Ordinary Differential Equations Framework for the Robotic Dog AIBO

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Outline

Motivation

Dynamical systems for locomotion control

- Interesting properties: attractors, synchronization
- . . . but finding parameters for a given property is hard
- Similarity with biological neural systems

AIBO robotic dog

- Plenty of sensors and actuators
- Free development kit (OPEN-R)
- Remote Control System and Webots API

Project goals

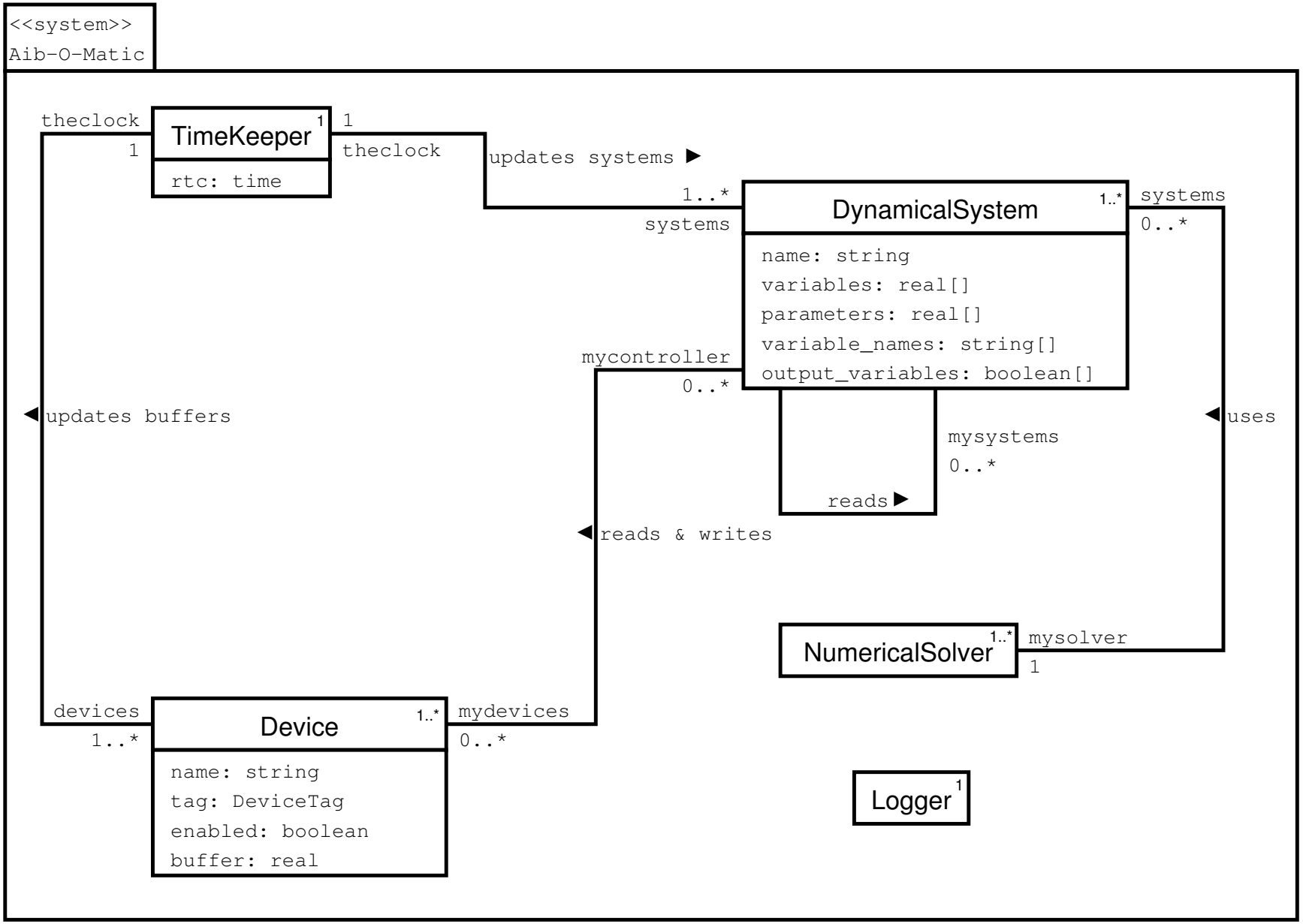
Develop a software framework

- **Control** of the AIBO robot with a set of **dynamical systems**
- **Same** controller **software** in simulation and real robot
- Robot **independent** from computer

