Symmetry Detection In Geometric Models

KATEDRA INFORMATIKY A VÝPOČETNÍ TECHNIKY

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Abstract

Reflectional symmetry is a potentially very useful feature which many real world objects exhibit. Its knowledge can be used in variety of applications such as object alignment, compression, symmetrical editing or reconstruction of incomplete objects. To acquire the symmetry information usable in such applications, often a robust symmetry detection algorithm needs to be used since most objects are not perfectly symmetrical and exhibit only approximate symmetry. We propose a new method for detecting the plane of reflectional symmetry for 3D objects which works on perfectly as well as approximately symmetrical objects. Furthermore, the method works on point clouds and therefore puts virtually no constraints on the input data.

Introduction

A 3D object X is reflectionally symmetrical with respect to a plane P if the object X stays the same when it is reflected over the plane P. In such a case we can call P the plane of symmetry, or the symmetry plane, of the object X.

In most cases the reflectional symmetry is not perfect but only approximate and in some cases the object can even have missing parts, like the human face depicted in Figure 1.

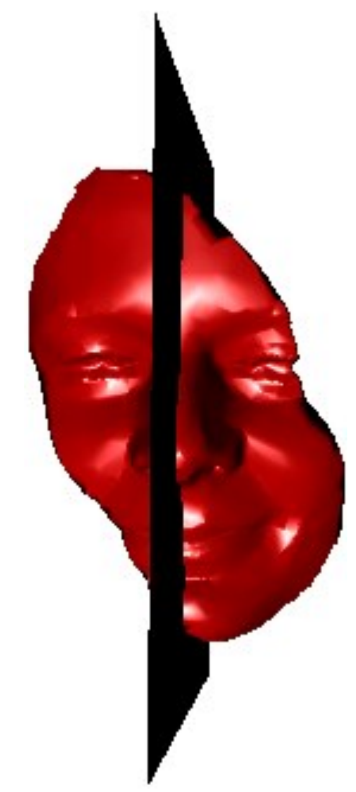

Figure 1: Human face with missing parts

We can see that the face is symmetrical with respect to a plane that passes between the eyes and through the nose and the mouth (such a plane is also shown in the figure), but since it is a real human face, and on top of it some of its parts were removed, it is certainly not perfectly symmetrical. Finding the plane that captures such approximate symmetry automatically is often not a simple task, let alone in objects with missing parts.

The goal of this work was to design a method which could be used to detect the plane of global reflectional symmetry of a given 3D object and would possibly be able to detect also an approximate symmetry and symmetry of an object with missing parts.

Proposed Method

The method we designed is based on maximizing a specific symmetry measure which is continuous and even differentiable. The input point cloud is simplified to a very low number of points and pairs of points of this simplified point cloud are used to create a number of candidate planes. From these candidate planes the one with the highest symmetry measure is chosen. For time reasons, the symmetry measure is computed on another simplified version of the input point cloud. In the end a local optimization is performed to find the final plane of symmetry. The symmetry measure also contains weights which allow using some additional information about the input object.

Results

The proposed method was tested and exhibits good results when used on perfectly as well as approximately symmetrical objects and even on objects with significant missing parts. Further testing also revealed that the method is robust to noise. Some of the results of the proposed method can be seen in Figure 2.

