Embedding Invisible Codes into Normal Video Projection: Principle, Evaluation and Applications

Jingwen Dai, *Student Member, IEEE,* and Ronald Chung, *Senior Member, IEEE*

Abstract

We describe a system of embedding codes into projection display for structured light based sensing, with the purpose of letting projector serve as both a display device and a 3D sensor. The challenge is to make the codes imperceptible to human eyes so as not to disrupt the content of the original projection. There is the temporal resolution limit of human vision that one can exploit, by having a higher than necessary frame rate in the projection and stealing some of frames for code projection. Yet there is still the conflict between imperceptibility of the embedded codes and the robustness of code retrieval that has to be addressed. We introduce noise-tolerant schemes to both the coding and decoding stages. At the coding end, specifically designed primitive shapes and large Hamming distance are employed to enhance tolerance toward noise. At the decoding end, pre-trained primitive shape detectors are used to detect and identify the embedded codes – a task difficult to achieve by segmentation that is used in general structured light methods, for the weakly embedded information is generally interfered by substantial noise. Extensive experiments including evaluations of code imperceptibility, decoding accuracy and sensitivity analysis show that the proposed system is effective, even with the prerequisite of incurring minimum disturbance to the original projection.

Index Terms

imperceptible structured light sensing, embedded pattern design, primitive shape detection and classification, sensitivity analysis

I. Introduction

The improving performance, declining price, and diminishing size of digital video projectors make it possible to use them prevalently. Being able to generate arbitrarily large display is a feature of projectors that makes them exceedingly attractive, especially in applications that demand portability. On the other hand, the adoption of structured light illumination has been proven to be an effective and accurate means for 3D information perception [1]. Recently, the availability of pico projectors with average dimensions of $4 \times 2 \times 1$ inches has widely extended the application domain of structured light system. There are already pocket DCs, DVs and cellular phones (as shown

J. Dai and R. Chung are with the Department of Mechanical and Automation Engineering, The Chinese University of Hong Kong, Shatin, NT, Hong Kong. e-mail: {jwdai, rchung}@mae.cuhk.edu.hk