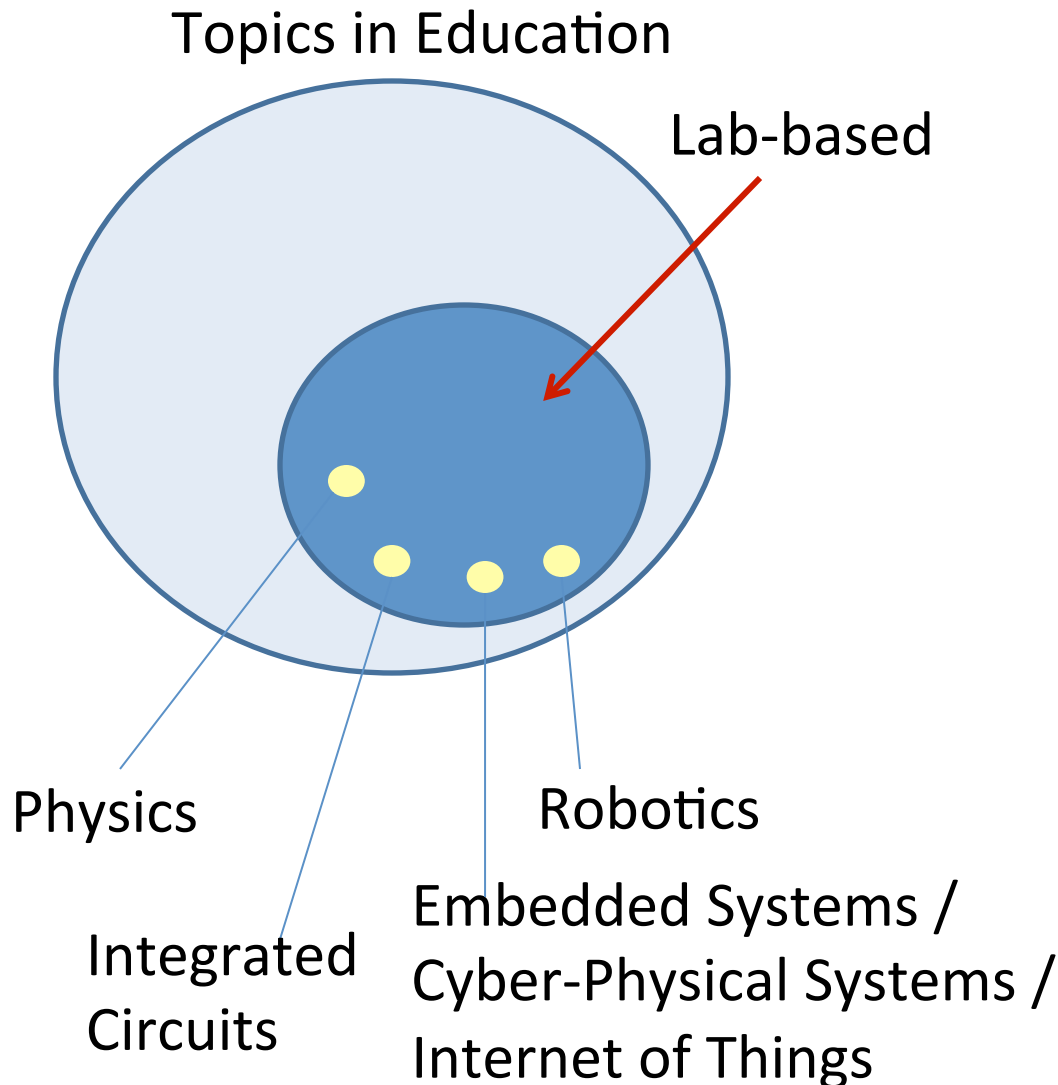
Garvit Juniwal, Alexandre Donzé, Jeff C. Jensen



CPSGrader.org

CCC Visioning Workshop
November 12, 2015

Formal Inductive Synthesis for Education (w/ focus on lab-based education)



Formal Methods
(computational proof)
+
Machine Learning

can be very effective for:

- Grading
- Personalized Feedback / Guidance
- Exercise generation
- ...

