Machine (or Reinforcement): Learning to assist vessel docking in extreme environments

Bachelor defense

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Agenda

- Quick introduction to the problem
- Reinforcement Learning
- Simplified model
- Results & Discussion
- Conclusion & Future work

Introduction
The Vessel and the problem

The issue is keeping the vessel stable enough to attach to the windmill during a storm.

Introduction

The problem and the solution

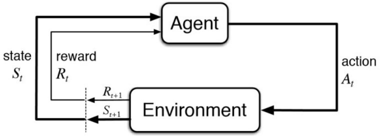
Overview of the problem

- Vessel stabilizer
- Why is a vessel stabilizer needed?
- What is Dacoma's current solution?
- The objective
- The approach

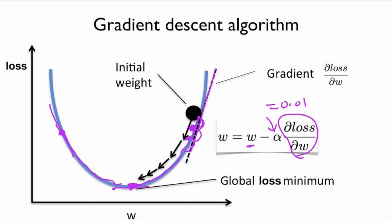
Overview:

- Classic Reinforcement Learning & Terminology
- The Approach
- Issues and Shortcomings

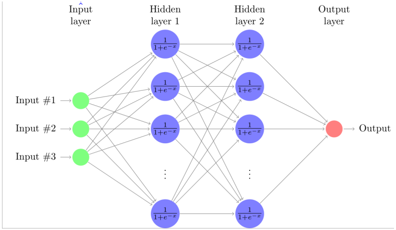
- Agent
- Environment
- States, Statespace, Actions & Actionspace
- Reward and Reward function
- Policy



Why does classic Reinforcement learning not work for this problem?



Gradient descent algorithm
loss
Initial weight
Gradient $\frac{\partial loss}{\partial w}$
$= 0.01$
$w = w - \alpha \frac{\partial loss}{\partial w}$
Global loss minimum
w



Input layer
Hidden layer 1
Hidden layer 2
Output layer
Input #1
Input #2
Input #3
Output

$$m_t = \beta_1 m_{t-1} + (1-\beta_1) g_t$$
$$v_t = \beta_2 v_{t-1} + (1-\beta_2) g_t^2$$

Moving averages of gradient and squared gradient.

$$\hat{m}_t = \frac{m_t}{1-\beta_1^t}$$
$$\hat{v}_t = \frac{v_t}{1-\beta_2^t}$$

Bias corrected estimators for the first and second moments.

$$w_t = w_{t-1} - \eta \frac{\hat{m}_t}{\sqrt{\hat{v}_t} + \epsilon}$$

Implementation specifics:

- Finite differences
- Reward & Reward Function

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- Finite differences
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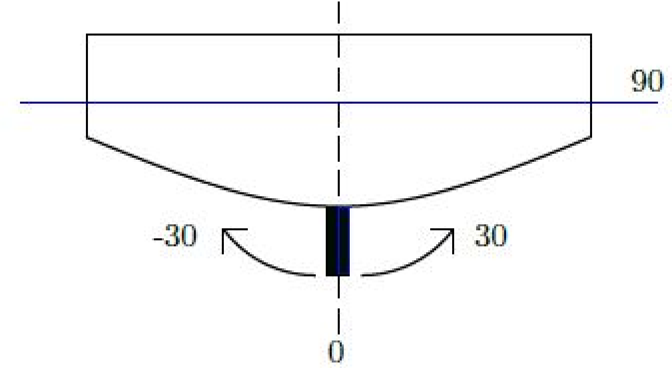
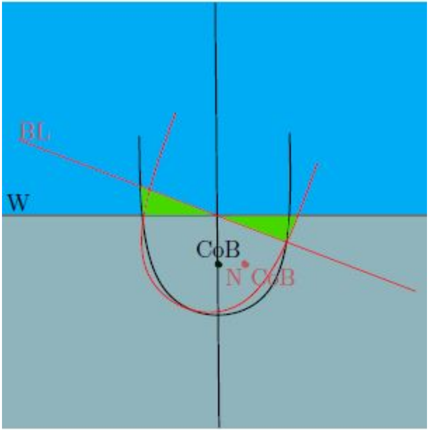
Using Archimedes principle and a adjustable air keel works to our advantages, the boat can stabilize itself.