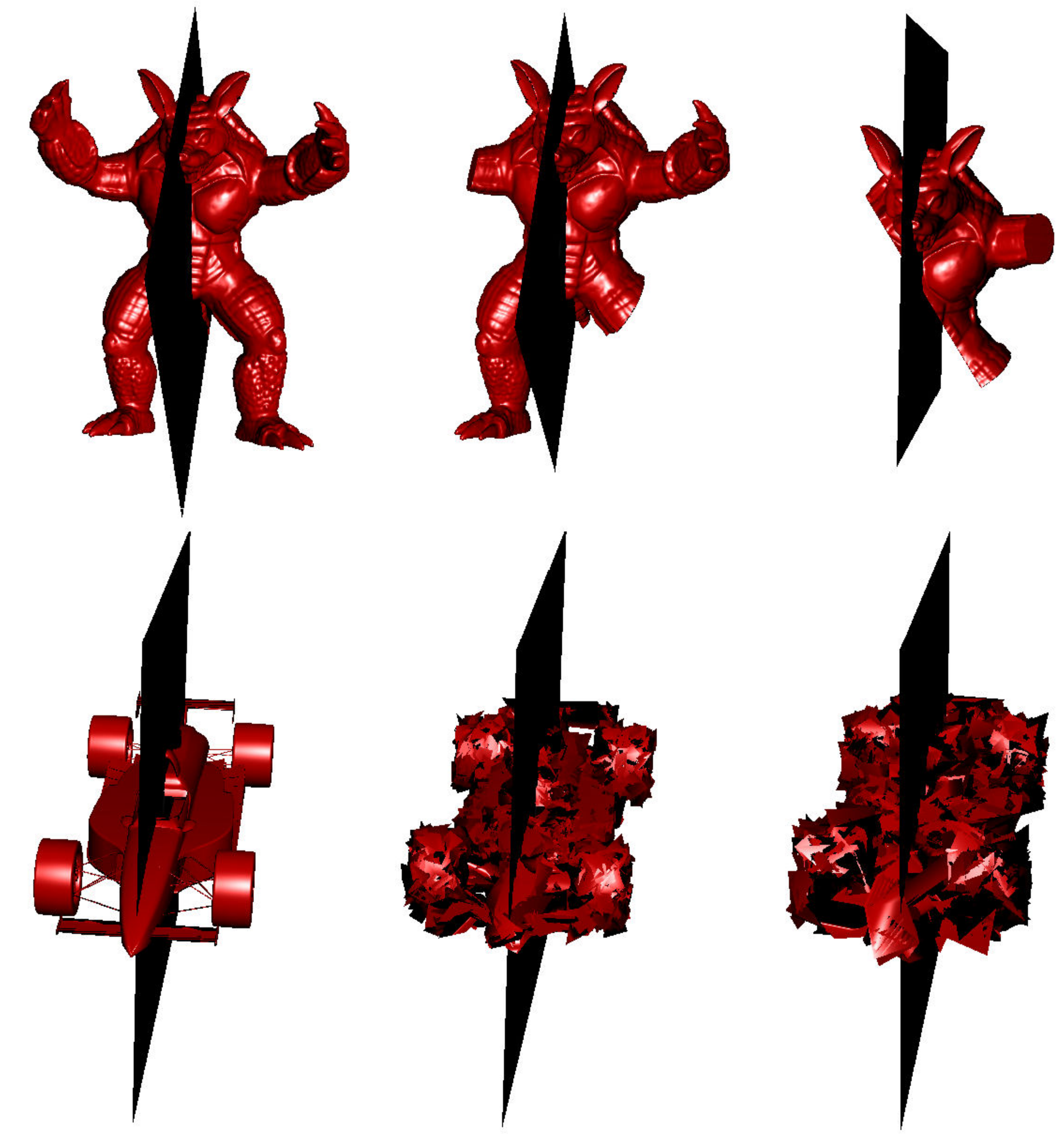

Figure 2: Results of the proposed method

The figure shows that our method really works well even on objects with significant missing parts and also on objects that are noticeably damaged by noise.

Conclusion

We have designed and proposed a new method for detecting the plane of global reflectional symmetry of 3D objects which is usable on objects represented by only a set of points (point cloud). The method works very well and seems to outperform other existing methods in the robustness, specifically it is robust to missing parts and to noise.

In the future, we plan to extend our method to detect more than one plane of symmetry in case the input object is symmetrical with respect to more planes. Also, we would like to find ways how our method could be generalized to detect symmetries of different types, such as rotational symmetry or some more general symmetry. Some of these generalizations were already proposed as part of this work but only on a theoretical level, none of these generalizations were implemented yet.