Creating 3D Models From Real World Objects for Personal Fabrication

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ABSTRACT
The creation of and use of 3D models in everyday life is increasing, however it still requires a lot of technical skill and can often be expensive to carry out. This review will look at some of the research being done towards bringing this technology to the mass market.

Author Keywords
3D Modelling; 3D Scanning; Object Discovery; Shape Acquisition; Shape Processing;

INTRODUCTION
The use of three dimensional (3D) models is increasing as things such as 3D printing, virtual and augmented reality become more and more commonplace. However, the creation of 3D models remains a lengthly and tedious task, requiring the user to have significant technical skill with 3D modelling software [4]. The requirement for 3D modelling skill also render these new technologies in-accessible to a large user group [5].

One way to lessen the burden of creating 3D models is to bring real world objects into the virtual worlds. This review will look at some of the processes and techniques being developed to enable virtualization of real world objects.

A 3D model is a digital representation of some object, it could be anything from a cup to an entire building. A 3D model may be comprised of one or more parts. Each part of a 3D model is itself a 3D model. For example, a 3D model of a table may consist of a single part modelling the entire shape of the table. Or, it may be a combination of parts representing the legs and the surface of the table.

A real world object refers to any 3D, physical object

3D MODEL CREATION
There already exist many different technologies for creating 3D models from real world objects such as 3D measuring arms, Haptic devices, triangulation using lasers and Infra Red (IR)[1]. Unfortunately many of these devices are expensive, slow and or requiring training to be used. In order to bring 3D model creation to the widest user group possible the technologies must be affordable and easy to use.

Izadi et al. use a Kinect camera from the Xbox video game system as a low-cost depth camera. The quality of the depth sensing was compelling given the price of the device, especially when compared to the other depth cameras that are commercially available. Depth sensing is still inherently noisy so to produce a high quality 3D model they use a process they have developed which they call KineticFusion. Using this system they are able to reconstruct 3D models, in real time, as a user moves around a room.[2]

Chen et al. use several Wii remote controllers as the IR signal receivers and combined them with an IR-LED pen in order to record the position in 3D space of points touched on an object. Using these points they are able to reconstruct 8 different types of 3D objects, almost all of which only require the user to provide 3 touch points. By using this method users are able to quickly build up objects that can be constructed from the primitive shapes. However the method struggled with objects with more complex surface geometry.[1]

Weichel et al. provide the user with two methods for creating a 3D model. The first method is to extrude the object from a 2D outline. The outline can be created by scanning an existing object or by the user tracing the outline on the surface of the device. The second method is to do a full 3D scan of the object using laser scanners and a rotating plane. Once a 3D model has been created by either method it can be combined with previously created models to build up a new 3D model. [5]

3D MODEL PARTITIONING
One of the problems that arises from creating a 3D model by scanning existing objects is that you end up with a 3D model as a single part when the object may in fact be made up from multiple parts. For example when you scan an entire room you end up with a 3D model where the floors, walls, chair and desk all become on part. In order to work with just the chair you must partition it from the rest of the model.

Izadi et al. allow the user to partition an object in their model in real time by interacting with that object. By reconstructing the entire room then having a user manually move the object

that they wished to partition the system is able to detect the changes to the model and automatically partition the object from the rest of the model. This approach has the advantage of not requiring the user to provide any input about which model they would like to select expect to move the object around in the environment. [2]

Karpathy et al. investigate discovering parts with in 3D models via shape analysis. By looking at the properties of a shape within a 3D model such as the compactness, symmetry, smoothness, local convexity and recurrence they are able to identify the different object within a 3D model. They tested their method on 58 different 3D models where the whole model was one part. Of the 400 objects they manually identified in the 3D models they were able to identify 303 of them, around a 75model they tested on and as scanning technology improves so to should the success rate of this method. They also found that object with a single part taking up the majority of the object can lead to the part be identified as more object like than the whole object, leading to rejection.[3]

Method of creating 3D models that build up the model from smaller part [1] [5] intrinsically provide information about the parts that make up the object. However the parts used to build the 3D model might not represent actual parts in the completed model. In these cases processing the model to discover the parts after creation may still be necessary.

Shape Analysis - Feature Extraction

The structure of a shape is the arrangement of a relations between the parts that make it up. By extracting the structure we enable structure aware shape editing, deformation, synthesis, reconstruction and design exploration.

Some techniques for shape creation inherently include information about the features of an object. For those that don't, such as 3D meshes there is a need to process the shape data to extract them as the process of reverse engineering the can be lengthy and laborious [1].

[4] looks at the whole process of extracting structural information from shape models. They first show that the structure of a shape is made up from it parts, the parameters of the parts and the relations between the parts.

They look at how you can identify the parts of a shapes and then how you can identify the parameters of those parts. The they look at how to identify the relations between the parts.

CONCLUSIONS AND FUTURE WORK

We have looked at three processes involved in creating 3D models from real world objects; 3D model creation, partitioning, and processing

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