An Implementation of Artificial Physics Using AIBO Robots and the Pyro Programming Environment

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1. Purpose

The purpose of this project is twofold. The first goal of the project is to create a Python interface for a C library which provides a useful framework for an artificial physics-based simulation. This interface will subsequently be used to create a simulation in Pyro (or Python Robotics) that can be used to control and coordinate the behavior of a group of autonomous Sony AIBO robots. When complete, this simulation would provide an excellent testing platform for research about artificial physics and autonomous robots.

2. Background

Artificial physics (AP) is very new system of robotic control that was developed at the Naval Research Laboratories Artificial Intelligence Center. It is a system that allows a group of robots to behave autonomously in order to complete various tasks. One possible behavior for a group of robots would be to arrange themselves into a grid without outside assistance. This could be useful in a number of different ways; for example, a group of satellites could autonomously arrange itself into an antenna array. At first glance, such a behavior would appear to require the use of an external camera capable of tracking all of the robots and directing their movements. However, it can in fact be accomplished by a robots equipped with only a rangefinder and guided by a simulated gravitational force. The robots are programmed to follow a single rule – if two robots are closer than a distance *r*, they repel, if they are further, they attract. If a group of seven robots are set into this environment, it is easy to see how they would eventually form a hexagonal grid (with one

in the center). Logically, the robots would settle into a formation that allows every robot to maintain a distance *r* from its neighbors. This elegant solution is the basis of artificial physics.

Since AP treats each robot as a particle, the actual shape and structure of the robot is unimportant. For the purposes of research, the Sony AIBO robot (modeled on a dog) serves as a useful platform. The AIBO was marketed as a toy robot to be used for entertainment, but software such as Tekkotsu (http://cs.cmu.edu/~tekkotsu) allows users to circumvent the original programming and directly control every aspect of the AIBO. Using this software, it is possible to gather the raw data from all of the AIBO's sensors, which include a camera, microphones, and three infrared rangefinders. One can also control the AIBO's movement, either from a high-level perspective (move forward, turn) or in more detail (control each joint individually). Also, the ability for the AIBO to communicate wirelessly with a single host computer makes them ideal for use in AP.

3. Methodology

The first step in completing this project is to find a way to interface a newly completed C library (created by researchers at NRL) with the Python programming language. To accomplish this task, I will begin by using the open-source tool SWIG (Simplified Wrapper and Interface Generator) to create a basic wrapper function for the C library. Presumably, I will need to do some work to edit the resulting code in order to fit my purpose. Once this wrapper function is complete, I will need to compile this code along with a number of external C++ classes into a single dynamic library, which I will be able to import into a standard Python program.

This Python module will be necessary for the second phase of the project, in which I

will use a Python-based robotics suite called Pyro to develop a multi-robot controller brain. By interfacing the Pyro simulator with software called Tekkotsu, it is possible to control the Sony AIBO robot using a Python program running on an external host machine.

5. Expected Results

The first objective of this project is to create a Python interface for an artificial physics C library that is currently being written by researchers at Naval Research Laboratories. This interface will serve as a useful tool for many robotics researchers who don't have enough programming experience to write in C, a relatively complex language. Instead, it will allow researchers to program in Python, a much more intuitive language. It also allows compatibility with Pyro, a Python-based robotics simulator.

The next stage of the project is to investigate the use of Sony AIBO robots as platforms for an artificial physics simulation. Hopefully, it will be possible to develop a working simulation of artificial physics running on the AIBO's. However, the AIBO's are extremely limited in their sensor capabilities, and it may prove impractical to use the AIBO's as a platform for future research. Also, the limited time frame allotted for this project makes it unlikely that the project will yield a working simulation.