Deep Learning for Digital Geometry Processing and Analysis: A Review

基於深度學習的數位幾何處理與分析技術研究進展

Xia Qing, Li Shuai, Hao Aimin, Zhao Qinping

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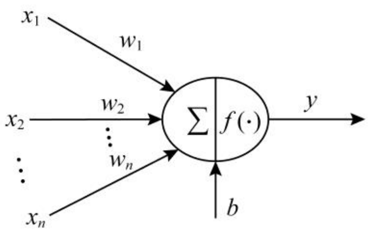
- 相關深度學習模型
- 面向深度學習的幾何資料表示
- 基於深度學習的數位幾何處理
- 總結與展望

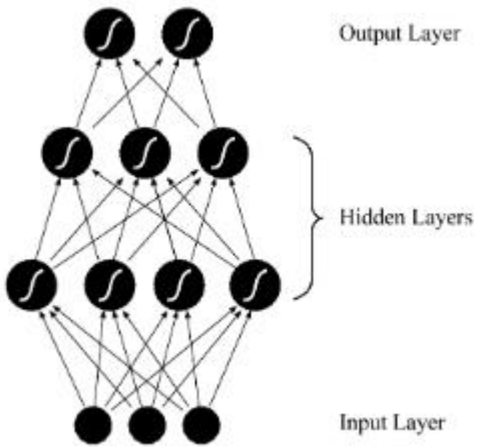
相關深度學習模型

- Neural networks
- Convolutional neural net-work
- Generative adversarial network
- Recurrent neural network
- Others. like DBN（deep belief network），AE（AutoEncoder）