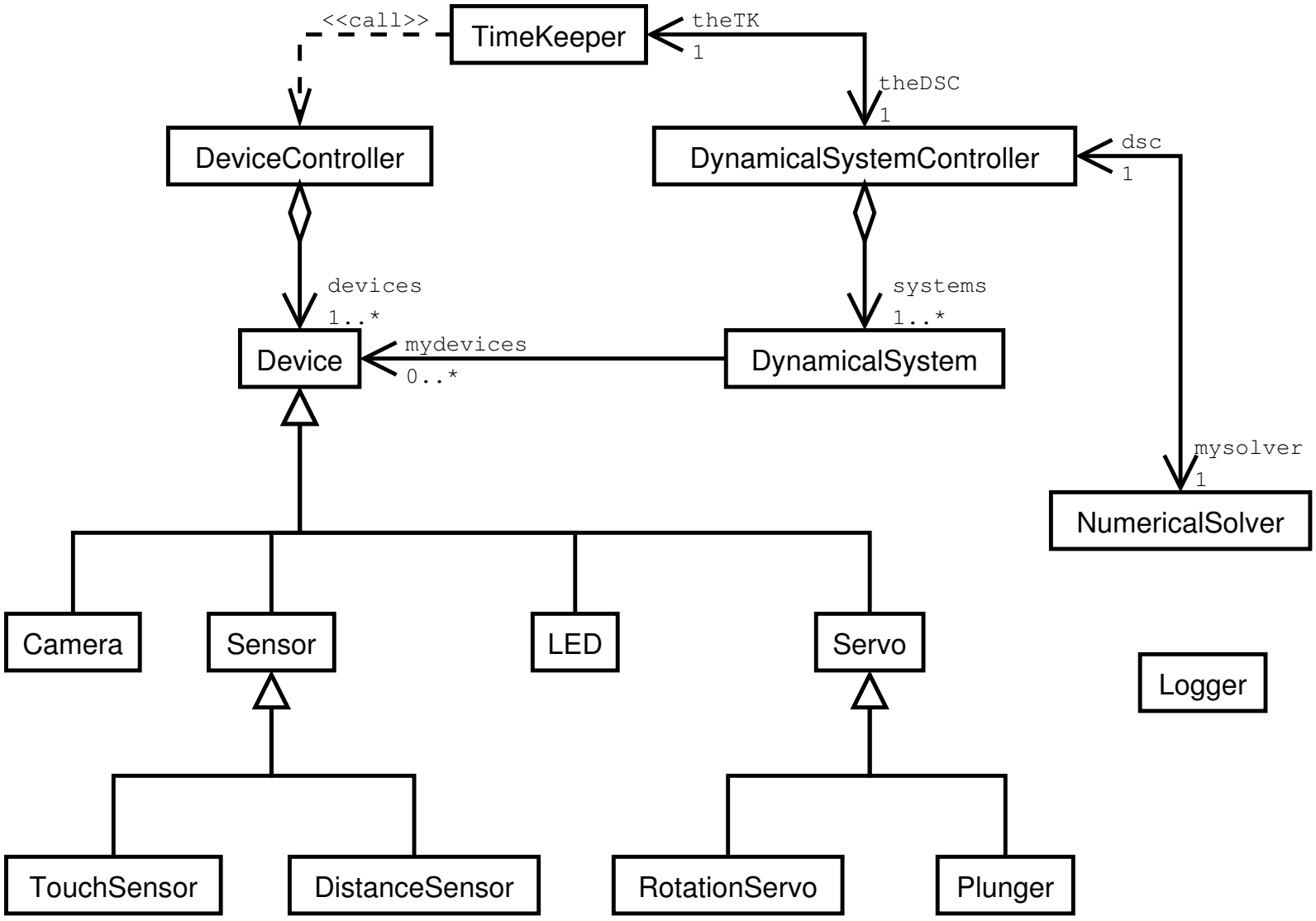
What is Fondue?

