Experiences with A First Course on CPS

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The Big Picture

Goal: A CPS appreciation course for

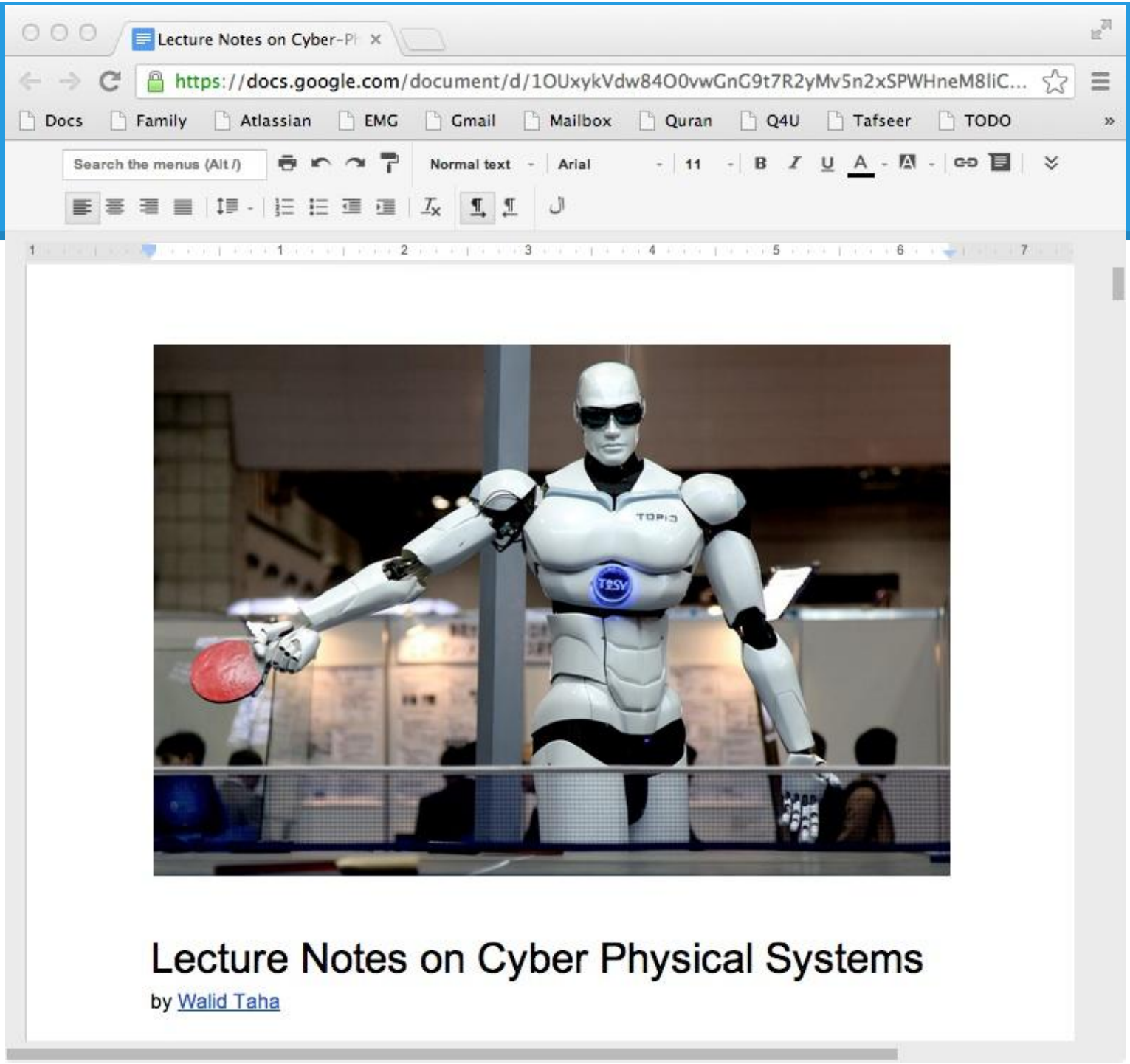
- B.A. and B.Sc. programs at Rice and Halmstad
  - Several departments (and schools?)
- M.Sc. programs
- PhD students

So far: Halmstad's M.Sc. in Emb. & Intel. Sys.

