

Spatial Intent Recognition using Optimal Margin Classifiers

16.412J Cognitive Robotics
Final Project Report

Thomas Coffee
Shannon Dong
Shen Qu

5/11/05

Abstract

Human-robot collaboration will be crucial to the productivity and success of future space missions. A simple yet intuitive means of communication between two parties—such as communication through gestures—is critical to the success of such collaboration. Optimal margin classifiers can be used for the classification and recognition of such gestures. Two pattern input methods are used to test the behavior and performance of these classifiers. The first is a 2-dimensional computer mouse interface which allows for ease of control and visualization of the patterns. Patterns obtained through this input include circles, lines, and written numerals 2, 3, and 4. The second is a 6 degree-of-freedom hardware tracking device comparable to systems that may be integrated into actual spacesuits. Patterns for this input include gestures designed to convey the intentions of “come here,” “lift,” and “move.” These gestures are meant to mirror the ones actual astronauts may make to communicate with their robotic assistants. We demonstrate a basic linear optimal margin classifier based on support vector methods to efficiently learn and recognize input patterns from multiple categories. We test the algorithm’s capability not only to distinguish different patterns but also to differentiate same pattern made by different users. We further characterize the performance of this algorithm and its sensitivity to training corpus size and input sampling resolution. Finally, we discuss directions for further development of these algorithms to support flexible, intuitive astronaut collaboration with automated space systems.

Table of Contents

ABSTRACT	2
TABLE OF CONTENTS	3
INTRODUCTION	4
1. OPTIMAL MARGIN CLASSIFIER¹	5
1.1 REPRESENTATION	5
1.2 DECISION FUNCTION	5
1.3 MAXIMIZING THE MARGIN	7
1.3.1 <i>A Note on Dimensionality</i>	8
1.3.2 <i>A Note on the Decision Function Bias</i>	9
2. IMPLEMENTATION METHODS	11
2.1 USER INPUT MECHANISMS	11
2.1.1 <i>Handwriting Input</i>	11
2.1.2 <i>Gesture Input</i>	12
2.2 INPUT PATTERNS OF INTEREST	14
2.2.1 <i>Circles and lines</i>	14
2.2.2 <i>Numerals</i>	15
2.2.3 <i>Gestures</i>	16
3. RESULTS AND ANALYSIS	17
3.1 BASIC SHAPES: A FIRST LOOK	17
3.2 HANDWRITING RECOGNITION: PERFORMANCE DRIVERS	21
3.3 GESTURE RECOGNITION: PUTTING IT ALL TOGETHER	30
4. POSSIBLE EXTENSIONS	37
4.1 PATTERN RECOGNITION GIVEN CONTINUOUS INPUT	37
4.2 DISTINGUISH PATTERN FROM NON-PATTERN	38
4.3 ALTERNATIVE CLASSIFICATION FOR MULTIPLE CLASSES	39
4.3.1 <i>Single classifier for Multiple Classes</i>	40
4.3.2 <i>Binary Tree-Structured Classifiers</i>	41
CONCLUSION	43
ACKNOWLEDGEMENTS	44
REFERENCES	45