## Curricula and Metrics to Investigate Human-Like Learning

Jacob Beal, Paul Robertson, Robert Laddaga BBN Technologies AAAI Symposium on Learning From Humans March, 2009



### It's not what you know, it's how you learn it.

## Context: Bootstrapped Learning Cup

- Contest that promotes LFH research
  - Open platform for curriculum development
  - Contributed domains for instruction
  - Base student, improved each year

### Problem: How do we measure success?

## What's needed to learn from humans?

- Embodied/grounded
- Many different cognitive specialists
- More parallel compute power
- Spelke principles/core knowledge
- Ecologically valid reasoning
- Shared experiences w. teacher
- Sheer quantity of background knowledge
- Autonomy of learner

## What's needed to learn from humans?

- Intuitive physics High quality sensory data Embodied/grounded
- Many different cognitive specialists Gaze tracking
  More parallel compute power
- Learning how to learn
- Spelke principles/core knowledge
- Ecologically valid reasoning Visual representations
- Shared experiences w. teacher
- Cueing from natural language
  Sheer quantity of background knowledge
- Autonomy of learner Learning by intervention

Social cueing Natural language understanding

## What's needed to learn from humans?

Large common-sense fact collection Motor degrees of freedom
 Embodied/arounded

- Teedom Intuitive physics High quality sensory data mputational power of neurons Intuitive pedagogy
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## Which are really important?

*Uh...* 

## Spectrum Curriculum

- Pick one dimension to focus on
- Sequence of lessons along dimension
  - Incrementally move from hard to easy
- Test before first lesson, after each lesson

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## **Dimension: Learner Autonomy**

- Autonomy hypothesis:
  - Student is hypothesizing about environment
  - Teacher's actions provide disambiguating hints
- Implications:
  - Incorrect signals still help if they favor a hypothesis
  - Student is expected to fill in "obvious" gaps
  - Perceptible affordances will trigger learning w/o intervention from teacher

Many scattered points



**Boolean function** 

- Many scattered points
- Many border points



### Decision is a single boundary

- Many scattered points
- Many border points
- Cardinal border points



Boundary is a rectangle

- Many scattered points
- Many border points
- Cardinal border points
- Opposite corner points



Rectangle is aligned w. cardinal axes

- Many scattered points
- Many border points
- Cardinal border points
- Opposite corner points
- Hint line & 2 examples



## Visible line is boundary of function

- Many scattered points
- Many border points
- Cardinal border points
- Opposite corner points
- Hint line & 2 examples
- Hint line & 1 example



### Other region has opposite value

- Many scattered points
- Many border points
- Cardinal border points
- Opposite corner points
- Hint line & 2 examples
- Hint line & 1 example
- Hint line only.



Inside is likely to be positive.



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Open Bootstrapped Learning Project

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### **Open Bootstrapped Learning Project**

Home Contest Rules Sample Curriculum

### It's not what you know, it's how you learn it.

#### **Teaching Computers**

What if computers could learn anything that a human mentor could teach them?

- We wouldn't need to write new software every time we wanted a new capability.
- Mentors wouldn't need to be computer programmers.
- Computer systems could keep up with advances in technology, techniques, or tactics by learning new tricks.

#### The Project

The Bootstrapped Learning Project is a DARPA research program to develop ways for machines to learn from naive human teachers, through a mixture of normal human interactions, such as sharing tips, correcting, and showing examples. Learn More.



Ok, here's what you do first to change a tire...

#### The Bootstrapped Learning Cup

- Are you doing research in artificial intelligence, machine learning, or computer knowledge?
- · Are you interested in pushing the state-of-the-art for how computers can learn?
- Do you want to help realize a future where regular people can teach computers in the same way that they mentor other people?

#### Here's your chance!

The Bootstrapped Learning Project is sponsoring a competition, open to any student or university research group. Starting with a baseline virtual student, your challenge will be to enhance its learning capabilities so that it's ready to be taught a simple game of virtual keepaway.

Your virtual student will compete with others to see who scores highest on a test after going through a set of tutorials on how to play keepaway. Then, these newly educated virtual students will play against each other, using the knowledge and skills learned during the tutorial.

Participants will get the opportunity to join the Bootstrapped Learning community, see early advances in natural instruction, and help shape the future research direction. Plus, you'll win recognition for your research group and your own programming skills. Sign up now for further competition notification. <u>I'm interested</u>



Must...pull...harder!

#### Join the Competition

We're betting that some of you have great ideas about natural instruction and human-like learning for computers. Showcase your skills and research into machine learning at the first Bootstrapped Learning competition in September 2009. Join now, and your entry will be eligible for a preliminary feedback round in July.

To enter the competition, email us at oblp@bbn.com



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## **Contest Structure**

- Given: teaching system, base student
- Goal: improve student's ability to learn
- 6 RoboCup skill spectra
  - All teach a function by example + hints
  - One whole spectrum and easiest 1/3 of others are provided in advance
  - Taught concepts used by KeepAway player
- Two scores: spectra test integral, play-off

## Beta Contest Codebase

- Java project, based on BAE/SRI BL framework
- Semi-competent base student
- Undergraduate
  level manuals

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# Looking for Participants!

- We need contestants!
  - Materials released: May 22<sup>nd</sup>
  - Feedback round: July 25<sup>th</sup>
  - First BL Cup competition: September 26<sup>th</sup>
- Other participation (e.g. curriculum design, base learner code) is invited as well

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Help us help build the community!