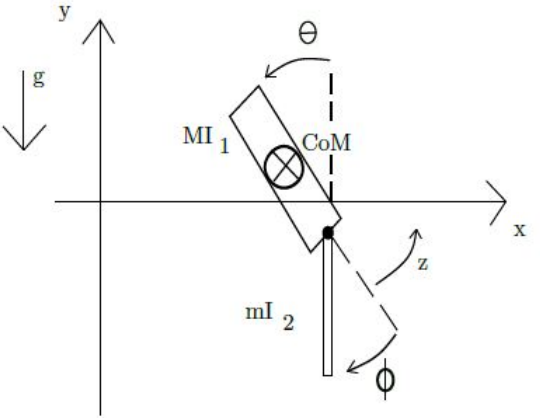


Simplified Model

Bouyancy



- Boat modelling



$$M(q)\dot{\dot{q}} + C(q, \dot{q})\dot{q} + G(g)k_\epsilon q + B_F\dot{q} = \Gamma$$

where M(q) is the inertia matrix, C(q,$\dot{q}$) are the Coriolis terms, G(q) is the gravity vector, $k_{eqsilon}$ is a matrix with the elastic constants, B_F is the friction terms and Γ is the vector of generalized external forces applied, i.e $\Gamma^\tau = [0, 0, 0, z]$.

Simplified Model

Limitations

- An approximation

- Training and testing settings and limitations
- Tuning hyperparameters
- Test and results

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- 500 rollouts, 200 iterations and two simulations
- Random generated bias values
- Angle limitations for the keel and boat

- Training and testing settings and limitations
- Tuning hyperparameters
- Test and results

- NN architecture
- Learning rate

	HL = 1 & NoN = 8 (HL1)	HL = 2 & NoN = 8,4 (HL2)	HL = 2 & NoN = 8,8 (
LR	0.1	0.01	0.001
LR	0.2	0.02	0.002
LR	0.5	0.05	0.005

Table: Displays the different learning rates tested with the three different architectural choices.

