Miniature Space-Variant Active Vision System: **Cortex-I**

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Abstract

We have developed a prototype miniaturized active vision system whose sensor architecture is based on a logarithmically structured space-variant pixel geometry. A space-variant image's resolution changes across the image. Typically, the central part of the image has a very high resolution, and the resolution falls off gradually in the periphery. Our system integrates a miniature CCD-based camera, pan-tilt actuator, controller, general purpose processors and display. Due to the ability of space-variant sensors to cover large work-spaces, yet provide high acuity with an extremely small number of pixels, space-variant active vision system architectures provide the potential for radical reductions in system size and cost. We have realized this by creating an entire system that takes up less than a third of a cubic foot. In this thesis, we describe a prototype space-variant active vision system (**Cortex-I**) which performs such tasks as tracking moving objects and license plate reading, and functions as a video telephone.

We report on the design and construction of the camera (which is $8 \times 8 \times 8$mm), its readout, and a fast mapping algorithm to convert the uniform image to a space-variant image. We introduce a new miniature pan-tilt actuator, the Spherical Pointing Motor (SPM), which is $4 \times 5 \times 6$cm. The basic idea behind the SPM is to orient a permanent magnet to the magnetic field induced by three orthogonal coils by applying the appropriate ratio of currents to the coils. Finally, we present results of integrating the system with several applications. Potential application domains for systems of this type include vision systems for mobile robots and robot manipulators, traffic monitoring systems, security and surveillance, telerobotics, and consumer video communications.

The long-range goal of this project is to demonstrate that major new applications of robotics will become feasible when small low-cost machine vision systems can be mass-produced. This notion of "commodity robotics" is expected to parallel the impact of the personal computer, in the sense of opening up new application niches for what has until now been expensive and therefore limited technology.

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Acknowledgements

This work is the result of a collaborative effort. It was a pleasure to have had the opportunity to work with such fine minds as I found in Eric Schwartz (my thesis advisor), Richard Wallace (my colleague and constant teacher), and Ping-Wen Ong (my fellow student and supporter).

Eric has been doing research leading up to this project for at least ten years. He found the funding for it, and had many of the critical ideas that got it moving. The Spherical Pointing Motor was his original idea, and only through (literally) years of bouncing it off each other, did we get it right.

Richard is largely responsible for the digital signal processing in the system. If it weren't for him, we wouldn't have a video display. He had infinite patience in helping me work through problems. He was always available to assist me, and helped to keep the project well directed.

Ping-wen came through at the last minute to integrate his license plate tracking software to work with **Cortex-I**. In addition, he was a motivating force in my studying Chinese. While not directly critical to this project, studying Chinese helped me keep my sanity during various traumas – such as when the first prototype went flying through the air as I got a great electric shock – a few hours before we departed for Chicago where **Cortex-I** was first publicly demonstrated.

Everyone at the NYU Robotics Lab was always optimistic and supportive as **Cortex-I** slowly took shape. Bud Mishra, especially, had good ideas, and was kind enough to read this thesis twice.

And of course, I thank my family, friends, and cat (Tria) who have had to put up with me as I've been counting down the months to finish this, and start the next phase of my life.

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