Reconstruction of Quadrics from Two Silhouettes

with an Application to Automated Fruit Grading

Sudanthi N. R. Wijewickrema, B.Sc. Eng. (hons)
sudanthi.wijewickrema@infotech.monash.edu.au
Monash University, 2007

Supervisor: A/Prof. Andrew Papliński
andrew.paplinski@infotech.monash.edu.au

Associate Supervisor: Prof. Bala Srinivasan
bala.srinivasan@infotech.monash.edu.au

External Supervisor: Mr. Charles Esson
charlesess@cvs.com.au

Abstract

This thesis considers the problem of quadric reconstruction from the silhouettes of two views obtained from calibrated cameras. It addresses the particular issue of reconstruction when the quadric under consideration is tangent to a known surface. Special emphasis is placed on speed, as the proposed solution is aimed at a practical application: automated sorting of fruit on production lines, where the most important constraint is time.

In devising a solution, the problem is divided into sub-problems, and novel methods are introduced at each step to accurately and efficiently deal with them. First, since the problem requires reconstructing a quadric tangent to a known surface, the issue of determining tangency between quadrics is investigated. In the process, the intersection of quadrics is also explored, along with its 2D counterpart: the intersection of conics.

As the projection of any quadric is a conic, the first step of quadric reconstruction, and therefore the next sub-problem addressed here, is to fit conics to the images of the object. To this end, two conic fitting methods are introduced, the first of which is a novel orthogonal distance least squares fitting algorithm for general conics. The second is ellipse specific and is particularly aimed at the target application.

The issue of adjusting the conics fitted to the two views so that they adhere to the geometry of the imaging system is a practical problem encountered in quadric reconstruction, and is explored next. A fast and accurate algorithm suitable for realtime applications is introduced to achieve this purpose.

Then, the reconstruction of quadrics tangent to a given surface from the fitted (and adjusted) conics of two views is investigated. This is addressed on three different levels: general quadric, ellipsoid, and sphere reconstruction. The algorithms introduced are fast and efficient, as required by the target application.

The complete process of quadric reconstruction is thus explored, and algorithms proposed, to achieve higher speed and simplicity of computation without compromising accuracy, when compared to existing methods. Each of the introduced algorithms are derived mathematically, and validated experimentally.