Department of Computer Sciences
University of Salzburg

PS Natural Computation
SS 13/14

Design and implementation of a robot task

July 13, 2014

Project Members:

Auinger, 1220321, auingerto@stud.sbg.ac.at
Müller, 1123410, mueller110@gmx.net
Pollhammer, 9520061, pollhammerand@stud.sbg.ac.at
Schwarz, 1220024, schwarzst@stud.sbg.ac.at

Academic Supervisor:

Helmut MAYER
helmut@cosy.sbg.ac.at

Correspondence to:

Universität Salzburg
Fachbereich Computerwissenschaften
Jakob–Haringer–Straße 2
A–5020 Salzburg
Austria

Contents

Abstract

The main goal of this project is designing a task that demonstrates that the usage of neuromodulators can influence the evolution of a neural network in a positive way. For implementation and simulation of the task we use SIMMA "a simulation framework mainly developed for the simulation of mobile autonomous robots and their behaviour".

1 Introduction

In this class our team of four people designed a task for neural networks. The main goal was to demonstrate that the usage of neuromodulators can influence the evolution of a neural network in a positive way.

1.1 The task

1.1.1 The initial task

After careful considerations we decided to implement a robot whose task is to collect several pegs, which are randomly distributed within a virtual rectangular world and transport them to a certain place we call spot. While transporting the pegs to the spot the robot has to avoid collisions with one or more enemies following the robot. If the robot is captured by the enemy, it will get some damage, which effects its speed. The robot is supposed to learn this task by means of evolving neural networks. Our hope was that neuromodulators will indeed influence the evolution of our neural network in a positive way. So the neuromodulators assist our robot by learning this task. For implementation and simulation of the task we used SIMMA "a simulation framework mainly developed for the simulation of mobile autonomous robots and their behaviour".

After several tests it turned out, that one part of the task worked very well. Namely the finding and collecting of the pegs, which includes the delivery to the spot. But to our disappointment robots trained to find and collect pegs, seamed to be unable to also learn how to avoid collisions with ghosts. So we focused on the second part of the task, the transportation of pegs through the enemy region.

1.1.2 The final task

For the final task, we divided the region of the simulation in three parts, each with a different purpose. The left side is where the spot spawns, which is the destination for the robots virtual delivery. The right side is the robot's starting position. Right between those regions, the enemy, named ghost, spawns. This enemy's mere function is to stop the robot's delivery. The ghost does not move around randomly, but it detects the robot's current position for hunting it down, though it has been given a radius in which the robot is followed, which alters the size each new start, depending on the randomly generated number from 0 to 1. This so called "aggression potential" will also influence the robots fitness, given that the bigger this aggression potential is, the harder the robots mission will be. The virtual load carried by the robot does decrease its speed, making it easier to be targeted, since the robot does move slower (or at nearly the same speed, depending on the settings) with a full load than the ghost. Therefore the robot has to drop a certain amount of this load, in order to

elude the ghost. By reaching the spot, hence fulfilling its task, the robot will drop the load, or what's left of it, and gains a specific amount of bonus. Does the robot fail its task, whether by getting caught, or not being capable of managing to deliver the load in the given time interval, then it won't have any fitness at all for this round of evaluation.

1.2 Neuromodulation

Neuromodulation basically describes a mechanism, which allows a neuron to switch between different states. There are different approaches how this may work in nature and also how neuromodulators are implemented in different variants of ANNs. In our case the mentioned states of the neuron are associated with a change of bias, the neurons output. In general, it is a complex problem, to find out in which cases bias changes would have a positive effect. So we simply left this to evolution.

For our project, we defined one neuromodulator using the SIMMA class `simma.ann.modulator.BiasChange`. As Brain we selected the also already existing class `simma.ann.NeuroModulatorController`. See appendix for a complete listing (xml) of our setup.

2 SIMMA

SIMMA (Simulator for EMMA) is ...

