Real World Optimization of Energy Efficient Vehicle Control

Bastian Lang

Bonn-Rhein-Sieg University of Applied Science

July 21, 2016

Content

What is the project about?

Creating Energy Efficient Vehicle Controller

What is the project about?

Creating Energy Efficient Vehicle Controller

What ML technologies are being used?

ANNs evolved using NEAT

What is the project about?

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 ([**?**])

Minimum

- Evolve Energy Efficient Controller with Simple Model

Minimum

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

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Expected

- Create Data Driven Model

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Expected

- Create Data Driven Model
- Evolve Energy Efficient Controller with DD Model

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Expected

- Create Data Driven Model
- Evolve Energy Efficient Controller with DD Model
- Evaluate in Reality

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Expected

- Create Data Driven Model
- Evolve Energy Efficient Controller with DD Model
- Evaluate in Reality
- Compare Solutions

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Expected

- Create Data Driven Model
- Evolve Energy Efficient Controller with DD Model
- Evaluate in Reality
- Compare Solutions

Minimum

- Evolve Energy Efficient Controller with Simple Model
- Evaluate in Reality
- Compare Simulation vs Reality

Expected

- Create Data Driven Model
- Evolve Energy Efficient Controller with DD Model
- Evaluate in Reality
- Compare Solutions

Maximum

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

Content

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

Simple Vehicle Model

TODO: Visualizations of Simulations

Content

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)

TODO: Plots of some tracks

On Set of Tracks

- Weighted Sum of Single Track Fitnesses

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:

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

- Average Best Fitness
- Average Nr Generations

Content

Hardware

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

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

Why a Problem?

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

Solution

- Write/read file in python/C $\rightarrow$ Synchronization

Why a Problem?

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

Solution

- Write/read file in python/C $\rightarrow$ Synchronization
- Write/Read output stream $\rightarrow$ Python script needs to call C script and resets state

Why a Problem?

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

Solution

- Write/read file in python/C $\rightarrow$ Synchronization
- Write/Read output stream $\rightarrow$ 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

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]

Why a Problem?

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

Why a Problem?

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

Solution

- Synchronize using mutexes $\rightarrow$ Still huge values

Why a Problem?

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

Solution

- Synchronize using mutexes → Still huge values
- Remove all possible multi-threading → Hall Sensor

Why a Problem?

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

Solution

- Synchronize using mutexes → Still huge values
- Remove all possible multi-threading → Hall Sensor
- Rewrite in Python → Files empty, occasional restarts

Why a Problem?

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

Solution

- Synchronize using mutexes → Still huge values
- Remove all possible multi-threading → Hall Sensor
- Rewrite in Python → Files empty, occasional restarts

Why a Problem?

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

Solution

- Synchronize using mutexes → Still huge values
- Remove all possible multi-threading → Hall Sensor
- Rewrite in Python → Files empty, occasional restarts

Open Approaches

- Use C-code with wiringPi synchronization mechanism

Software Architecture

TODO: Diagram

Content

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.