- 2 year program (1.5 courses, 0.5 thesis)
- diverse, international student body
- graduates work in Sweden and abroad

Technical Contents

1. What is CPS?
2. Modeling Physical Systems
3. Hybrid Systems
4. Control
5. Modeling Computational Systems
6. Communications
7. Single-Link Robot (case study)
8. Game theory


Lecture Notes on Cyber-Pl
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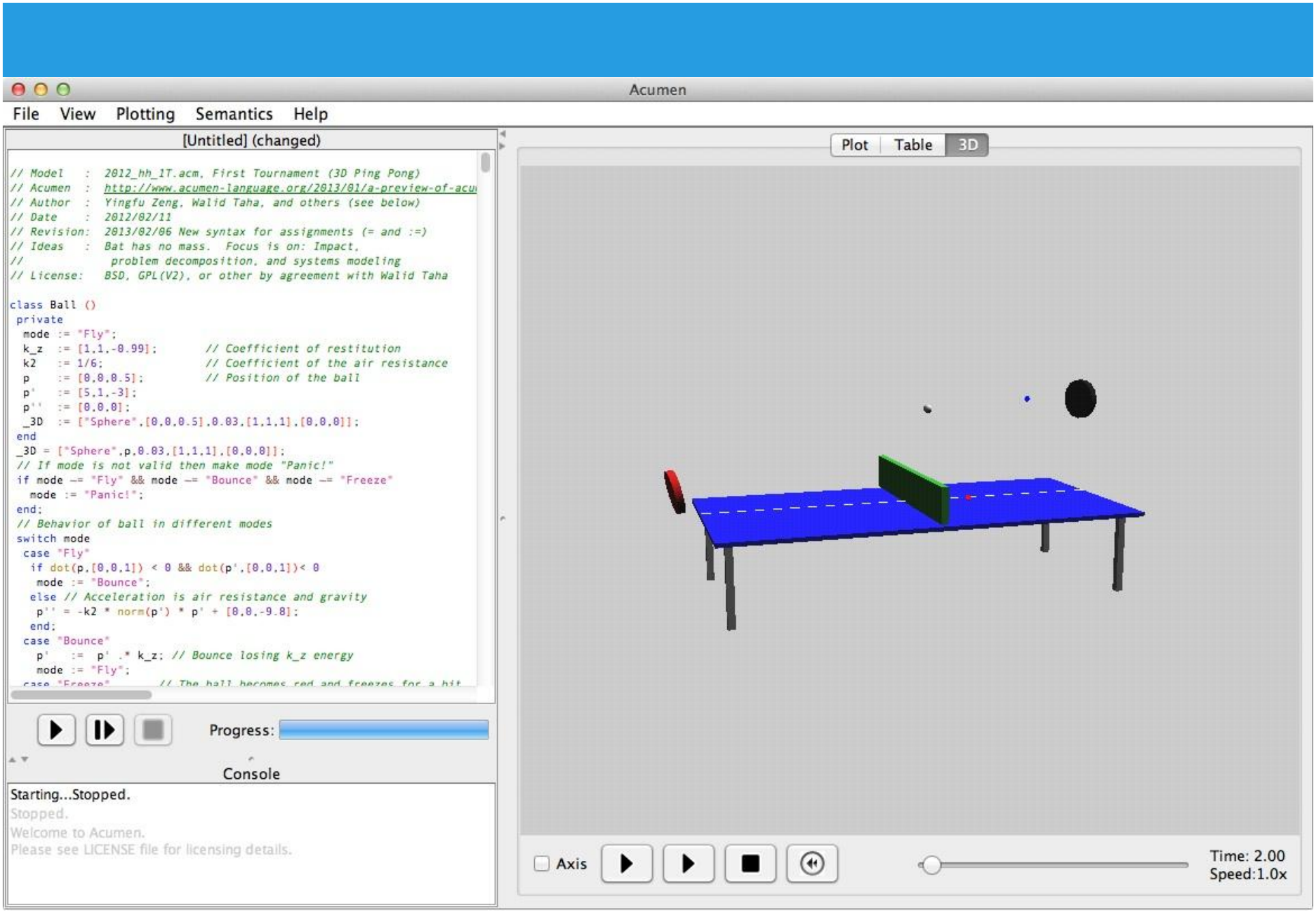
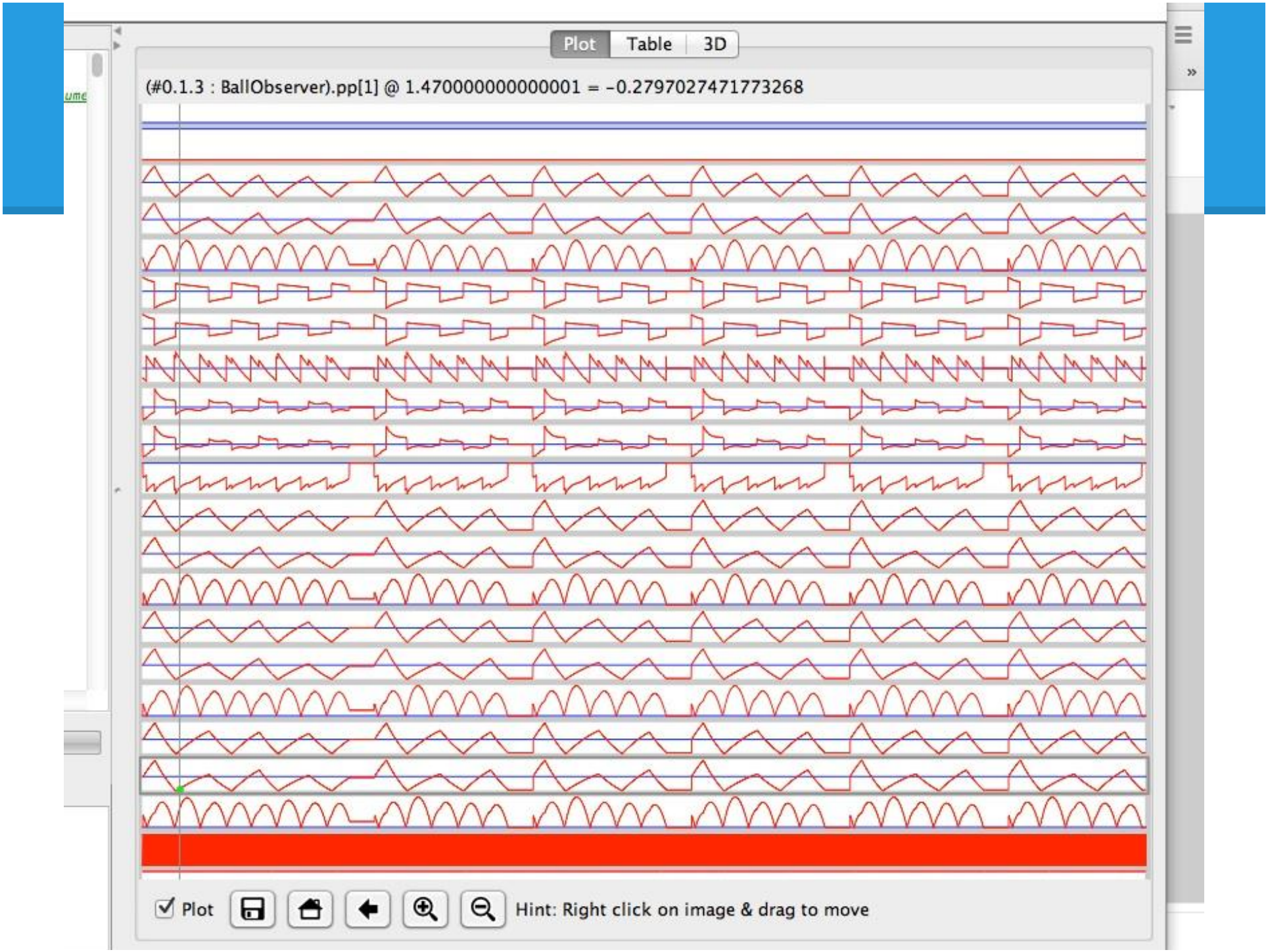
Lecture Notes on Cyber Physical Systems
by Walid Taha