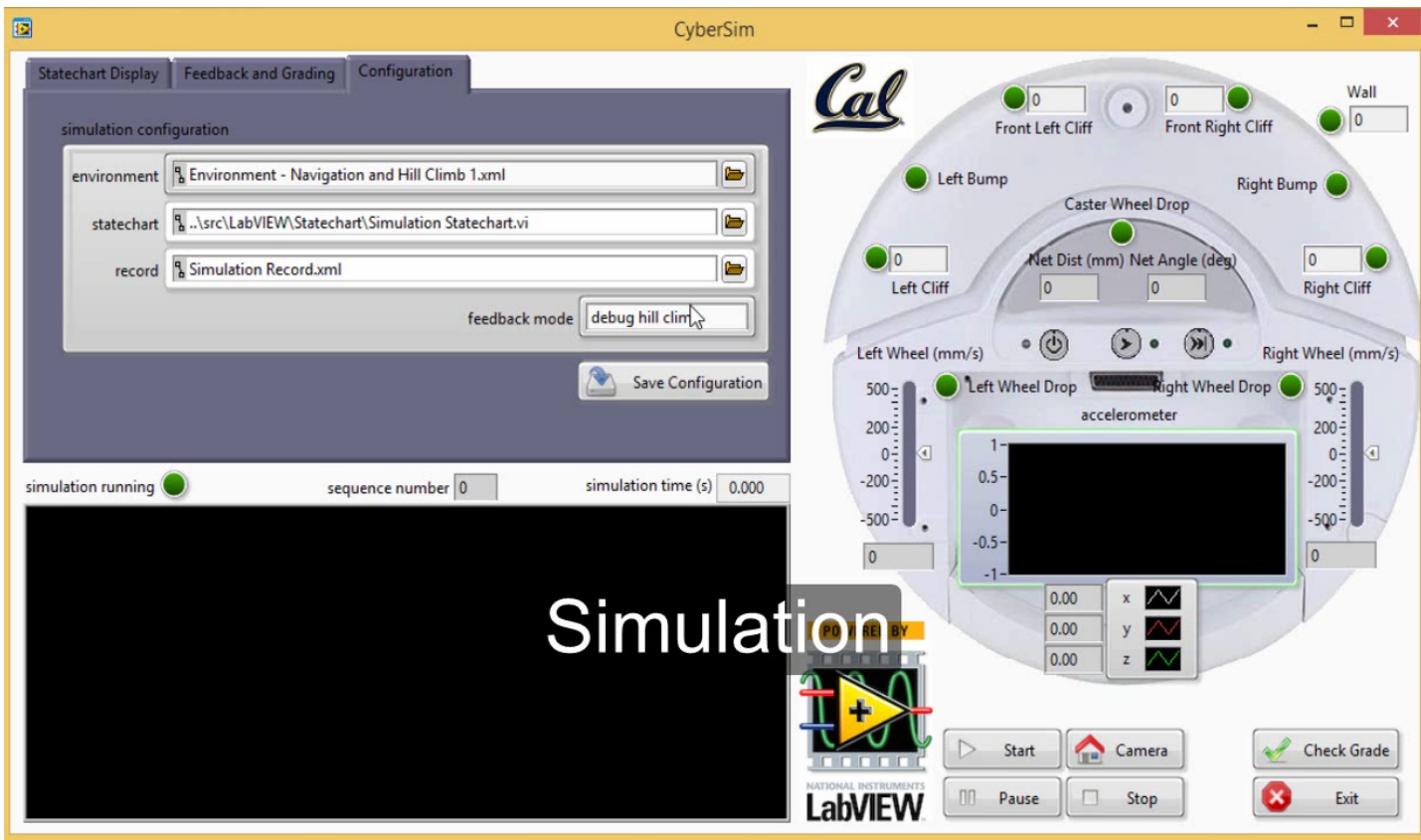
EECS 149: Intro to Embedded Systems at UC Berkeley Lab on The “Hill-Climbing” Robot