- Requirements
- Analysis
- Design
- Implementation

Concept model



Design class model



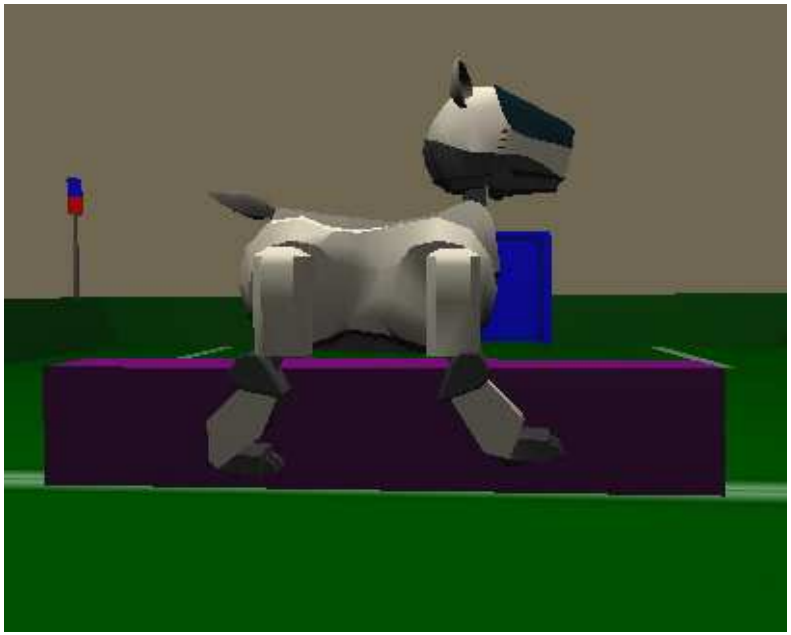
Amplitude Controlled Phase Oscillator (ACPO)

$$\begin{bmatrix} \dot{x} \\ \dot{y} \end{bmatrix} = \begin{bmatrix} g\left(\frac{r_0}{\sqrt{x^2+y^2}} - 1\right)x - yw \\ g\left(\frac{r_0}{\sqrt{x^2+y^2}} - 1\right)y + xw \end{bmatrix} + k\begin{bmatrix} p \\ 0 \end{bmatrix}$$

where:

- p is right fore leg position input
- x drives left fore leg position
- k is the **coupling constant**
- parameters: $g = 10$, $r_0 = 1$, $w = 2\pi$