3 The task

3.1 The Robot

3.2 The Enemy

3.3 The Fitness Funciton

4 Results

5 Conclusion

6   Links

- Project Page: http://student.cosy.sbg.ac.at/~cmueller/natcomp/
- PS Page: http://www.cosy.sbg.ac.at/~helmut/Teaching/NaturalComputation/proseminar.html

7   Appendix

7.1   XML-Listing

```xml
<Configuration Name="Peg Pushing Evolution">
 <General>
  <UpdateXMLFile>false</UpdateXMLFile>
  <SimTimeStep>0.1</SimTimeStep>
  <ScreenScale>904.0</ScreenScale>
  <ScreenRefreshTime>0.1</ScreenRefreshTime>
  <Animate3D>true</Animate3D>
 </General>
 <Experiment>
  <Objects>
   <World Name="World">
    <Class>simma.worlds.RectangularArena</Class>
    <Width>1.05</Width>
    <Height>0.7</Height>
    <Depth>0.3</Depth>
   </World>
   <Robot Name="Rescuer">
    <Class>simma.robots.CircleRobot</Class>
    <BoundingRadius>0.03</BoundingRadius>
    <MotionTrail>false</MotionTrail>
    <ResetMode>None</ResetMode>
    <Height>0.15</Height>
    <Controller Name="Brain">
     <Class>simma.ann.NeuroModulatorController</Class>
     <!--<Class>simma.ann.NeuroFeedForwardController</Class>-->
     <Structure>20-20-3</Structure>
     <LearnRate>0.01</LearnRate>
     <MaxDose>1.0</MaxDose>
     <ResetMode>None</ResetMode>
     <Areas>1</Areas>

     <Modulator Name="ModA">
      <Color>GREEN</Color>
     </Modulator>
     <Reaction>
      <Class>simma.ann.modulator.BiasChange</Class>
      <Positive>true</Positive>
     </Reaction>
     <Evolution Enabled="true">
```

```xml
  <Neurons>false</Neurons>
  <Links>true</Links>
  <Weights>true</Weights>
  <MutationRate>0.0050</MutationRate>
  <CrossoverPoints>2</CrossoverPoints>
  <OutputBias>true</OutputBias>
 </Evolution>
</Controller>
<Actuator Name="Two-Wheel Drive">
 <Class>simma.kernel.equipment.TwoWheelDrive</Class>
 <Mass>0.15</Mass>
 <Gain>5.0</Gain>
 <Offset>-0.5</Offset>
 <MotorResistance>2.5</MotorResistance>
 <AxisLength>0.03</AxisLength>
 <WheelRadius>0.01</WheelRadius>
 <Position>
  <R>0.0</R>
  <Phi>0.0</Phi>
 </Position>
</Actuator>
<Sensor Name="LoadSensor">
 <Class>simma.equipment.sensors.LoadSensor</Class>
 <Position>
  <R>0.030</R>
  <Phi>-40.0</Phi>
 </Position>
 <GroundClearance>0.001</GroundClearance>
 <Mass>0.0020</Mass>
</Sensor>
<Sensor Name="DamageSensor">
 <Class>simma.equipment.sensors.DamageSensor</Class>
 <Position>
  <R>0.030</R>
  <Phi>-40.0</Phi>
 </Position>
 <GroundClearance>0.001</GroundClearance>
 <Mass>0.0020</Mass>
</Sensor>
<Sensor Name="InfraRedLeftBehind">
 <Class>simma.equipment.sensors.InfraRedSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>-135.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
</Sensor>
<Sensor Name="InfraRedLeft">
 <Class>simma.equipment.sensors.InfraRedSensor</Class>
```

```xml
    <Position>
     <R>0.025</R>
     <Phi>-90.0</Phi>
    </Position>
    <GroundClearance>0.015</GroundClearance>
    <Mass>0.0020</Mass>
   </Sensor>
   <Sensor Name="InfraRedHalfLeft">
    <Class>simma.equipment.sensors.InfraRedSensor</Class>
    <Position>
     <R>0.025</R>
     <Phi>-45.0</Phi>
    </Position>
    <GroundClearance>0.015</GroundClearance>
    <Mass>0.0020</Mass>
   </Sensor>
   <Sensor Name="InfraRedCenterLeft">
    <Class>simma.equipment.sensors.InfraRedSensor</Class>
    <Position>
     <R>0.025</R>
     <Phi>-15.0</Phi>
    </Position>
    <GroundClearance>0.015</GroundClearance>
    <Mass>0.0020</Mass>
   </Sensor>
   <Sensor Name="InfraRedCenterRight">
    <Class>simma.equipment.sensors.InfraRedSensor</Class>
    <Position>
     <R>0.025</R>
     <Phi>15.0</Phi>
    </Position>
    <GroundClearance>0.015</GroundClearance>
    <Mass>0.0020</Mass>
   </Sensor>
   <Sensor Name="InfraRedHalfRight">
    <Class>simma.equipment.sensors.InfraRedSensor</Class>
    <Position>
     <R>0.025</R>
     <Phi>45.0</Phi>
    </Position>
    <GroundClearance>0.015</GroundClearance>
    <Mass>0.0020</Mass>
   </Sensor>
   <Sensor Name="InfraRedRight">
