Neuro-Symbolic Reinforcement Learning: Natural Language Driven Multi-Task Agents

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(ABSTRACT)

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(GENERAL AUDIENCE ABSTRACT)

Dedication

This is where you put your dedications.

Acknowledgments

This is where you put your acknowledgement.

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NLP is a field of computer science, artificial intelligence, and linguistics concerned with the interactions between computers and human (natural) languages.

σ is the eighteenth letter of the Greek alphabet, and carries the 's' sound. In the system of Greek numerals, it has a value of 200.

Chapter 1

Introduction

Neuro-symbolic learning methods and concepts have been used in recent years to achieve results that standalone deep learning and symbolic programming methods have not been able to achieve. [EXAMPLES]. The emerging developments in the field of neuro-symbolic learning has created opportunities to explore applications and adaptations of these methods. The field of Reinforcement Learning (RL) has also made advances – demonstrating the paradigms effectiveness in creating agents that can perform complex tasks autonomously. The intersection of these two research areas has led to developments that have allowed agents to perform tasks with with both programatic interpretability and learned performance. [EXAMPLES].

1.1 Objectives

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1.1.1 A sub-section

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1.2 Applications

1.3 Challenges

1.4 Contributions

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Chapter 2

Background

2.1 Markov Decision Process

2.2 Reinforcement Learning

2.3 Neuro-symbolic Architectures

2.4 Sim-to-Real

2.4.1 Transfer Learning

2.4.2 Multitask Learning

Chapter 3

Neuro-symbolic Reinforcment Learning Model

Neuro

./images/architecture_overview.png

Figure 3.1: Overview of proposed architecture.

Chapter 4

Environment and Dataset

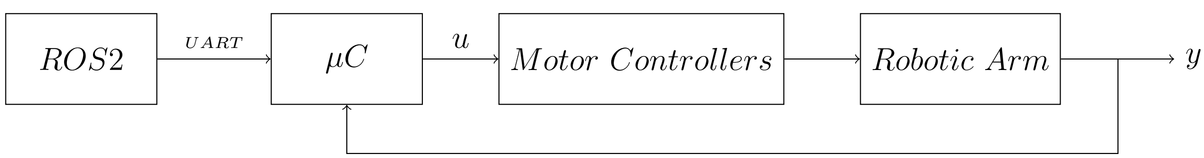
Given the problem space two environments were created to validate the neuro-symblic alogirithms mentioned in the previous sections

Custom real and cooresponding simulated environments were created to demonstrate the possibilities of the Neuro-Symbolic Reinforcement Learning Methods presented in the previous chapter. The environment was set up for basic object manipulation tasks. The cooresponding dataset used to train the model that can be seen as an extension of the CLEVR dataset – which instead prompts the agent to act on the objects in the environment.

4.1 Real-Time Hardware Environment

The physical hardware used to test the algorithms is made up of a 6-axis robot arm communicating over serial (UART) with a PC running the algorithms in a ROS2 Jazzy workspace. The rigid components of the arm including gears and structural pieces are made of 3D-printed Polylactic Acid (PLA). The robotic arm uses stepper motors, belts, and pulleys to articluate the 6 joints. The first 5 joints (J1 to J5) use bipolar NEMA 17 stepper motors, while the last joint J6, responsible for manipulating the end effector, uses a bipolar NEMA 8 stepper motor. The belts and pulleys are "off-the-shelf" GT2 timing belts and pulleys of varying sizes, used to the torque applied to each joint (belts and pulleys connect every motor to a joint with the exception of J6). Ball and shunt bearings of verious sizes are also used to reduce friction in the joints.

The electronic hardware is controlled by an ATmega328p microcontoller and 6 A4988 stepper motor drivers originally setup for controlling the stepper motors of a 3D-Printer. Custom firmware was written for the microcontroller to run the 6 stepper motor drivers simultaineously with a serial (UART) inturrupt to recieve control commands from the host PC.



Feedback system

4.2 Virtual Environment

The environment consists of the same six axis robot arm described in the previous section set up in the Gazebo Robotic Simulator (using a ROS Universal Robot Description File and Gazebo Simulation Description File). Within the arm's working envelop various basic 3-D shapes (i.e. spheres, cubes, cylinders, etc.) are present.

4.3 Robot Operating System

The Robot Operating System is a middleware suite used for robot software development. ROS workspaces consist of packages that interface with ROS libraries.

4.3.1 Description Package

The `arm_description` package is a ROS package that contains various files used to describe the physcial characteristics of the robot including its visual, collision, control, and forward kinematics.

The six-axis robotic arm model deployed in this package is a slightly modified version of an open source six-axis robot design with modfications made to some of the pulleys and end-effector design. The robot arm is made up of six joints (J1-J6) all described as revolute joints in the `arm_description`'s Universal Robot Description File (`.urdf`). Meshes for rendering the robot imported as `.stl` files and the meshes for collision areas are described by COLLADA (`.dae`) files. These meshes are linked together in the URDF in a kinematic chain to form the robotic arm manipulator. Control of the robot is accomplished through the ROS Jazzy control package.

4.4 Gazebo Robotics Simulator

Gazebo is a robotic physics simulator developed by Open Robotics which integrates the ODE physics engine, ORGE rendering engine, and support code for sensor and actuator control integration. This environment leverages Gazebo Harmonic (the latest release of Gazebo at the time of writing) to visually render and simulate the physics of the robotic manipulator and the objects in its environment.

4.4.1 Simulation Package

4.5 Dataset

Chapter 5

Simulations

Chapter 6

Reality

Chapter 7

Discussion

Chapter 8

Conclusions