# 3D ShapeNets

### Propose to represent a geometric 3D shape as a probability distribution of binary variables on a 3D voxel grid, using a Convolutional Deep Belief Network

### It supports joint object recognition and shape completion from 2.5D depth maps

### It enables active object recognition through view planning

# 3D geometric shape

## ||3D representation||

#### 87--Recognition-by-components: a theory of human image understanding (Biedeman)

#### 06--Object recognition in the geometric era: A retrospective (Mundy)

## ||3D instance recognition||

#### 06-IJCV-3d object modeling and recognition using local affine-invariant image descriptors and multi-view spatial constraints (Schmid)

#### 12-ICRA-A textured object recognition pipeline for color and depth image data (Tang)

## ||2D Object category recognition||

#### 10-PAMI-Object detection with discriminatively trained part based models (Felzenszwalb)

#### 12-NIPS-Imagenet classification with deep convolutional neural networks (Hinton)

# 2.5D depth sensors

### Microsoft Kinect

### Intel RealSense

### Google Project Tango

### Apple PrimeSense

# Related work

## ||Deformable part-based models||

#### 04-TOG-Modeling by example (Funkhouser)

#### 11-TOG-Probabilistic reasoning for assembly-based 3d modeling (Chaudhuri)

#### 12-TOG-A probabilistic model for component-based shape synthesis (Kalogerakis)

### These methods are limited to a specific class of shapes with small variations, with surface correspondence being one of the key problems in such approaches

### Part annotation is tedious and expensive, assembly-based modeling can be rather cumbersome

## ||Surface reconstruction||

#### 10-TOG-Cone carving for surface reconstruction (Shalon)

#### 10-Visual Computer-A lightweight approach to repairing digitized polygon meshes (Attene)

### Largely based on smooth interpolation or extrapolation

### Can only tackle small missing holes or deficiencies

#### 12-TOG-Structure recovery by part assembly (Shen)

### Able to deal with large space corruption

### but are limited by the quality of available templates

### Often do not provide different semantic interpretations of reconstructions

## ||Deep generative models for 2D shapes||

#### 06-Neural computing-A fast learning algorithm for deep belief nets (Hilton)

##### Generate handwritten digits

#### 12-CVPR-The shape boltzmann machine: a strong model of object shape (Eslami)

##### Generate horses

### Effectively capture intra-class variations

### We focus on more complex real world object shapes in 3D

## ||2.5D deep learning||

#### 12-NIPS-Convolutional-recursive deep learning for 3d object classification (Andrew Ng)

#### 14-ECCV-Learning rich features from rgb-d images for object detection and segmentation (Malik)

##### Build discriminative convolutional neural nets to model images and depth maps

##### applied to depth maps, they use depth as an extra 2D channel, and they do not model in full 3D

#### 11-Communication-Unsupervised learning of hierarchical representations with convolutional deep belief networks (Andrew Ng)

## ||Active object recognition||

#### 01-IJCV-Active object recognition: Looking for differences (Callari & Ferrie)

#### 03-Computing Survey-View planning for automated 3d object reconstruction inspection (Scott)

### Build their view planning strategy using 2D color information

###### 09-ICCV workshop-Active view selection for object and pose recognition (Jia)

###### 02-PAMI-Information theoretic sensor data selection for active object recognition and state estimation (Denzeler)

### Implement the idea in real world robots

###### 13-ICRA-Hypothesis testing framework for active object detection (Atanasov)

### Similar to 02-PAMI

##### We use mutual information to decide the NBV

##### Consider this problem at the precise voxel level allowing us to infer how voxels in a 3D region would contribute to the reduction of recognition uncertainty