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ALVINN: AN AUTONOMOUS LAND VEHICLE IN A NEURAL NETWORK

Technical Report AIP -77

Dean A. Pomerleau

Department of Psychology
Carnegie Mellon University
Pittsburgh, PA 15213-3890

The Artificial Intelligence and Psychology Project

Departments of
Computer Science and Psychology
Carnegie Mellon University

Learning Research and Development Center
University of Pittsburgh

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January 1989

This research was supported by the Computer Sciences Division, Office of Naval Research, under contract number N00014-86-K-0678, N00014-87-K-0385, and N00014-87-K-0533, by National Science Foundation Grant EET-8716324, by the Defense Advanced Research Projects Agency (DOD) monitored by the Space and Naval Warfare Systems Command under Contract N00039-87-C-0251, and by the Strategic Computing Initiative of DARPA, through ARPA Order 5351, and monitored by the U.S. Army Engineer Topographic Laboratories under contract DACA76-85-C-0003 titled "Road Following".

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; Distribution unlimited
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AIP - 77	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Carnegie-Mellon University 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION Computer Sciences Division Office of Naval Research
6c. ADDRESS (City, State, and ZIP Code) Department of Psychology Pittsburgh, Pennsylvania 15213	7b. ADDRESS (City, State, and ZIP Code) 800 N. Quincy Street Arlington, Virginia 22217-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION Same as Monitoring Organization 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N00014-86-K-0678
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS p4000ub201/7-4-86

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
N/A	N/A	N/A	N/A

11. TITLE (Include Security Classification)

ALVINN: An Autonomous Land Vehicle in a Neural Network

12. PERSONAL AUTHOR(S)

Pomerleau, Dean A.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Technical	FROM 86Sept15 TO 91Sept14	January, 1989	13

16. SUPPLEMENTARY NOTATION Paper was presented at the IEEE Conference on Neural Information Processing Systems--Natural and Synthetic, Denver, November, 1988

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	autonomous navigation, road following, neural networks, machine vision,

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

SEE REVERSE SIDE

20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION
22a. NAME OF RESPONSIBLE INDIVIDUAL Dr. Alan L. Meyrowitz	22b. TELEPHONE (Include Area Code) (202) 696-4302 22c. OFFICE SYMBOL N00014

DD FORM 1473, 84 MAR

83 APR edition may be used until exhausted.
All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

Unclassified

ABSTRACT

ALVINN (Autonomous Land Vehicle In a Neural Network) is a 3-layer back-propagation network designed for the task of road following. Currently ALVINN takes images from a camera and a laser range finder as input and produces as output the direction the vehicle should travel in order to follow the road. Training has been conducted using simulated road images. Successful tests on the Carnegie Mellon autonomous navigation test vehicle indicate that the network can effectively follow real roads under certain field conditions. The representation developed to perform the task differs dramatically when the network is trained under various conditions, suggesting the possibility of a novel adaptive autonomous navigation system capable of tailoring its processing to the conditions at hand.

INTRODUCTION

Autonomous navigation has been a difficult problem for traditional vision and robotic techniques, primarily because of the noise and variability associated with real world scenes. Autonomous navigation systems based on traditional image processing and pattern recognition techniques often perform well under certain conditions but have problems with others. Part of the difficulty stems from the fact that the processing performed by these systems remains fixed across various driving situations.

Artificial neural networks have displayed promising performance and flexibility in other domains characterized by high degrees of noise and variability, such as handwritten character recognition [Jackel et al., 1988] [Pawlicki et al., 1988] and speech recognition [Waibel et al., 1988]. ALVINN (Autonomous Land Vehicle In a Neural Network) is a connectionist approach to the navigational task of road following. Specifically, ALVINN is an artificial neural network designed to control the NAVLAB, the Carnegie Mellon autonomous navigation test vehicle.

NETWORK ARCHITECTURE

ALVINN's current architecture consists of a single hidden layer back-propagation network (See Figure 1). The input layer is divided into three sets of units: two "retinas" and a single intensity feedback unit. The two retinas correspond to the two forms of sensory input available on the NAVLAB vehicle; video and range information. The first retina, consisting of 30x32 units, receives video camera input from a road scene. The activation level of each unit in this retina is proportional to the intensity in the blue color band of the corresponding patch of the image. The blue band of the color image is used because it provides the highest contrast between the road and the non-road. The second retina, consisting of 8x32 units, receives input from a laser range finder. The activation level of each unit in this retina is proportional to the proximity of the corresponding area in the image. The road intensity feedback unit indicates whether the road is lighter or darker than the non-road in the previous image. Each of these 1217 input units is fully connected to the hidden layer of 29 units, which is in turn fully connected to the output layer.

The output layer consists of 46 units, divided into two groups. The first set of 45 units is a linear representation of the turn curvature along which the vehicle should travel in order to head towards the road center. The middle unit represents the "travel straight ahead" condition while units to the left and right of the center represent successively sharper left and right turns. The network is trained with a desired output vector of all zeros except for a "hill" of activation centered on the unit representing the correct turn curvature, which is the curvature which would bring the vehicle to the road center 7 meters ahead of its current position. More specifically, the desired activation levels for the nine units centered around the correct turn curvature unit are 0.10, 0.32, 0.61, 0.89, 1.00, 0.89, 0.61, 0.32 and 0.10. During testing, the turn curvature dictated by the network is taken to be the curvature represented by the output unit with the highest activation level.

The final output unit is a road intensity feedback unit which indicates whether the road

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