Computer Graphics Literature Review 3

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Paper 1: Differential 3D Scanning
(Ammar Hattab, Ian Gonsher, Daniel Moreno, and Gabriel Taubin ■ Brown University) (link)
Date of Publication: 26 April 2017

Paper 2: Applications of Tensor Theory to Object Recognition and Orientation Determination
(DAVID CYGANSKI and JOHN A. ORR) (link)
Date of Publication**:** Nov. 1985

Introduction:

Paper 1 talks about the rise of digital fabrication. It has revolutionized this process. Yet, at the same time, many designers bemoan the loss of hands-on, craft-based approaches to prototyping. Is something important lost when you cannot touch the thing you are making? Using your hands to give something form is a different cognitive process than drawing something on a screen. We must make assumptions about form and function when a model is more abstract than when it emerges from a direct engagement with materials.

A digital fabrication device like a 3D printer can facilitate moving from the digital to the physical, while moving from the physical to the digital requires using a 3D scanning device. Such devices work by making a copy of an entire 3D model. The designer then usually applies only a few changes to the object's 3D shape in each design iteration. Therefore, we argue that we don't need to operate on the whole 3D model, only on the relevant changes in each iteration. Differential 3D scanning can detect the differences between a scanned model (point cloud) and a reference model (polygon mesh or CAD model) and then reflect those changes in the reference model. This can save designers time by reconstructing only the small changed regions rather than the entire object.

Paper 2 talks about a method to develop images resulting from orthogonal projection of rigid planar-patch objects arbitrarily oriented in three-dimensional (3-D) space may be used to form systems of linear equations which are solved for the affine transform relating the images. The technique is applicable to complete images and to unlabeled feature sets derived from images, and with small modification may be used to transform images of unknown objects such that they represent images of those objects from a known orientation, for use in object identification. No knowledge of point correspondence between images is required. Theoretical development of the method and experimental results are presented. The method is shown to be computationally efficient, requiring O(N) multiplications and additions where, depending on the computation algorithm, N may equal the number of object or edge picture elements. The purpose of this paper is to present new and more general methods, compared to previously reported techniques, for affine transform determination and image recognition which are derived via tensor analysis. The results represent new capabilities in that they remove previous restrictions to object motion, such as to rotation out of the plane perpendicular to the projection axis or to differential motion between images, and they remove requirements for additional knowledge about the images, such as point correspondences.

Study:

Paper 1 present a method to start with a point cloud that contains the physical changes and a reference model. The designer could use 3D modeling software to manually apply the changes to the reference model. For example, MeshLab is a popular open source software program that could be used for 3D alignment and surface reconstruction. Then the designer could use mesh-editing software such as 3D Studio Max to identify the differences between the two models by applying a Boolean difference operation. The problem is that the two models match everywhere, except for a few regions. That means that many faces will be incident to each other, which is problematic when applying the Boolean operation. That approach will also detect all small deviations resulting from fabrication and scanning errors and mistakenly consider them as real changes.

The digital representation of the reference 3D model varies between different applications. It could be a polygon mesh, or it could be a CAD model as used in mechanical and industrial applications. A polygon mesh is collection of vertices (3D points) connected by edges to form faces, whereas CAD models are based on ideal mathematical formulations. There are several representations for CAD models, like parametric surface patches or constructive solid geometry (CSG). CSG represents the model using a tree, where leafs are the simple geometry objects (sphere, cylinder, cube, and so on), and the links are the binary Boolean operators applied to them (union, intersection, difference). The method for transferring the physical changes to the reference model consists of three steps: Align the two models. Find the changes. Reflect the changes. The first two steps are similar for polygon mesh and CAD models, but the third step requires surface reconstruction of the changes in the case of polygon mesh and reverse-engineering of the changes in the case of CAD models.

Paper 2 talks about several methods, that have been studied in the past as means for identifying the motion parameters relating the orientations of an object as depicted in two images. Tensors were developed as a natural representation for physical quantities and relations; they exhibit specific invariances and transformation properties under coordinate system transformation. It is these same properties that make tensors an ideal vehicle for describing the relationship between images that differ by linear transformation Specific applications to determination of the affine transformation relating projections of rpp objects and to "normalization" of object orientation for identification are presented here, together with experimental results.

Syntactic methods have been investigated for the preprocessing, such as feature correspondence determination, that is needed by some techniques. Below, the tensor-based technique will be contrasted with the popular transform, feature matching, and optical flow (temporal and spatial gradient) techniques. The new contributions of this work in both the areas of affine transform determination and image recognition will be identified. The phase components themselves may be useful for the determination of motion parameters. These phase components are, in fact, special moments of the image, so the moment methods and transform methods are related. Previous use of moment methods has been principally directed at object identification by creation of moment forms which are invariant to certain changes in object orientation.

Conclusion:

The fluent translation from the virtual to the physical and from the physical to the virtual has many implications in the near future. By giving artists, art historians, designers, engineers, and many other creative professionals better tools to navigate between these spaces, new possibilities will emerge. When compared with digital modeling, physical modifications are more intuitive for many designers. For thousands of years, people have used various tools to modify physical objects, including hand and power tools that perform operations such as cutting, sculpting, and carving.

Furthermore, many designers already integrate 3D scanning devices with their physical sculpting work. A method for representation of the essential geometric characteristics of images by use of tensors has been presented. Specific applications with pairs of rigid planarpatch objects for the determination of the general affine transformation have been illustrated. In addition, an efficient method for identification of randomly oriented objects has been developed and demonstrated. As is illustrated by the required numbers of additions and multiplications, the method is computationally efficient. Principal extensions of this work include the capability of handling perspective distortion and determination of transformations of 3D objects.