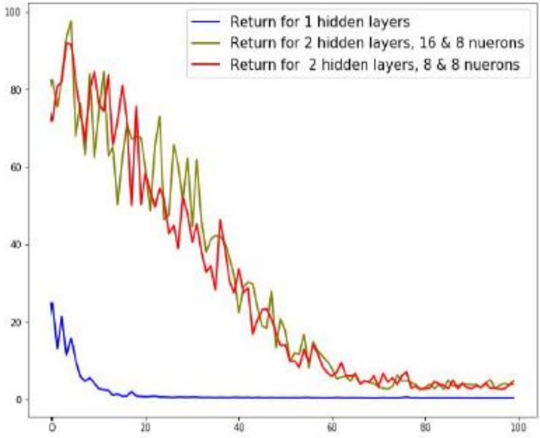

Figure: Learning rate: 0.001

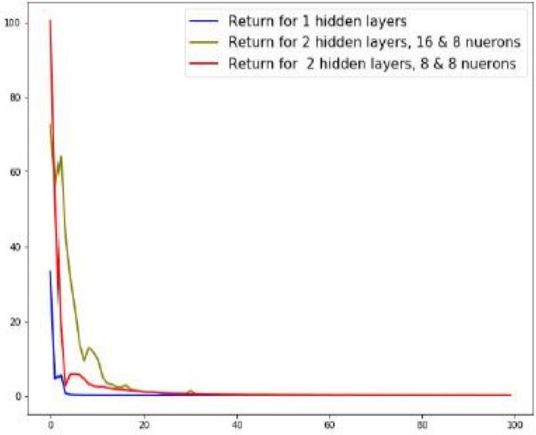

Figure: Learning rate: 0.01

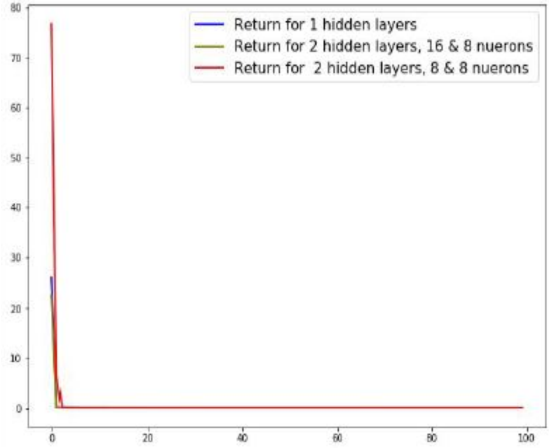

Figure: Learning rate: 0.1

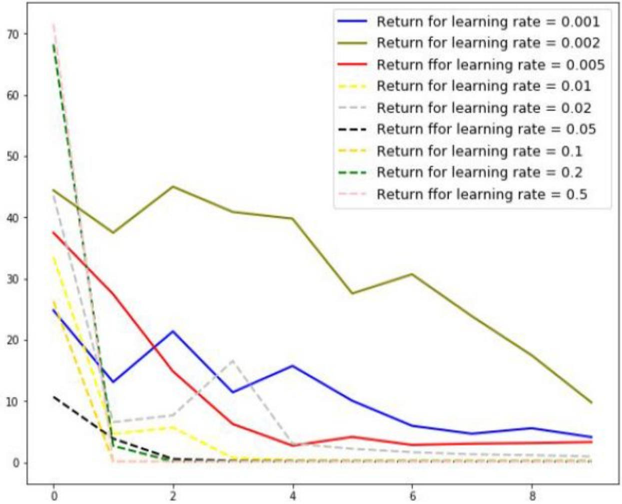

Figure: All learning rates cropped from 0 to 10 iterations

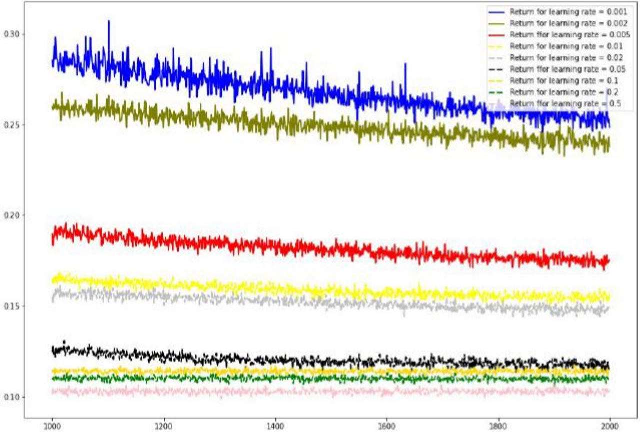

Figure: All learning rates cropped from 1000 to 2000 iterations

Figure: Shows the weights from chosen learning rates

- Training and testing settings and limitations
- Tuning hyperparameters
- Test and results

ϕ	θ
0°	$\pm 20^\circ$
0°	$\pm 15^\circ$
0°	$\pm 10^\circ$
$\pm 5^\circ$	$\pm 20^\circ$
$\pm 5^\circ$	$\pm 15^\circ$
$\pm 5^\circ$	$\pm 10^\circ$
$\pm 10^\circ$	$\pm 20^\circ$
$\pm 10^\circ$	$\pm 15^\circ$
$\pm 10^\circ$	$\pm 10^\circ$
$\pm 15^\circ$	$\pm 20^\circ$
$\pm 15^\circ$	$\pm 15^\circ$
$\pm 15^\circ$	$\pm 10^\circ$
$\pm 20^\circ$	$\pm 20^\circ$
$\pm 20^\circ$	$\pm 15^\circ$
$\pm 20^\circ$	$\pm 10^\circ$

Test #	ϕ	θ	CC without torque limit	CC with torque limit
1	0°	-20°	0.1345	0.9
2	0°	-15°	0.1341	0.73
3	0°	-10°	0.1320	0.48
4	5°	-20°	0.1423	0.9
5	5°	-15°	0.1395	0.74
6	5°	-10°	0.1350	0.48
7	10°	-20°	0.1384	0.9
8	10°	-15°	0.1365	0.73
9	10°	-10°	0.1324	0.48
10	15°	-20°	0.1348	0.74
11	15°	-15°	0.1384	0.73
12	15°	-10°	0.1354	0.73
13	20°	-20°	0.320	0.91
14	20°	-15°	0.1315	0.91
15	20°	-10°	0.1321	0.9

Conclusion

- Torque limitations
- A model that includes the proper effect of Dacoma's air keel
- Adding waves to the model/training the model out in the sea