Demonstrations



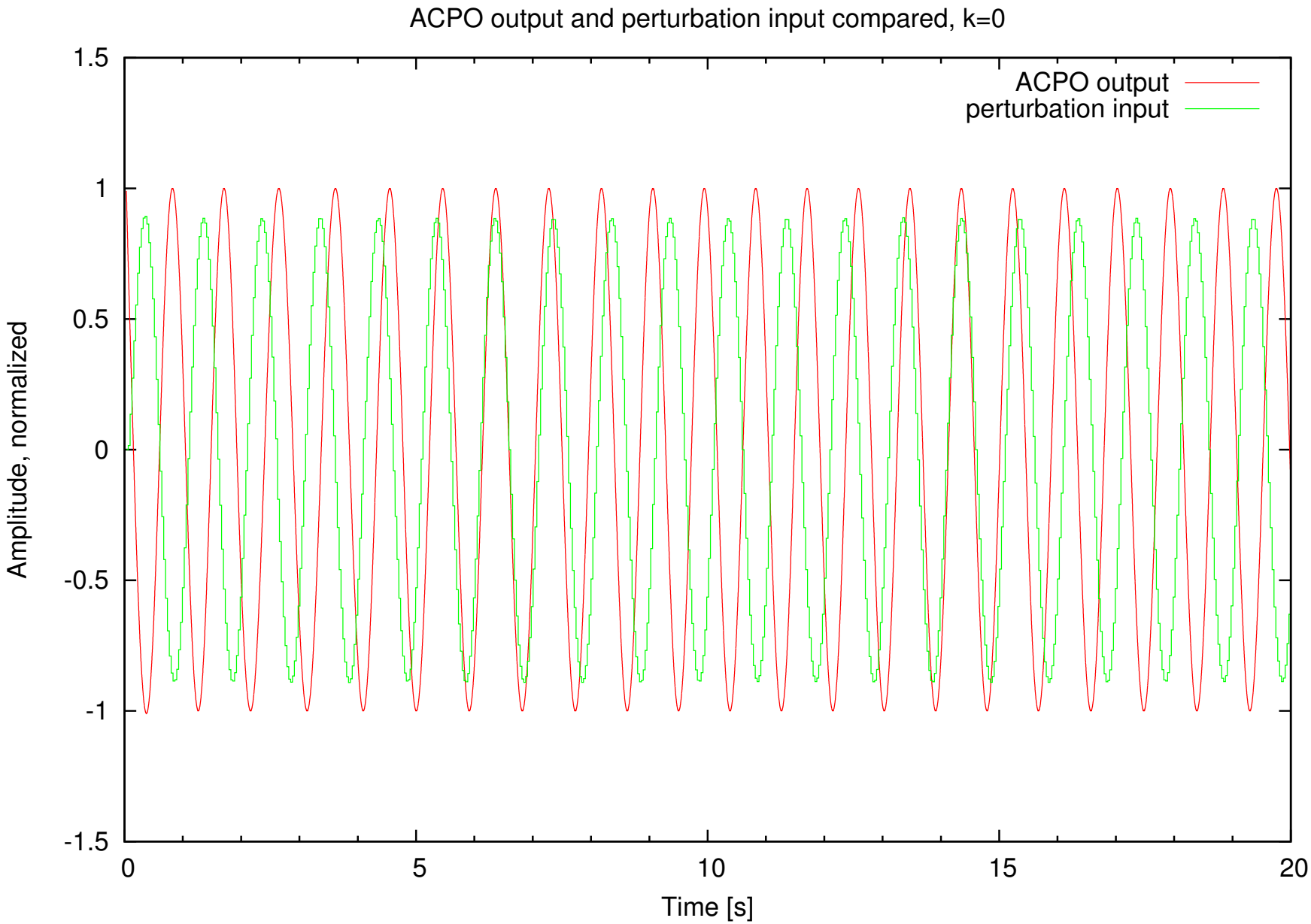
No synchronization

$k = 0$

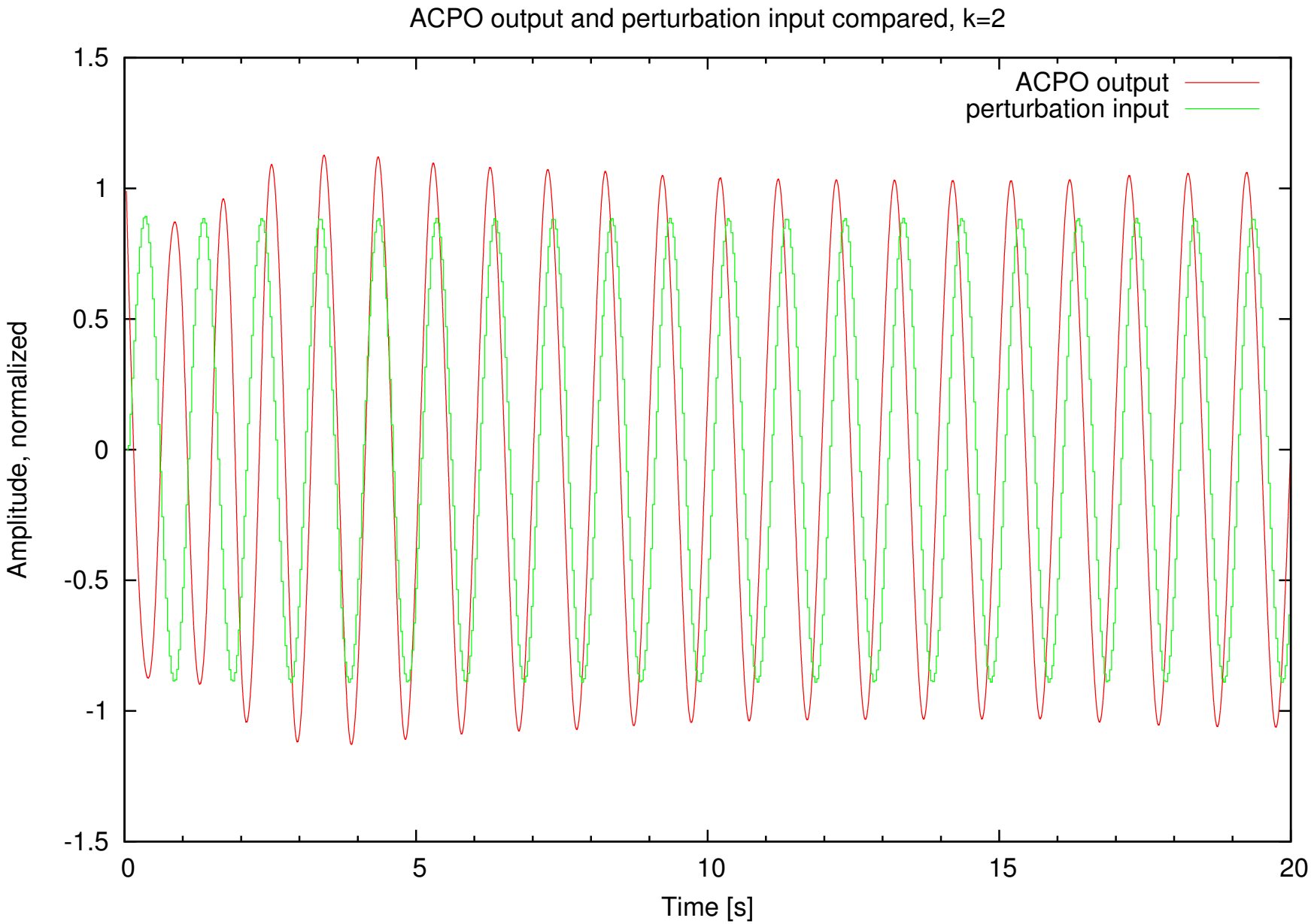
Synchronization

$k = 2$

Data — no synchronization



Data — synchronization



Conclusions

Negative

- Limited testing
- Only really works in simulation