Neural networks

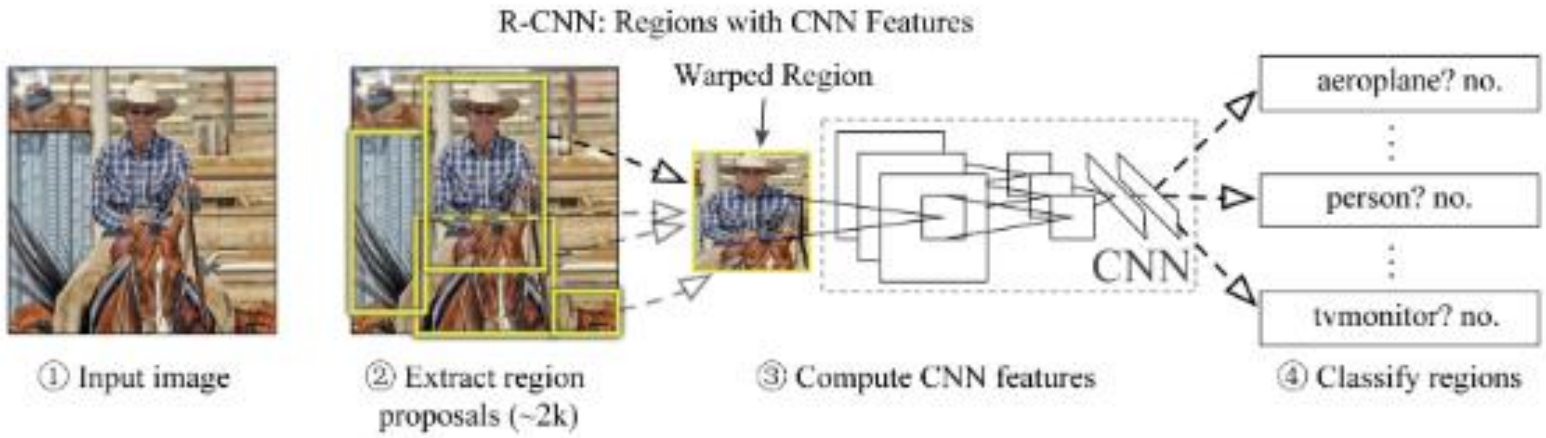


A typical neuron in neural networks

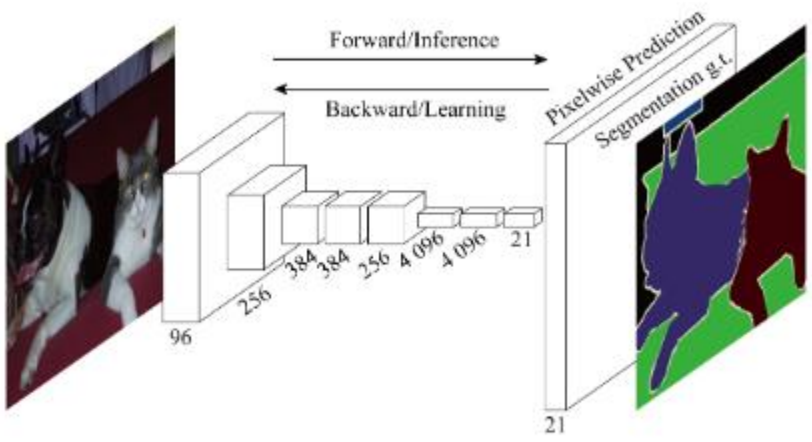


A typical multi-layer neural network model

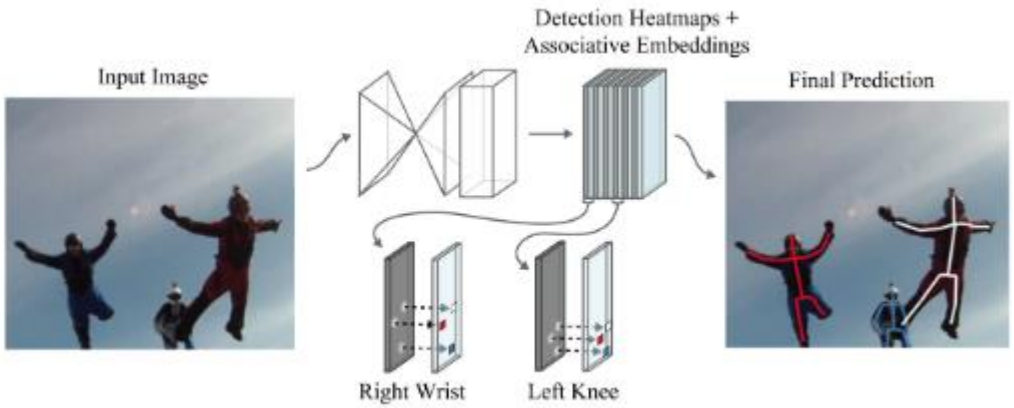
convolutional neural net-work