    <Class>simma.equipment.sensors.InfraRedSensor</Class>
    <Position>
     <R>0.025</R>
     <Phi>90.0</Phi>
    </Position>
    <GroundClearance>0.015</GroundClearance>
```

```xml
  <Mass>0.0020</Mass>
 </Sensor>
 <Sensor Name="InfraRedRightBehind">
  <Class>simma.equipment.sensors.InfraRedSensor</Class>
  <Position>
   <R>0.025</R>
   <Phi>135.0</Phi>
  </Position>
  <GroundClearance>0.015</GroundClearance>
  <Mass>0.0020</Mass>
 </Sensor>
 <Sensor Name="InfraRedBehind">
  <Class>simma.equipment.sensors.InfraRedSensor</Class>
  <Position>
   <R>0.025</R>
   <Phi>180.0</Phi>
  </Position>
  <GroundClearance>0.015</GroundClearance>
  <Mass>0.0020</Mass>
 </Sensor>
 <Sensor Name="SmellLeftBehind">
  <Class>simma.equipment.sensors.SmellSensor</Class>
  <Position>
   <R>0.025</R>
   <Phi>-135.0</Phi>
  </Position>
  <GroundClearance>0.015</GroundClearance>
  <Mass>0.0020</Mass>
  <Substance>Smell</Substance>
 </Sensor>
 <Sensor Name="SmellLeft">
  <Class>simma.equipment.sensors.SmellSensor</Class>
  <Position>
   <R>0.025</R>
   <Phi>-90.0</Phi>
  </Position>
  <GroundClearance>0.015</GroundClearance>
  <Mass>0.0020</Mass>
  <Substance>Smell</Substance>
 </Sensor>
 <Sensor Name="SmellHalfLeft">
  <Class>simma.equipment.sensors.SmellSensor</Class>
  <Position>
   <R>0.025</R>
   <Phi>-45.0</Phi>
  </Position>
  <GroundClearance>0.015</GroundClearance>
  <Mass>0.0020</Mass>
  <Substance>Smell</Substance>
 </Sensor>
```

```xml
<Sensor Name="SmellCenterLeft">
 <Class>simma.equipment.sensors.SmellSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>-15.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
 <Substance>Smell</Substance>
</Sensor>
<Sensor Name="SmellCenterRight">
 <Class>simma.equipment.sensors.SmellSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>15.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
 <Substance>Smell</Substance>
</Sensor>
<Sensor Name="SmellHalfRight">
 <Class>simma.equipment.sensors.SmellSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>45.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
 <Substance>Smell</Substance>
</Sensor>
<Sensor Name="SmellRight">
 <Class>simma.equipment.sensors.SmellSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>90.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
 <Substance>Smell</Substance>
</Sensor>
<Sensor Name="SmellRedRightBehind">
 <Class>simma.equipment.sensors.SmellSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>135.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
 <Substance>Smell</Substance>
</Sensor>
```

```xml
<Sensor Name="SmellBehind">
 <Class>simma.equipment.sensors.SmellSensor</Class>
 <Position>
  <R>0.025</R>
  <Phi>180.0</Phi>
 </Position>
 <GroundClearance>0.015</GroundClearance>
 <Mass>0.0020</Mass>
 <Substance>Smell</Substance>
</Sensor><!--<Sensor Name="LightLeft"> <Class>simma.equipment.sensors.ParticleSens
 <Position> <R>0.015</R> <Phi>-90.0</Phi> </Position> <GroundClearance>0.06</Groun
 <Mass>0.0020</Mass> <Substance>Photon</Substance> <ApertureAngle>90.0</ApertureAn
 </Sensor> <Sensor Name="LightCenter"> <Class>simma.equipment.sensors.ParticleSens
 <Position> <R>0.0175</R> <Phi>0.0</Phi> </Position> <GroundClearance>0.045</Groun
 <Mass>0.0020</Mass> <Substance>Photon</Substance> <ApertureAngle>90.0</ApertureAn
 </Sensor> <Sensor Name="LightRight"> <Class>simma.equipment.sensors.ParticleSenso
 <Position> <R>0.015</R> <Phi>90.0</Phi> </Position> <GroundClearance>0.06</Ground
 <Mass>0.0020</Mass> <Substance>Photon</Substance> <ApertureAngle>90.0</ApertureAn
 </Sensor> -->
<Mass>0.2</Mass>
</Robot><!-- <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class>
 <Particle Name="Heat"> <Quantum>1.0</Quantum> <Color>BLUE</Color> </Particle>
 <BoundingRadius>0.02</BoundingRadius> <Height>0.015</Height> <Color>RED</Color>
 <ResetMode>Random</ResetMode> <MotionTrail>true</MotionTrail> </Peg> <Peg
 Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle Name="Heat">
 <Quantum>1.0</Quantum> <Color>BLUE</Color> </Particle> <BoundingRadius>0.02</Bound
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle
 Name="Heat"> <Quantum>1.0</Quantum> <Color>BLUE</Color> </Particle> <BoundingRadiu
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> --><!--<Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class>
 <Particle Name="Heat"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle>
 <BoundingRadius>0.02</BoundingRadius> <Height>0.015</Height> <Color>RED</Color>
 <ResetMode>Random</ResetMode> <MotionTrail>true</MotionTrail> </Peg> <Peg
 Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle Name="Heat">
 <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle> <BoundingRadius>0.02</Boun
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle
 Name="Heat"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle> <BoundingRadi
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle
 Name="Heat"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle> <BoundingRadi
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle
 Name="Heat"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle> <BoundingRadi
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle
 Name="Heat"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle> <BoundingRadi
 <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
 </Peg> <Peg Name="LostPeg"> <Class>simma.equipment.LostPeg</Class> <Particle
```

```xml
     Name="Heat"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle> <BoundingRadi
     <Height>0.015</Height> <Color>RED</Color> <ResetMode>Random</ResetMode> <MotionTra
     </Peg> -->
    <Ghost Name="Ghost">
     <Class>simma.equipment.Ghost</Class>
     <Particle Name="Heat">
      <Quantum>1.0</Quantum>
      <Color>WHITE</Color>
     </Particle>
     <BoundingRadius>0.045</BoundingRadius>
     <Height>0.015</Height>
     <Color>WHITE</Color>
     <ResetMode>Random</ResetMode>
     <MotionTrail>false</MotionTrail>
     <MoveArea>
      <X>0.1</X>
      <Y>0.1</Y>
      <XX>0.98</XX>
      <YY>0.67</YY>
     </MoveArea>
     <Speed>
      <VX>0.0095</VX>
      <VY>0.0095</VY>
     </Speed>
    </Ghost><!--<Ghost Name="Ghost"> <Class>simma.equipment.Ghost</Class>
     <Particle Name="Smell"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle>
     <BoundingRadius>0.05</BoundingRadius> <Height>0.015</Height> <Color>WHITE</Color>
     <ResetMode>Random</ResetMode> <MotionTrail>false</MotionTrail> <MoveArea>
     <X>0.3</X> <Y>0.1</Y> <XX>0.98</XX> <YY>0.67</YY> </MoveArea> <Speed> <VX>0.001</V
     <VY>0.001</VY> </Speed> </Ghost> <Ghost Name="Ghost"> <Class>simma.equipment.Ghost
     <Particle Name="Smell"> <Quantum>1.0</Quantum> <Color>WHITE</Color> </Particle>
     <BoundingRadius>0.05</BoundingRadius> <Height>0.015</Height> <Color>WHITE</Color>
     <ResetMode>Random</ResetMode> <MotionTrail>false</MotionTrail> <MoveArea>
     <X>0.01</X> <Y>0.01</Y> <XX>0.98</XX> <YY>0.67</YY> </MoveArea> <Speed> <VX>0.00</
     <VY>0.01</VY> </Speed> </Ghost> -->
    <Spot Name="Spot">
     <Class>simma.equipment.Spot</Class>
     <Particle Name="Smell">
      <Quantum>1.0</Quantum>
      <Color>YELLOW</Color>
     </Particle>
     <BoundingRadius>0.06</BoundingRadius>
     <Color>yellow</Color>
     <ResetMode>None</ResetMode>
    </Spot>
   </Objects>
   <Reporter Name="RescueTaskReporter">
    <Class>simma.reporters.RescueTaskReporter</Class>
    <ReportObject>Rescuer</ReportObject>
    <EpisodeCount>50</EpisodeCount>
```

```xml
    <TestPhase>false</TestPhase>
    <ReportTimeInterval>800.0</ReportTimeInterval>
  </Reporter>
 </Experiment>
 <Evolution>
  <Runs>1</Runs>
  <PopulationSize>20</PopulationSize>
  <MinimalGenerations>10</MinimalGenerations>
  <MaximalGenerations>600</MaximalGenerations>
  <FitnessThreshold>300000.0</FitnessThreshold>
 </Evolution>
</Configuration>
```