Positive

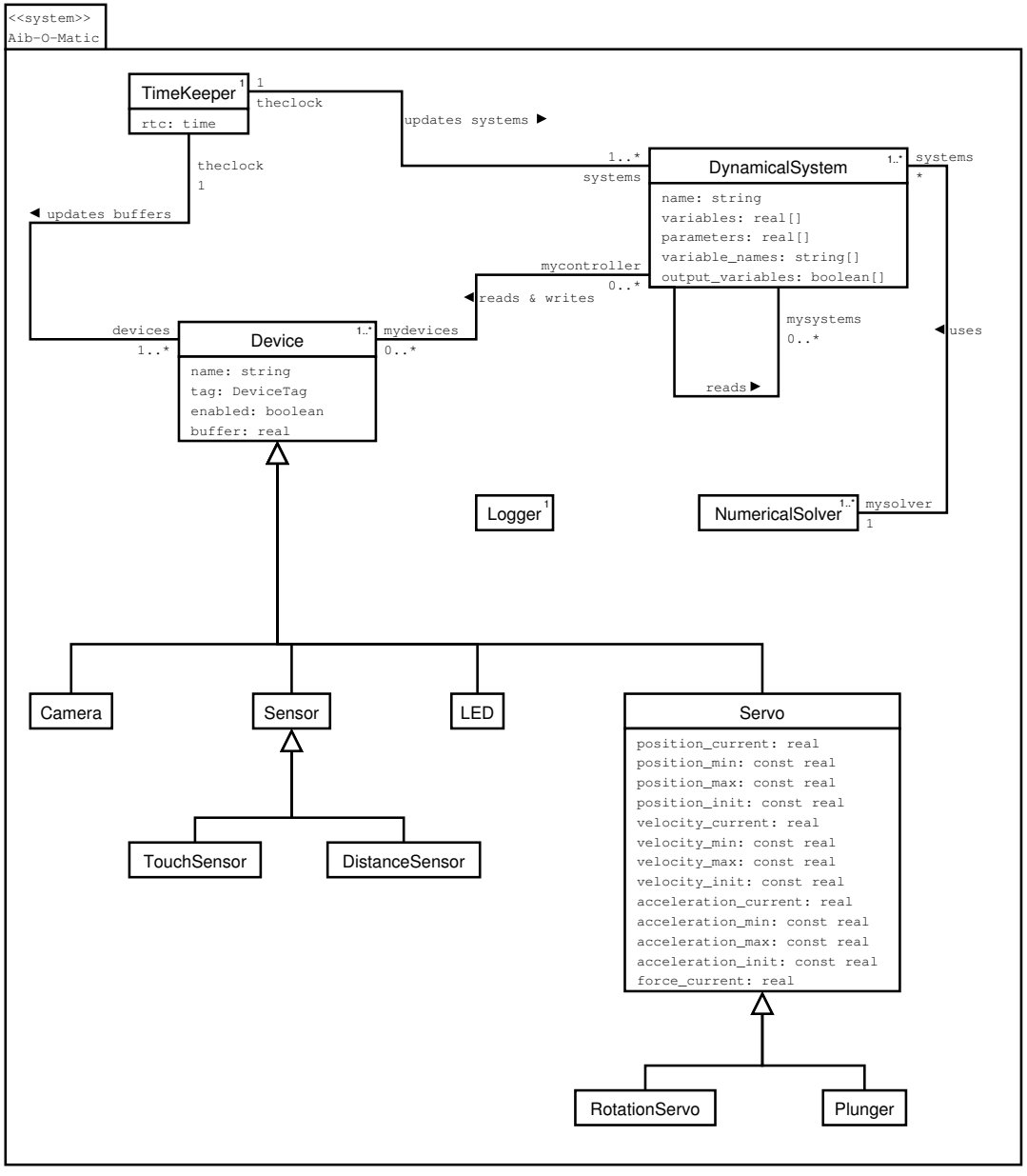
- Software complete
- Documentation

Future work

Things to improve

- Debug runs on AIBO
- Refactoring for use with optimization algorithms
- Speed up numerical solver

Concept model (complete)



Design class model (complete)