Real World Optimization of Energy Efficient Vehicle Control

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Content

1. Project Description
2. The Simple Model
3. NEAT with Simple Model
4. Control Program for Velomobile
5. Open Tasks

What is the project about?

Creating Energy Efficient Vehicle Controller

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What ML technologies are being used?

ANNs evolved using NEAT

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Creating Energy Efficient Vehicle Controller

What ML technologies are being used?

ANNs evolved using NEAT

What is the project based on?

Paper showing ANNs can compete with state-of-the-art approaches ([Gaier and Asteroth, 2014])

Minimum

- Evolve Energy Efficient Controller with Simple Model

Project Description

Task Overview

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality

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- Compare Simulation vs Reality

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Maximum

- Use Multi-Objective Approach (i.e. Surrogate Modelling)

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Simple Vehicle Model

Time Based Model

$$\frac{ds}{dt} = \begin{pmatrix} t' \\ x' \\ v' \\ W' \end{pmatrix} = \begin{pmatrix} 1 \\ v \\ \frac{F(x,v)}{m} \\ F_u * v \end{pmatrix}$$

Where

- F_U: Force at wheel due to control command
- $F(x, v)$: F_U - some drag

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NEAT with Simple Model

Parameters

- Population size: 60
- Maximum Generations: 40
- Speciation algorithm: k-means
- Number of Species: 3
- Drop-off rate: 25
- Dataset of 30/5 tracks (Training/Test)

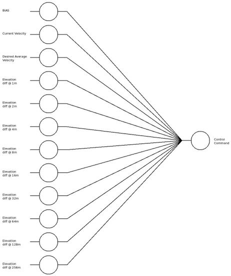


Figure : Initial Network Topology

NEAT with Simple Model

Evaluating Fitness

On Set of Tracks

- Weighted Sum of Single Track Fitnesses

NEAT with Simple Model

Evaluating Fitness

On Set of Tracks

- Weighted Sum of Single Track Fitnesses

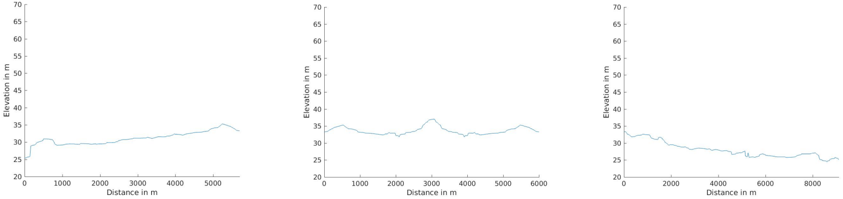
On Single Track

- Fitness: Saved Energy - Time Penalty
- Saved Energy: Maximum Energy Consumption - Actual Energy Consumption
- Time Penalty:

$$\begin{cases} 0 & \text{if } \mathit{neededTime} \leq \mathit{desiredTime} \\ (\mathit{neededTime} - \mathit{desiredTime})^2 & \text{else} \end{cases}$$

NEAT with Simple Model

Some Tracks



(a) Track 6

(b) Track 8

(c) Track 31

Figure : Some Example Tracks

NEAT with the Simple Model

Results

- Average Best Fitness
- Average Nr Generations

NEAT with the Simple Model

Simulations

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1. Project Description
2. The Simple Model
3. NEAT with Simple Model
4. Control Program for Velomobile
   - Given Hardware/Software
   - Problems
   - Control Program(s)
5. Open Tasks

Hardware

- Velomobile
- Electric Motor (Vivax-Assist)
- Speed Controller (MasterSPIN 75 Pro OPTO)
- Brake Sensor
- Hall Sensor
- Power Sensor
- Simple Button

Control Program

Given

Hardware

- Velomobile
- Electric Motor (Vivax-Assist)
- Speed Controller (MasterSPIN 75 Pro OPTO)
- Brake Sensor
- Hall Sensor
- Power Sensor
- Simple Button

Software

- Run motor on constant speed
- Read brake sensor
- Read hall sensor
- Shuts off above 25km/h
- Shuts off on brake activation
- Shuts off on button press

Why a Problem?

- Needed for velocity data
- Python-code to read sensor
- C-code to control motor
- Not implemented

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Solution

- Write/read file in python/C → Synchronization
- Write/Read output stream → Python script needs to call C script and resets state
- Use socket communication

Why a Problem?

- Needed for collecting data
- Not implemented

Solution

- Increase speed on button click
- Shut motor off on brake activation only

Problems

No Motor Reaction

Why a Problem?

- Cannot drive vehicle

Solution

- (Hardware-)Debug with working initial code
- Only send signal on change
- Range [7,19] instead of [0,100]

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- Obviously wrong data gets logged
- No synchronization during data access

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Open Approaches

- Use C-code with wiringPi synchronization mechanism

Software Architecture

TODO: Diagram

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Open Tasks

- Fix Logging
- Evaluate Solutions Simple Model
- Collect Data
- Learn Model
- NEAT on DD Model
- Evaluate Solutions DD Model

Sources I

Gaier, A. and Asteroth, A. (2014).
Evolving look ahead controllers for energy optimal driving and path planning.
In *Innovations in Intelligent Systems and Applications (INISTA) Proceedings, 2014 IEEE International Symposium on*, pages 138–145. IEEE.