Object detection based on R-CNN

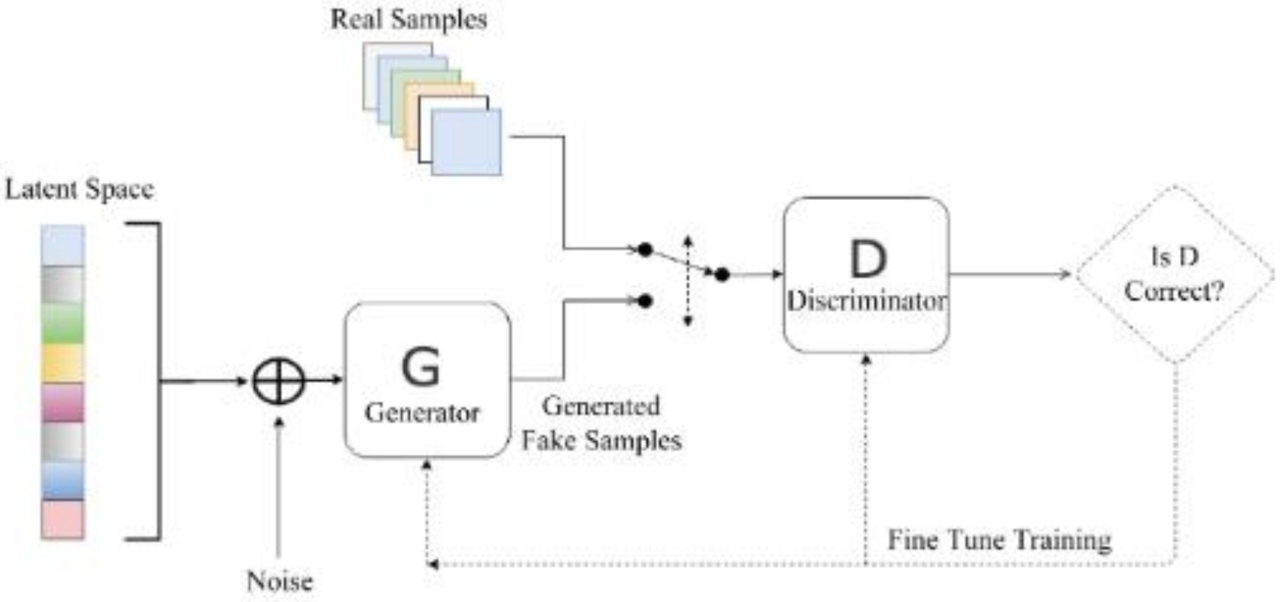


Architecture of FCN



Associative Embedding

generative adversarial network



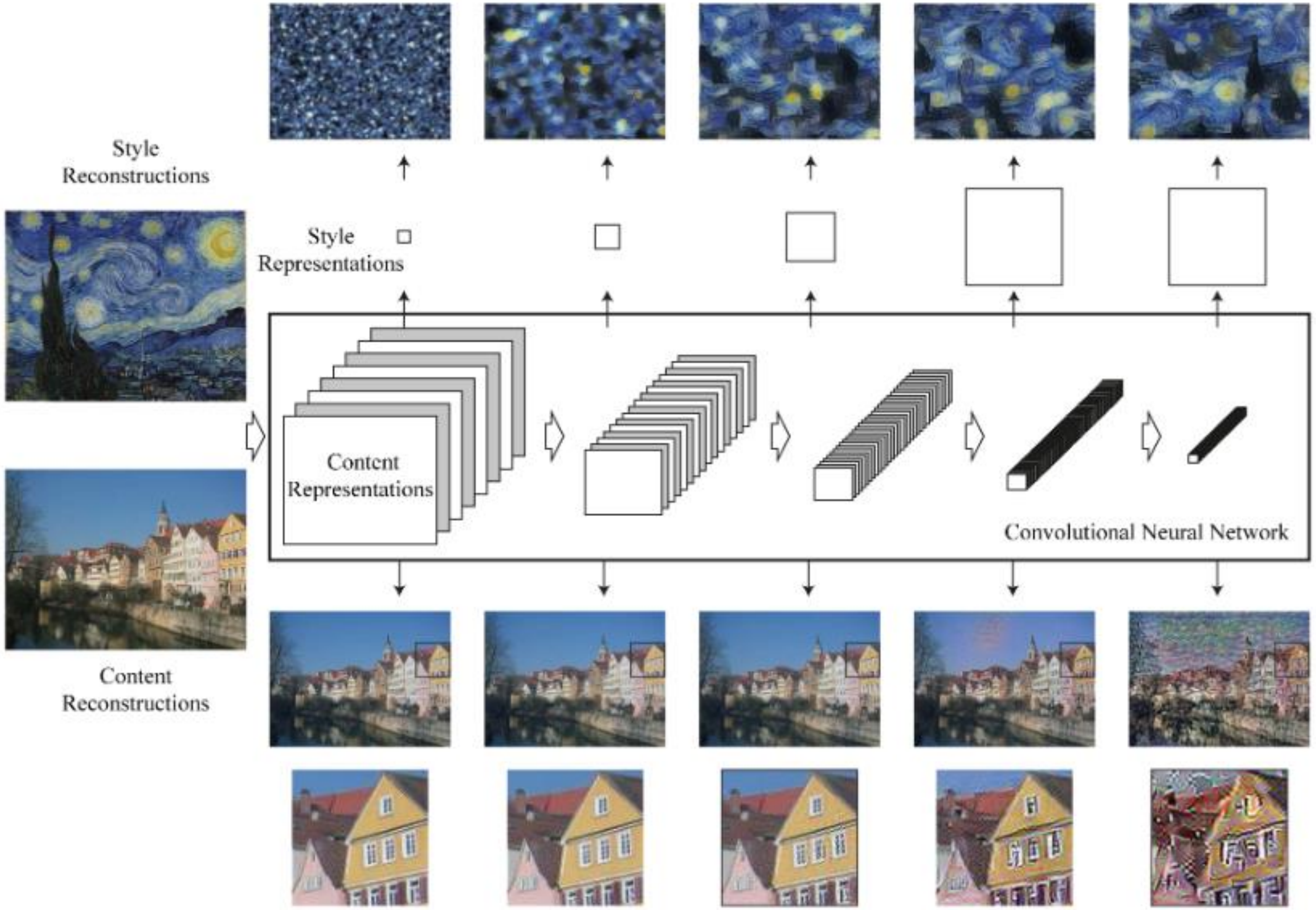
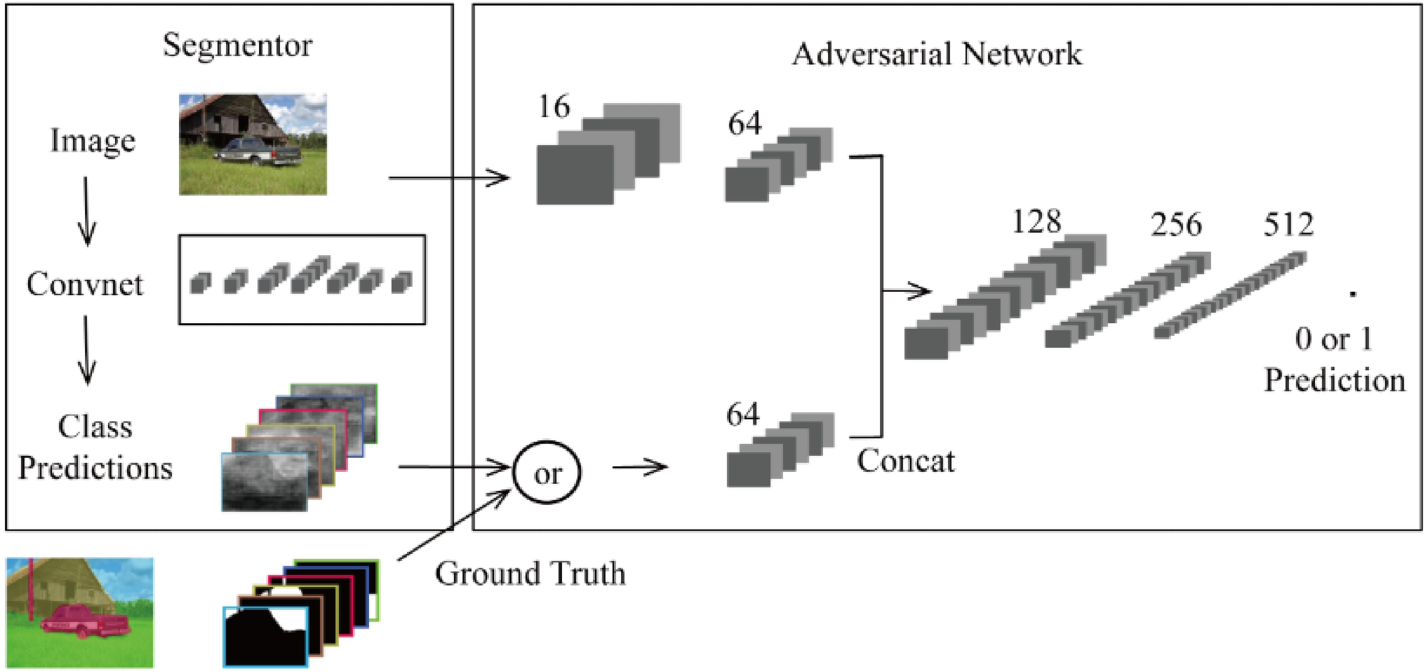
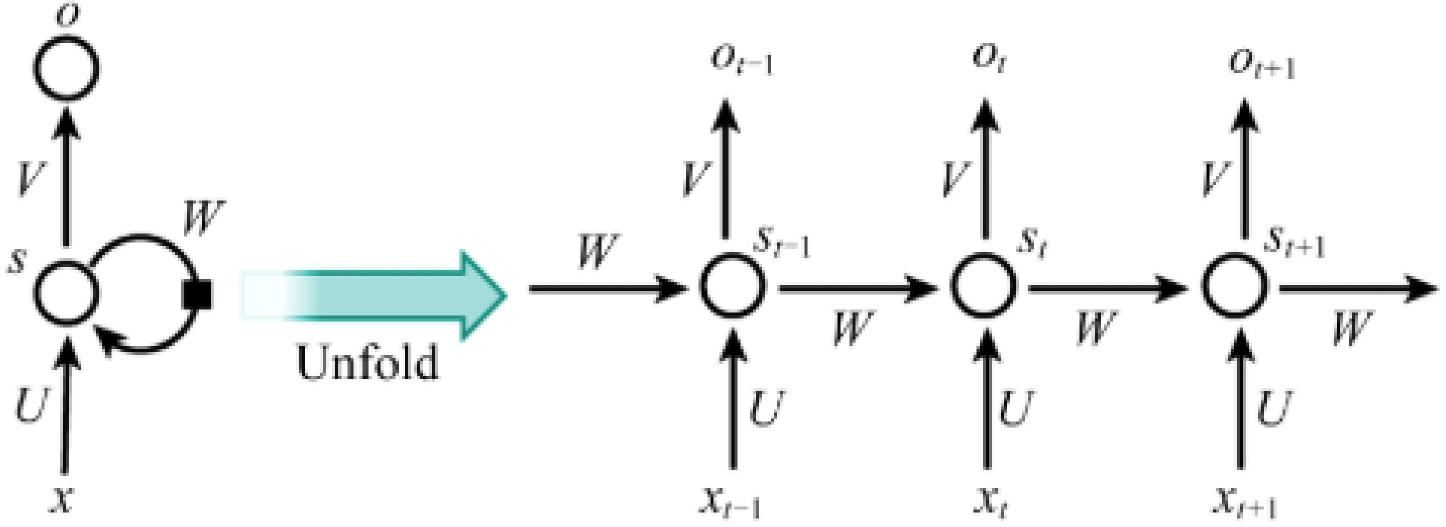