Approach

- Lectures (and external resources)
- Labs (Acumen, our free SW tool)
- Reading (Notes free online)
- Homeworks
- Final exam
- Course project (Acumen)
  - Design a Ping Pong playing robot
  - Design by iterative refinement
  - Three tournaments during the term


Acumen
File View Plotting Semantics Help
[Untitled] (changed)
// Model : 2012_hh_1T.acm, First Tournament (3D Ping Pong)
// Acumen : http://www.acumen-language.org/2013/01/a-preview-of-acu
// Author : Yingfu Zeng, Walid Taha, and others (see below)
// Date : 2012/02/11
// Revision: 2013/02/06 New syntax for assignments (= and :=)
// Ideas : Bat has no mass. Focus is on: Impact,
// problem decomposition, and systems modeling
// License: BSD, GPL(V2), or other by agreement with Walid Taha
class Ball ()
private
mode := "Fly";
k_z := [1,1,-0.99]; // Coefficient of restitution
k2 := 1/6; // Coefficient of the air resistance
p := [0,0,0.5]; // Position of the ball
p' := [5,1,-3];
p'' := [0,0,0];
_3D := ["Sphere",[0,0,0.5],0.03,[1,1,1],[0,0,0]];
end
_3D = ["Sphere",p,0.03,[1,1,1],[0,0,0]];
// If mode is not valid then make mode "Panic!"
if mode -= "Fly" && mode -= "Bounce" && mode -= "Freeze"
mode := "Panic!";
end;
// Behavior of ball in different modes
switch mode
case "Fly"
if dot(p,[0,0,1]) < 0 && dot(p',[0,0,1])< 0
mode := "Bounce";
else // Acceleration is air resistance and gravity
p'' = -k2 * norm(p') * p' + [0,0,-9.8];
end;
case "Bounce"
p' := p' .* k_z; // Bounce losing k_z energy
mode := "Fly";
Progress:
Console
Starting...Stopped.
Stopped.
Welcome to Acumen.
Please see LICENSE file for licensing details.
Plot
Table
3D
Axis
Time: 2.00
Speed:1.0x


Plot
Table
3D
(#0.1.3 : BallObserver).pp[1] @ 1.470000000000001 = -0.2797027471773268
Plot
Hint: Right click on image & drag to move

Feedback on First Offering

- "it was fun to run the design"
- "support for 3D visualization was very useful"
- requests for "more intermediate exercises"
  - improved in 2nd offering
- "the current project is difficult enough"
- "too much reading on something easy"
  - improved in 2nd offering

Overall Student Satisfaction

- 5 on a scale from 1 (worst) to 6 (best)

Feedback on Second Offering

Things that work:

- lecturing style: whiteboard, no slides, interactive, conversational
- open access course material
- collaborative real-time note taking

