Super fancy title about RL and manipulation

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Master Project Proposal

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1 Introduction

Service robots are slowly becoming more popular, mostly small robots with limited functionality like vacuum cleaner robots. Bigger service robots that could help in a household environment are still much in development. These service robots need to be able to perform many complex tasks, in all kinds of environments, while doing them safely by not colliding with objects, humans and itself. Tasks like navigating, speech recognition, following/recognizing humans, object detection/recognition and manipulation are all important parts for a service robot, and these tasks are tested in competitions like the RoboCup and RoCKin [REFS]. The difficulty in programming these robots is that they need to operate in all kinds of different environments, no household is same, and this makes it hard to make sure that the robot can operate safely and correctly in situations that is has never seen before. This means that the robots needs to have intelligent behaviour so it can cope with any environment it encounters.
In this project we will focus on the manipulation and perception part of a service robot by making use of reinforcement learning so that the robot has learned how to grasp an object that it has seen with its camera. Common used approaches for grasping objects with service robots are currenlty by using simple cartesian control, or by making use of a planner that creates a path for the arm to traverse so it can grasp an object. The downside of using a planner is that it requires to make new calculations every time it needs to grasp an object, with the downside that sometimes it can not find a valid plan, or it takes to long to find a valid plan for the arm to move by.
*Something about deeplearning**
*Something about continues control vs discrete control**

2 Theoretical framework

Reinforcement learning is an area in machine learning in which an agent needs to take actions in an environment which provides the highest reward for that agent. The environment of a reinforcement learning problem is described as a Markov decision process (MDP). A MDP consists out of States, Actions, and Rewards ** NEEDS BETTER EXPLANATION ****. The goal is to find a policy that will provide the best action based on the current state. For this purpose we will use the CACLA algorithm. CACLA is created to handle the continues action space, which is needed to control a robotic arm. An action in this case is the velocity of a single actuator (joint) of the robotic arm, which can move with different speeds. CACLA is a model-free algorithm, meaning that the agent does not need know about the environment beforehand, it can therefore be used in all sorts of problems, like controlling a robotic arm. *** NEEDS MORE CACLA EXPLANATION? ***. To improve learning extra parameters will be added to the CACLA algorithm to test their performance. For example we can look at the insights from the Deep Q Network (DQN)[REF]. DQN shows for example that make it is possible for large, non-linear networks to become robust and stable by training networks off-policy by using samples from a replay buffer to minimize the correlations between samples. In [PAPER TO GOOGLE RL] they make use of batch normalization [REF], a recent advance in deep learning.

Also methods like dropout [REF] to reduce overfitting will be tested.

3 Research question

The goal of this project is to create a neural network that can control a robotic arm so that it is able to grasp and object that it has seen by using a (3D) camera. The main algorithm for learning to control the arm will be the CACLA algorithm, we will use a convolutional neural network (CNN) for the perception of objects that the arm needs to grasp. The project will be divided into two aspects, control and perception. For the control part the focus will be on creating a neural network that can grasp an object given by an operator manually. The perception part will focus on the detection of an object and extracting the location and orientation needed to grasp the object. The final stage is to make the control part depended on the perception part so it can autonomously grasp objects that are seen by the camera. An other aspect in the research project is to look at different architectures. Instead of having one neural network that controls that arm, perhaps a better result or faster training can be achieved by having multiple networks where each network controls a single joint or smaller groups of joints, a network used for approaching the object and one network used for the actual grasping part, separate the CNN and the control neural network or combine both CNN and control neural network into one big neural network.
The main research question is: Is it possible for a robotic arm to grasp an object by using reinforcement learning?
The sub-question: Which architectures results in the best performance?

4 Methods

- how to use CACLA - how to use CNN - Simulation / Real robot - Control Velocity / Current robot limitations - programming languages

Reinforcement learning problems are often solved within a discrete action space. But to control a robotic arm continues actions are required. This is the purpose of the CALCA algorithm, it allows to learn in the continues action space.