BRSU

Advanced Scientific Working -Reading Report- Evolving Look Ahead Controllers for Energy Optimal Driving and Path Planning

Bastian Lang

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1 Reading Report

1.1 Problem Formulation

- Developing techniques for near energy-optimal control of vehicles using controllers that base their decisions on characteristics of the road.
- Developing control strategies that make the best use of the terrain.

1.2 Why is this still a problem?

- Engineering of transport systems resulted in efficient designs, but further optimizations are diminishing.
- Driver-training programs have yielded impressive results.
- Instead of being reduced, emissions caused by transportation drastically increased in 2005 and 2007.

1.3 State of the art

- Energy-optimal control of commercial trucks and trains
- Energy-optimal control of experimental vehicles
- Energy-optimal control of hybrid gas-electric vehicles
- Finding fuel-optimal behavior of an experimental fuel-cell vehicle using optimal control theory and a simplified model of environment and vehicle
- It was found that only three commands are needed to produce an optimal strategy:
  - full power
  - maintain velocity
  - coast
- Reformulating the problem as a graph-search problem using A* and a special heuristic the number of nodes needed could be drastically decreased with still achieving near-optimal solutions
- Using dynamic programming to reduce complexity and rounding errors from state space discretisation
- Using inverted system equations real valued controls could be used. But not all equations can be inverted and it is often non-trivial
- Avoiding numerical issues by first defining the boundary line between feasible and infeasible states. This reduced computation costs by an order of magnitude.

- Neuroevolution techniques have shown to be more effective on some benchmark tests than reinforcement learning techniques
- NEAT is the current most successful algorithm within neuroevolutionary algorithms

1.4 What is the author's contribution?

- Use of evolutionary algorithms instead of graph search algorithms
- Application of a state-of-the-art evolutionary algorithm to the energy-optimal control problem

1.5 How did the solution solve the addressed problem?

- By using the method of NEAT (NeuroEvolution of Augmented Topologies) the authors evolve a controller for an e-bike
- Use of simplified vehicle model
- Use of three motor commands
- Evolutionary algorithms do not need to work in a discretized state space, so rounding errors are no problem
- Evolutionary algorithms do not use state space models. Therefore increasing the complexity of the model does not have a huge effect on the space complexity.
- Using a local solution that calculates new commands at every meter, a deggree of precision can be achieved that is not possible for graph search in most scenarios.

1.6 Evaluation

- Comparison of performance on 35 routes with a Graph Search algorithm
- Training of net using cross-validation
- Training on 5 maps, testing on remaining 30
- 50 training runs, each containing of evolving a population of size 150 for 1000 generations.
- Comparison to graph search in three different resolution levels
- Performance is only slightly worse than the highest depth graph.
- Analysed in detail most solutions performed better
- Computation time was nearly instantaneous versus about 1 minute for an 8km route
- Space complexity was about 1KB versus 11GB

1.7 SCIENTIFIC DEFICIT

1.8 SCIENTIFIC CONTRIBUTION