Image style transfer using convolutional neural networks



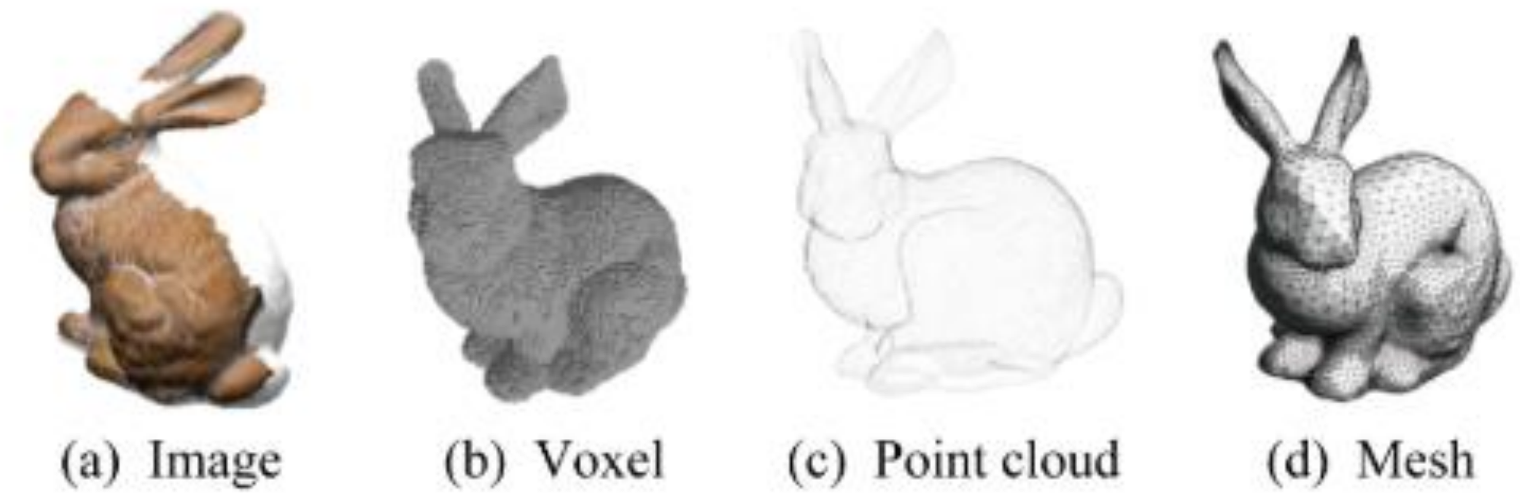
Semantic segmentation using adversarial networks

recurrent neural network



Architecture of RNN

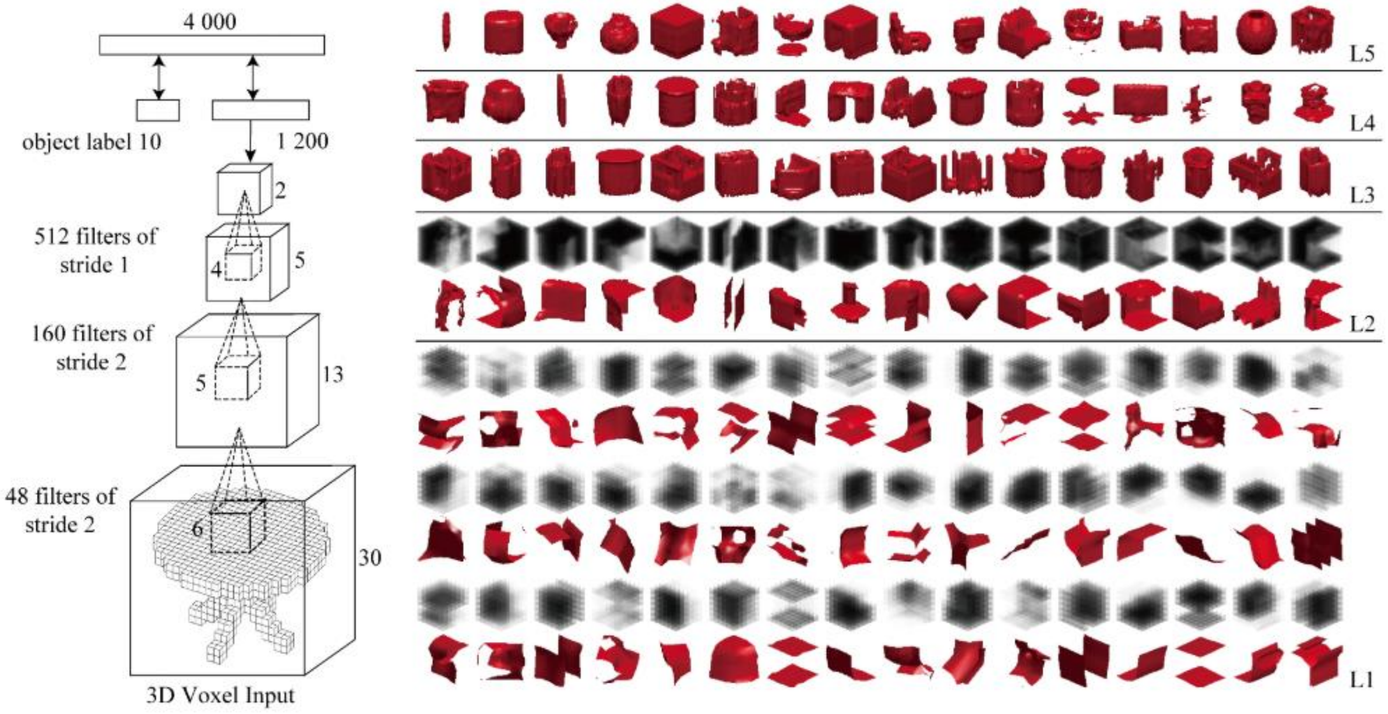
面向深度學習的幾何資料表示



Voxel

- 3D ShapeNets: A deep representation for volumetric shapes
- VoxNet: A 3D convolutional neural network for real-time object recognition
- Volumetric and multi-view CNNs for object classification on 3D data

