EXTRACTING CROSS-SECTIONAL PROFILES FROM UNORGANISED POINT CLOUDS

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Abstract

Ancient architectures, medieval in particular, often utilised stone carvings to decorate salient areas of buildings. Mostly these carvings consist of a planar pattern which is extruded along the length of, or swept out around, the stone. Therefore a single cross-section is often all that is required to model the features within the carving. This form of data has been widely used for recording purposes. In this paper we present a strategy for extracting the cross-sectional profile from a set of unconnected points, i.e. a point cloud. We use a density measure to evaluate the "goodness" of a cross-section and, a voting algorithm for the generation of a candidate axis or axes. A local optimisation algorithm, fueled by the density measure, is then used to improve upon this candidate.

Keywords: Modeling, Density Metric, Randomised Voting, Error Propagation.

1 Introduction

Salient areas of medieval buildings were often decorated with the use of carved stone. One of the most common forms of carving consisted of a planar pattern, which runs along the length of the stone, or is swept out into an arc. The varying complexity of these profiles allow historians to reason about the authorship and period of a building. Therefore the profile is a crucial form of data, and often provides the majority of the information needed to model the stone-work. For further details on moulding profiles please refer to [9, 10, 11, 12, 13, 17].

Many historians have dedicated their life's work to the collection and analysis of medieval moulding profiles. This has resulted in large private collections which have been gathered by a variety of manual techniques. While their work does catalog the buildings, many of which are in a state of ruin, they have not facilitated a program of comprehensive analysis as they are not generally accessible by people wishing to study them.

The strategy presented in this paper aims to allow the extraction of the cross-sectional profile from a totally unconnected "cloud" of 3-dimensional points which form a surface representation. There is no requirement for the points to form a tessellated surface, i.e. the points alone are used. Much research has tackled the formation [1, 2, 15] and optimisation [5, 6, 7, 8] of surface meshes and the merging of range images [3, 4, 18]. The algorithm presented here foregoes the use of these techniques as a preprocessing step.

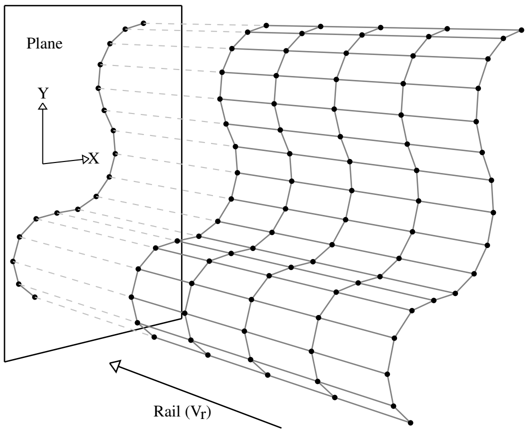
The rest of this paper is organised as follows; in Section 2 we give an overview of the algorithm, detailing how we model the profiles; in Section 3 we derive a function which evaluates the "goodness" of a given transformation; then in Section 4 we present a randomised voting strategy for generating initial estimates for the linear or radial transform; next Section 5 shows how we propagate the effects of noise into the algorithms; we conclude with Section 7 where we also comment on possible future directions of research.

2 Overview

As mentioned in Section 1 the medieval masons often used profiles for creating their carvings. There are two main forms of profile based carving, linear as shown in Figure 1(a) and, radial as shown in Figure 1(b). For linear mouldings, the characteristic profile is extruded along the length of the stone, akin to sliding it along a rail. For radial mouldings, the profile pattern sweeps around the stone, i.e. is swept around an axis.

In order to extract these profiles it is necessary that we examine the way the surface was made and reverse it. Thus a linear moulding can be modeled as a projection along a "rail" vector, onto any plane which is perpendicular to the vector. Figure 1(a) shows a surface mesh which can be collapsed, along the rail, onto a plane. This results in a planar set of points representing the profile. Thus we express the linear model as a vector, V_r.

For a radial moulding the process is a little more complicated. We model it as a rotation about an axis, onto any plane which intersects with the axis of rotation. Each point is rotated about the axis until it lies on the plane, as illustrated in Figure 1(b). Thus we express the radial model as



(a) Linear