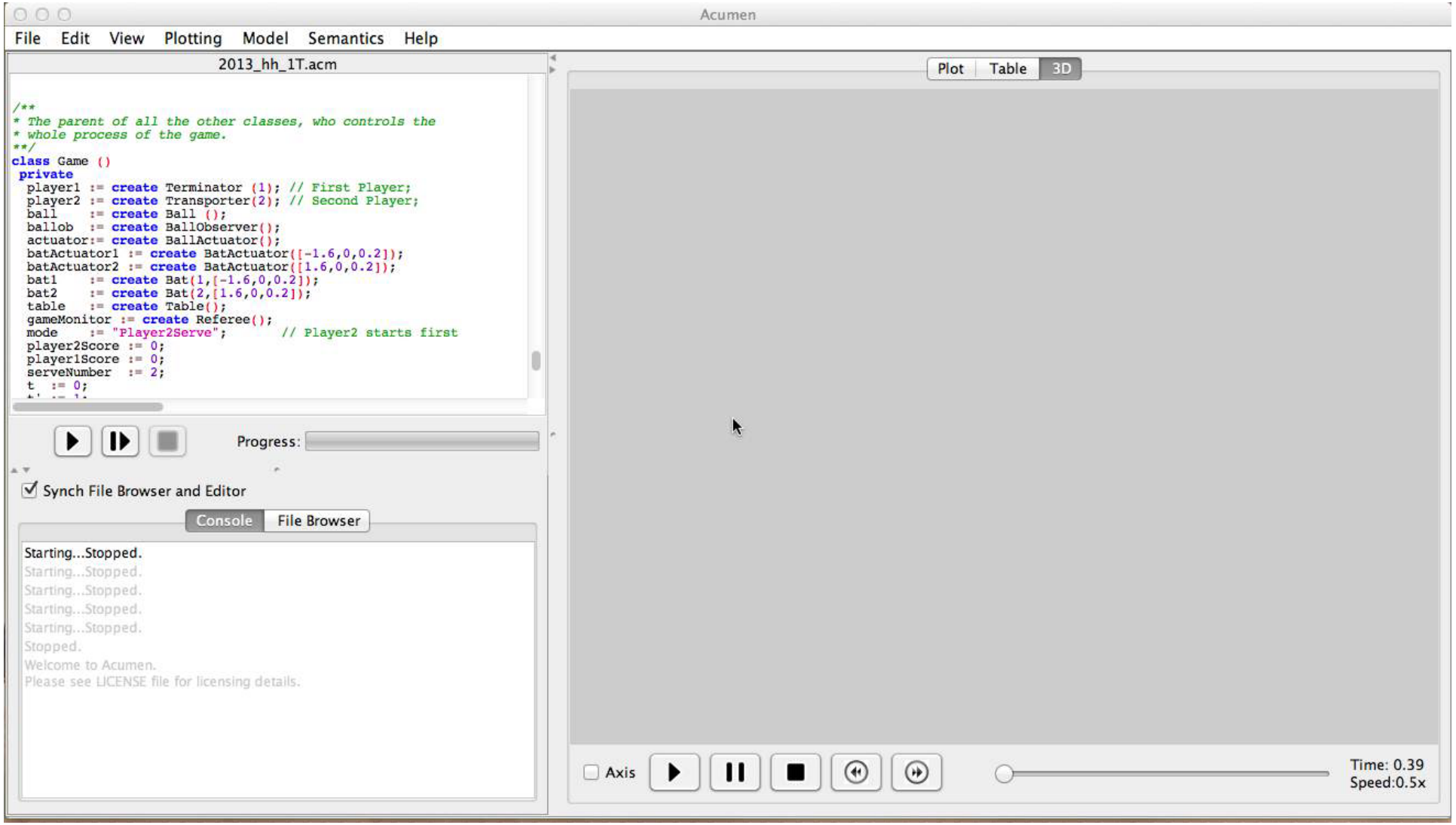
Things that can be improved:

- gap between lectures and assignments: need more progressive levels of difficulty
- some open-ended problems are too big and difficult
- chapter on communication "is too abstract"

Preparations for Third Offering

- New class is 55 students
- Revising ping pong model
  - The need for path planning
  - More cooperative utility functions
- Last three chapters
  - Comm., case study, & game theory
- Incorporating past exam questions
- Online quiz questions
- Consolidated manual for Acumen
- Using Piazza for Q&A

Working with Acumen (2x slow mo)

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Conclusions

Everyone happy, engaged

- Course become a required first-year course

Takeaway:

- The current topic selection works
- Tournament project works
- Acumen provides "language" and "virtual lab"
  - Interactive IDE
  - Chronological or “animated” 3D visualization

For More Information

http://bit.ly/CPS-course