Voxel



(a) Architecture of 3D ShapeNets model (b) Data-driven visualization

3D object recognition based on voxel representation and deep model

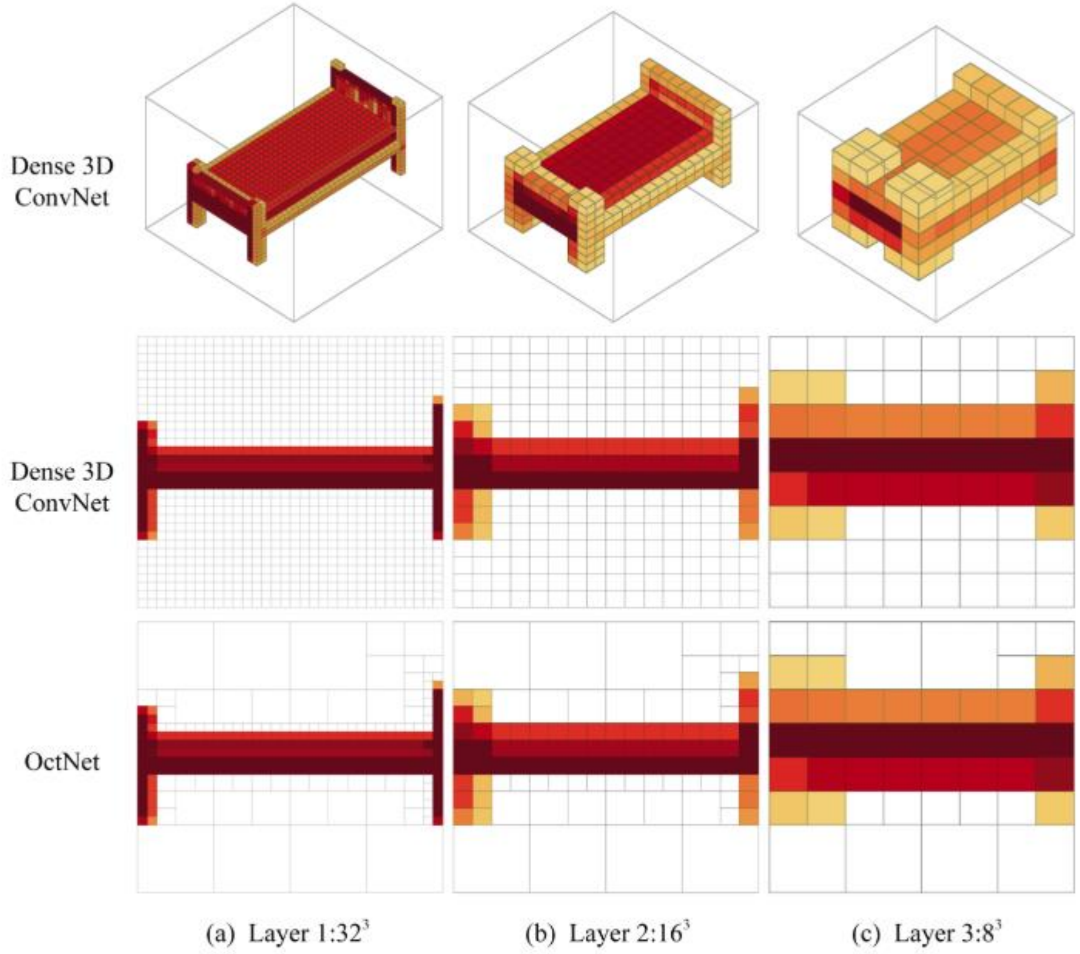
Voxel

- Volumetric 3D mapping in real-time on a CPU
- OctNet: Learning deep 3D representations at high resolutions
- O-CNN: Octree-based convolutional neural networks for 3D shape analysis

- Octree generating networks: Efficient convolutional architectures for high-resolution 3D outputs

