Neural Network Perception for Mobile Robot Guidance

Dean A. Pomerleau

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School of Computer Science
Carnegie Mellon University
Pittsburgh, PA 15213

Submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

Support for this work has come from DARPA, under contracts DACA76-85-C-0019, DACA76-85-C-0003, DACA76-85-C-0002, DACA76-89-C-0014 and DAAE07-90-C-R059. These contracts were monitored by the Topographic Engineering Center and by TACOM. This research was also funded in part by grants from the Fujitsu Corporation and the Shimizu Corporation.

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DOCTORAL THESIS
in the field of
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ACCEPTED:

David S. Touretzky — MAJOR PROFESSOR — 2/10/92 DATE

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APPROVED:

[signature] — PROVOST — 2/18/92 DATE

Dedicated to Terry, Glen and Phyllis

Abstract

Vision based mobile robot guidance has proven difficult for classical machine vision methods because of the diversity and real time constraints inherent in the task. This thesis describes a connectionist system called ALVINN (Autonomous Land Vehicle In a Neural Network) that overcomes these difficulties. ALVINN learns to guide mobile robots using the back-propagation training algorithm. Because of its ability to learn from example, ALVINN can adapt to new situations and therefore cope with the diversity of the autonomous navigation task.

But real world problems like vision based mobile robot guidance presents a different set of challenges for the connectionist paradigm. Among them are:

- How to develop a general representation from a limited amount of real training data,
- How to understand the internal representations developed by artificial neural networks,
- How to estimate the reliability of individual networks,
- How to combine multiple networks trained for different situations into a single system,
- How to combine connectionist perception with symbolic reasoning.

This thesis presents novel solutions to each of these problems. Using these techniques, the ALVINN system can learn to control an autonomous van in under 5 minutes by watching a person drive. Once trained, individual ALVINN networks can drive in a variety of circumstances, including single-lane paved and unpaved roads, and multi-lane lined and unlined roads, at speeds of up to 55 miles per hour. The techniques also are shown to generalize to the task of controlling the precise foot placement of a walking robot.

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