Garvit,
Course TA

Goal: **Online Virtual Lab** with learning experience
“comparable” to **On-Campus Real Lab**

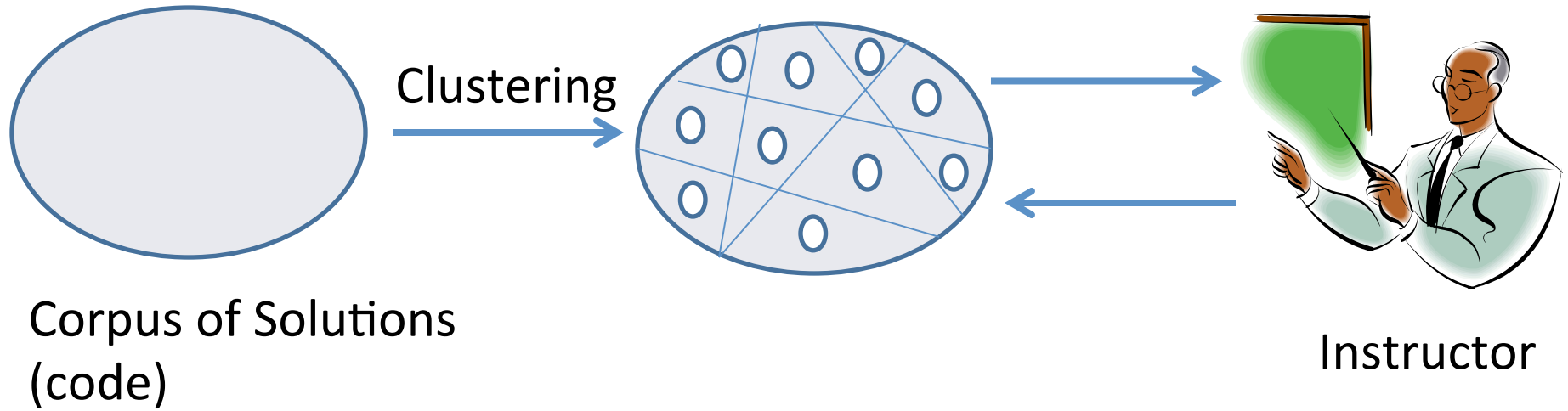
Virtual Lab: CyberSim + CPSGrader



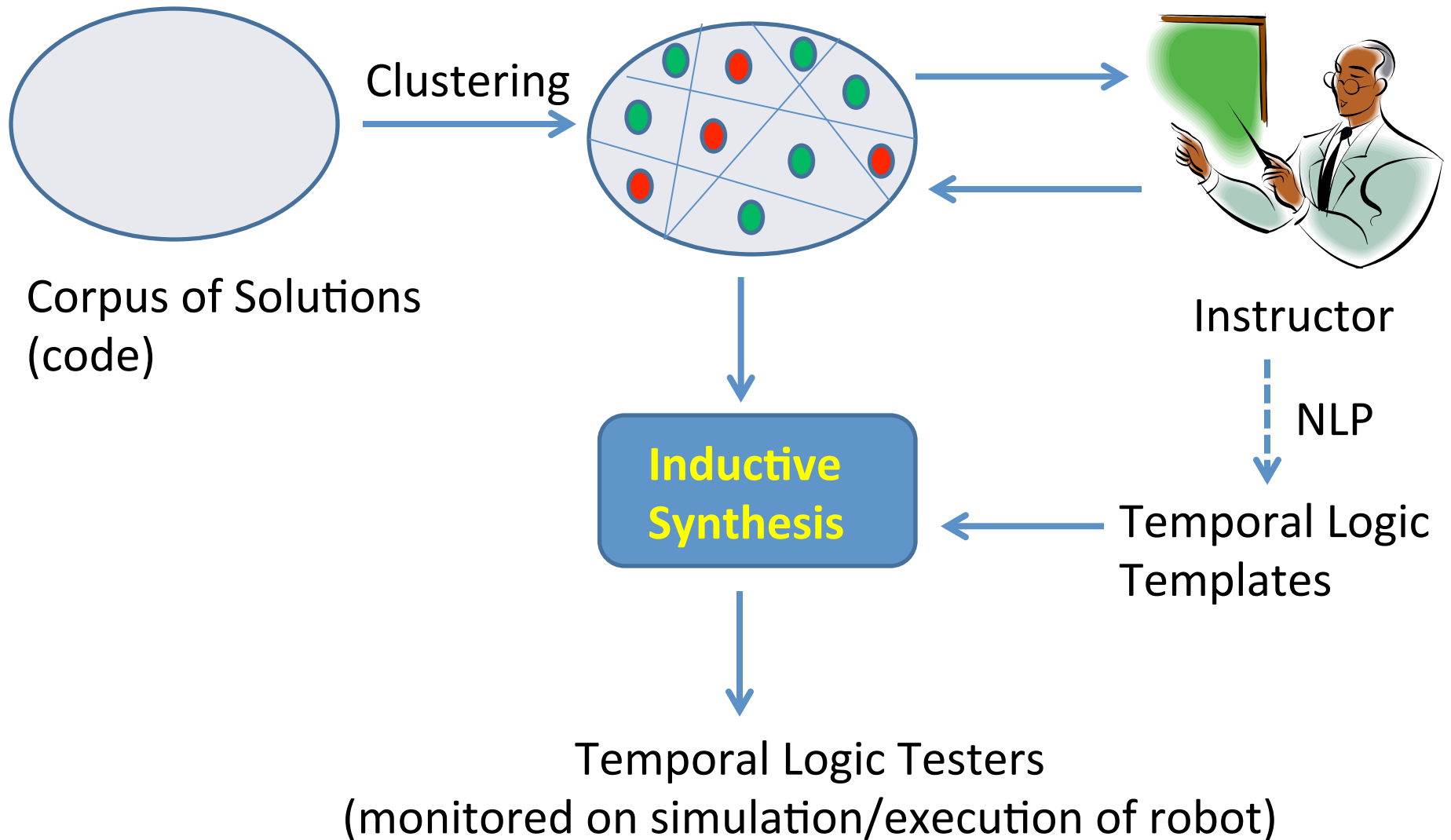
Technology based on **Formal Methods + Active Learning**

- Run-time verification of Properties in *Signal Temporal Logic*
- Automatic Synthesis of Temporal Logic Testers [EMSOFT 2014]
- Clustering-based Active Learning Framework [L@S 2015]

Instructor View of CPSGrader



Instructor View of CPSGrader



Student Feedback has been Positive: Online and On Campus

- EECS149.1x on edX
 - **86%** found auto-grader feedback useful for debugging
 - **>90%** of solutions that passed CPSGrader worked on the real robot with no or minor modifications [optional hardware track]
- EECS149 on campus at UC Berkeley
 - Course taught by other instructors [Lee & Sangiovanni-Vincentelli]
 - Enrollment nearly doubled from previous year!
 - Same lab space and similar resources!
 - Debug Tests: **75%** rated as somewhat to very useful
 - Feedback: **82%** rated as somewhat to very useful

Formal Inductive Synthesis is very promising

- **CPSGrader** – Automatic grading and personalized feedback in lab-based education
 - Released open source at <http://cpsgrader.org>
 - Lots of future work:
 - Combination with NLP, crowdsourcing, ...
 - Other lab-based courses: frequency-domain properties, ...
 - Extra/partial credit
- **FMEE** – graduate course exploring applications of Formal Methods for (Engineering) Education
 - Constrained Random Sampling for Problem Generation
 - E.g., to deter cheating
 - More formal methods + machine learning
 - E.g., FM can generate “interesting data points” for ML
 - <http://www.eecs.berkeley.edu/~sseshia/fmee/>