- Hierarchical surface prediction for 3D object reconstruction

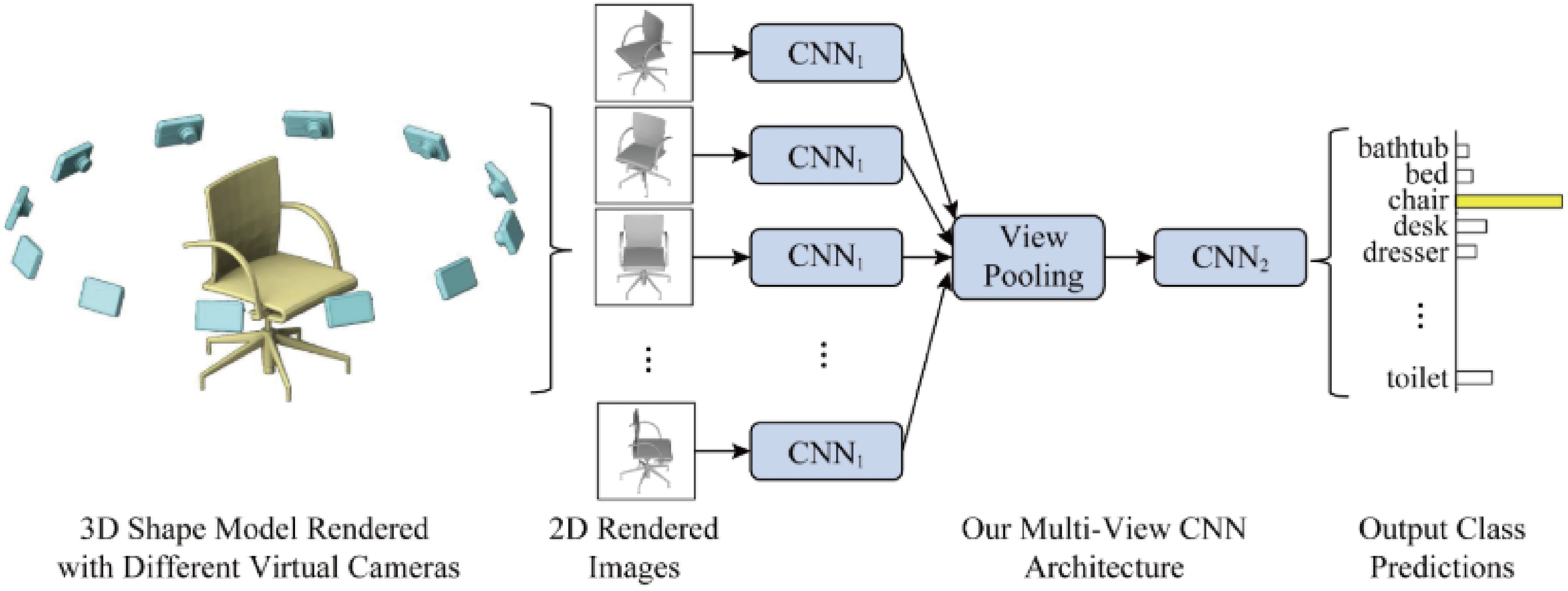
Voxel



Voxel representation based on Octree

Multi-view image

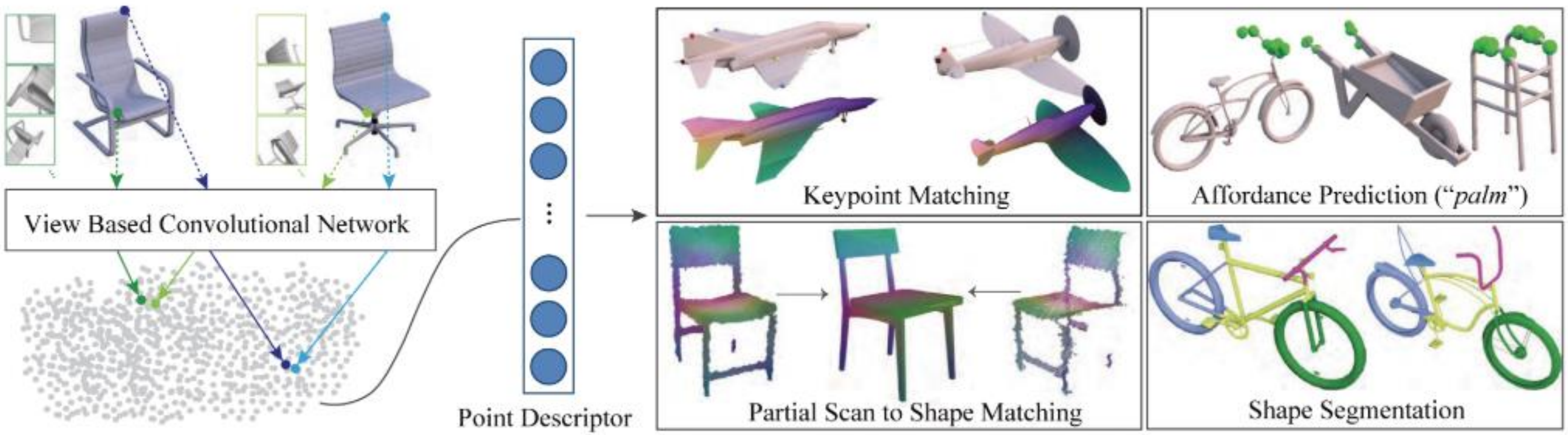
- Image-guided 3D model labeling via multiview alignment
- Multi-view convolu-tional neural networks for 3D shape recognition



Learning multi-view feature fusion using CNN

Multi-view image

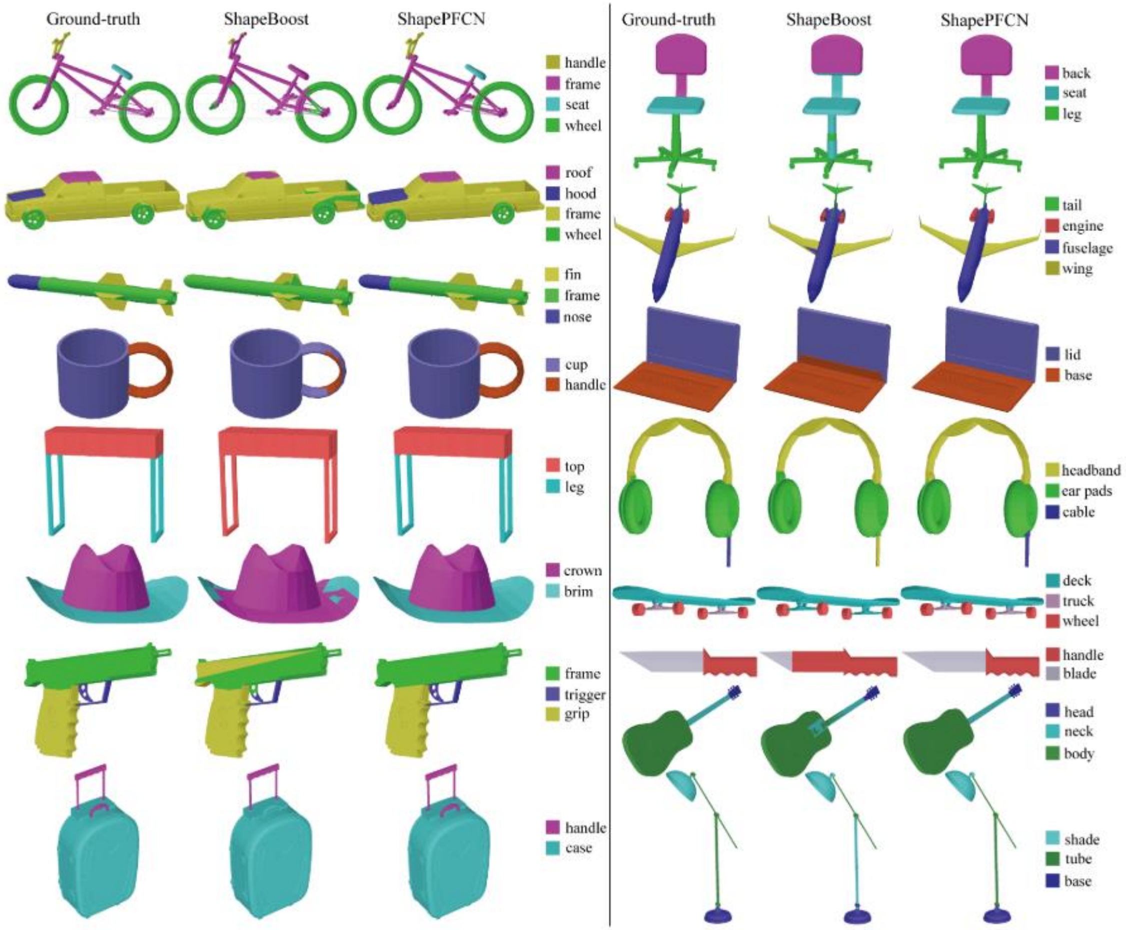
- Learning local shape descriptors from part correspondences with multiview convolutional networks



Extraction of local shape descriptor using images from local and global views

Multi-view image

- 3D shape segmentation with projective convolutional networks

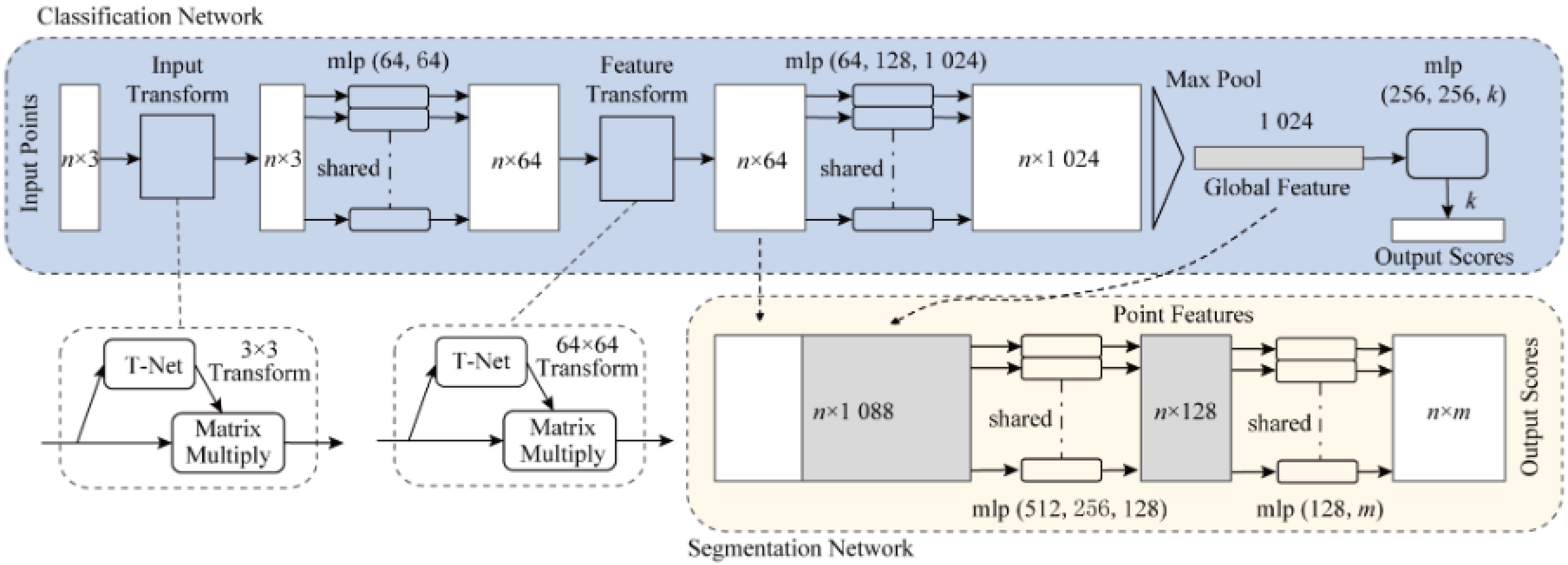


Point cloud

- Point
- Gragh

Point cloud

- PointNet: Deep learning on point sets for 3D classification and segmentation
- PointNet++: Deep hierarchical feature learning on point sets in a metric space



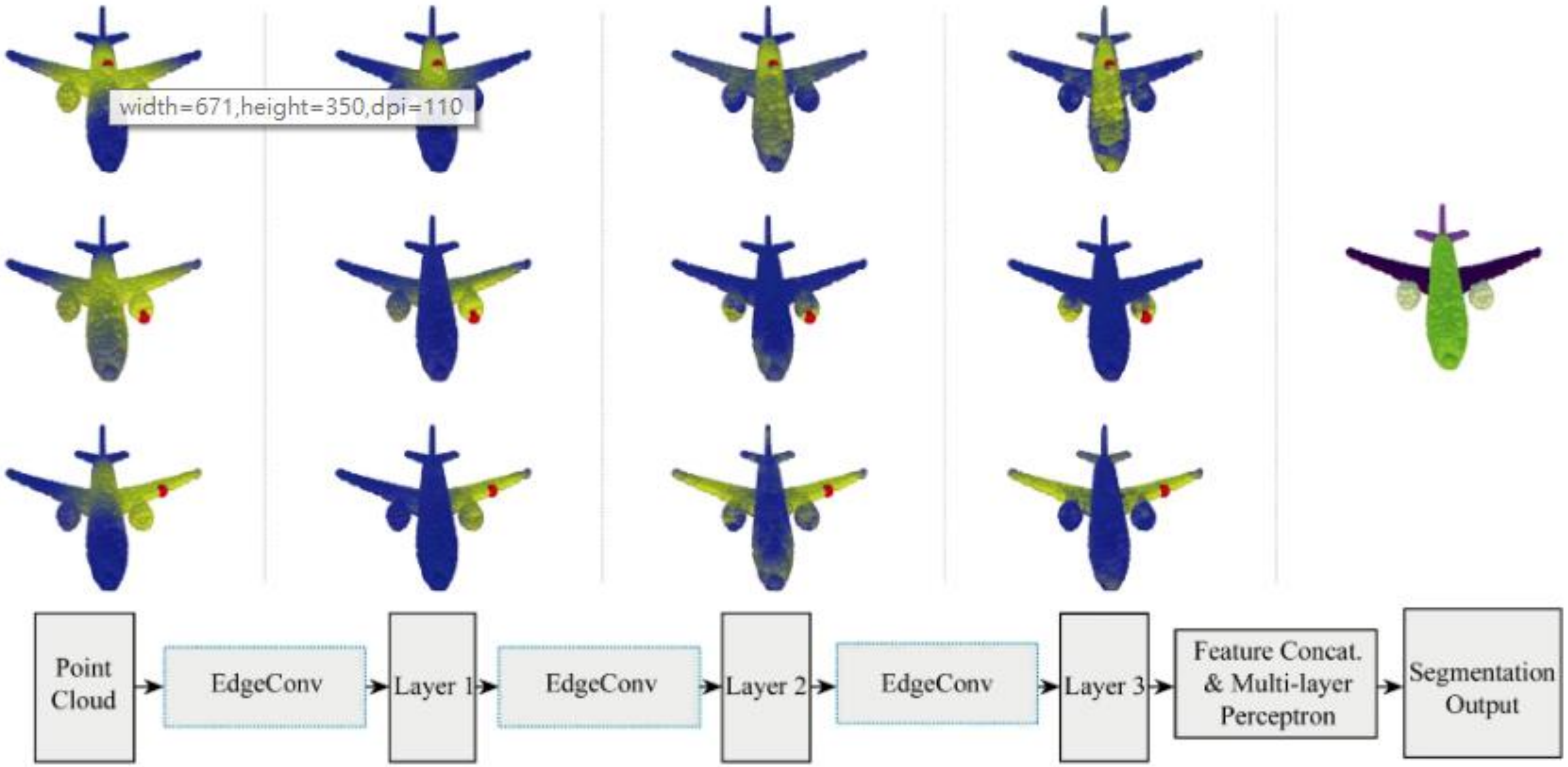
Point cloud

- A new model for learning in graph domains
- The graph neural network model
- Spectral networks and locally connected networks on graphs

- 3D graph neural networks for RGB-D semantic segmentation

- SyncSpecCNN: Synchronized spectral CNN for 3D shape segmentation
- RGCNN: Regularized graph CNN for point cloud segmentation
- Dynamic graph CNN for learning on point clouds

Point cloud



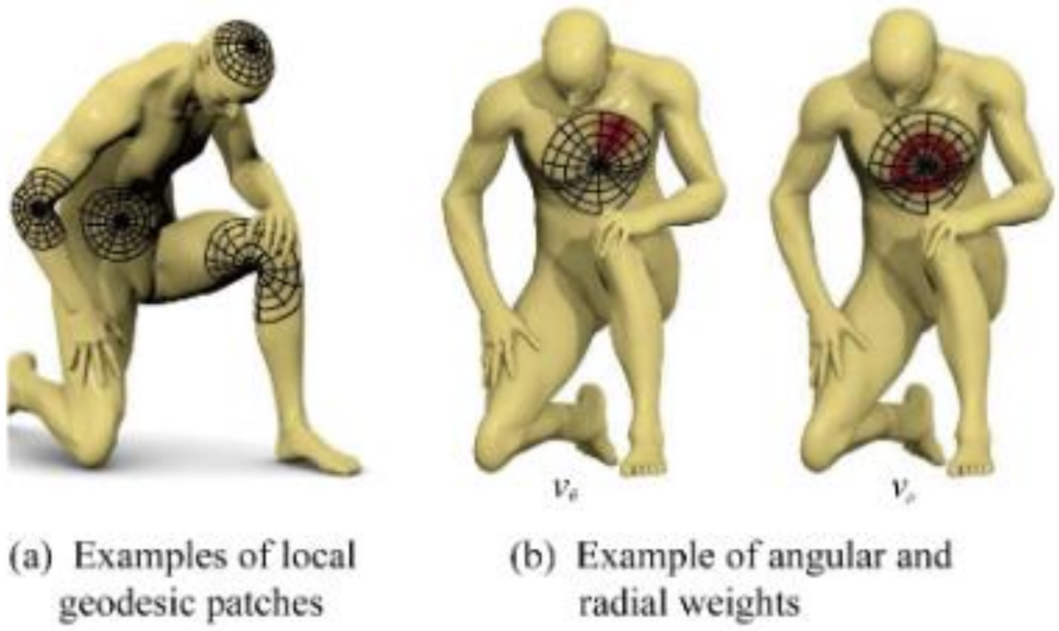
Architecture of DynGCNN

Mesh

- Gragh
- Manifolds
- Traditional descriptor

Mesh

- Geodesic convolutional neural networks on riemannian manifolds
- ShapeNet: Convolutional neural networks on non-euclidean manifolds



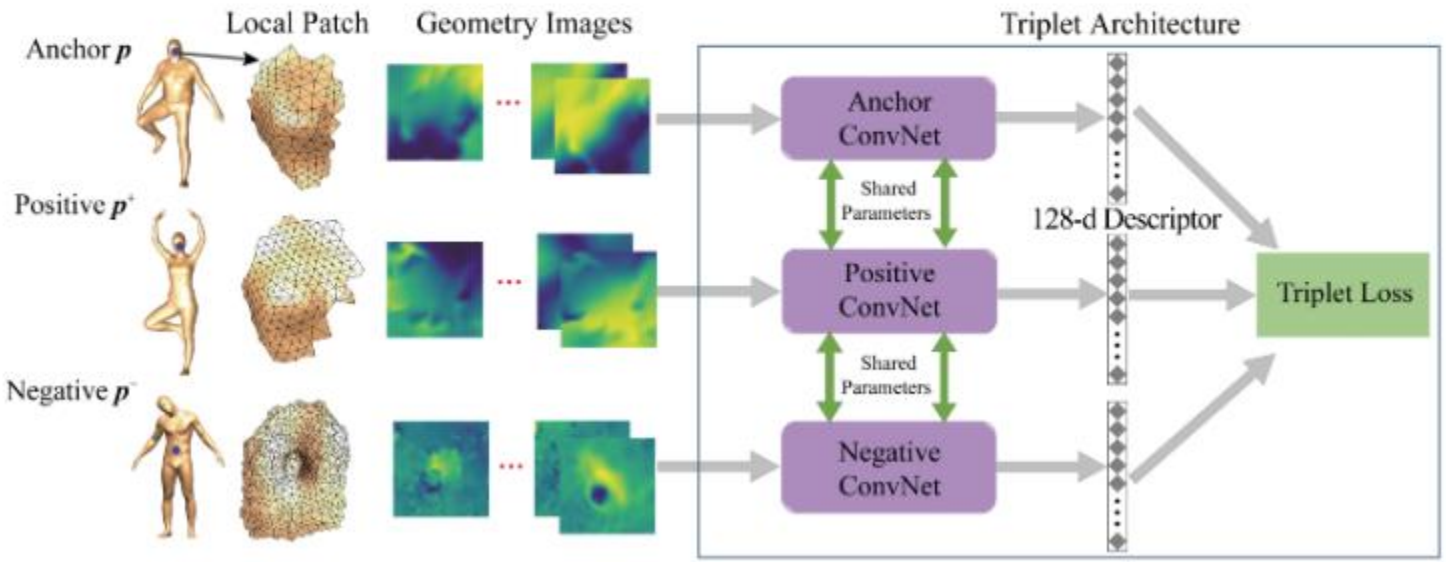
Geodesic polar system built on mesh surface

Mesh

- Learning shape correspondence with anisotropic convolutional neural networks
- Learning class-specific descriptors for deformable shapes using localized spectral convolutional networks
- Geometric deep learning on graphs and manifolds using mixture model CNNs

Mesh

- 3D mesh labeling via deep convolutional neural networks
  （curvature (CUR), PCA feature (PCA), shape diameter function (SDF), distance from medial surface (DIS)， average geodesic distance (AGD), shape context (SC), and spin image (SI)）
- Jointly learning shape descriptors and their correspondence via deep triplet CNNs
- Learning 3D keypoint descriptors for non-rigid shape matching



Extraction of high-level features using local low-level features

基於深度學習的數位幾何處理

- 模型匹配與檢索
- 模型分類與分割
- 模型生成
- 模型修復與重建
- 模型變形與編輯

模型匹配與檢索

- Dense human body correspondences using convolutional networks

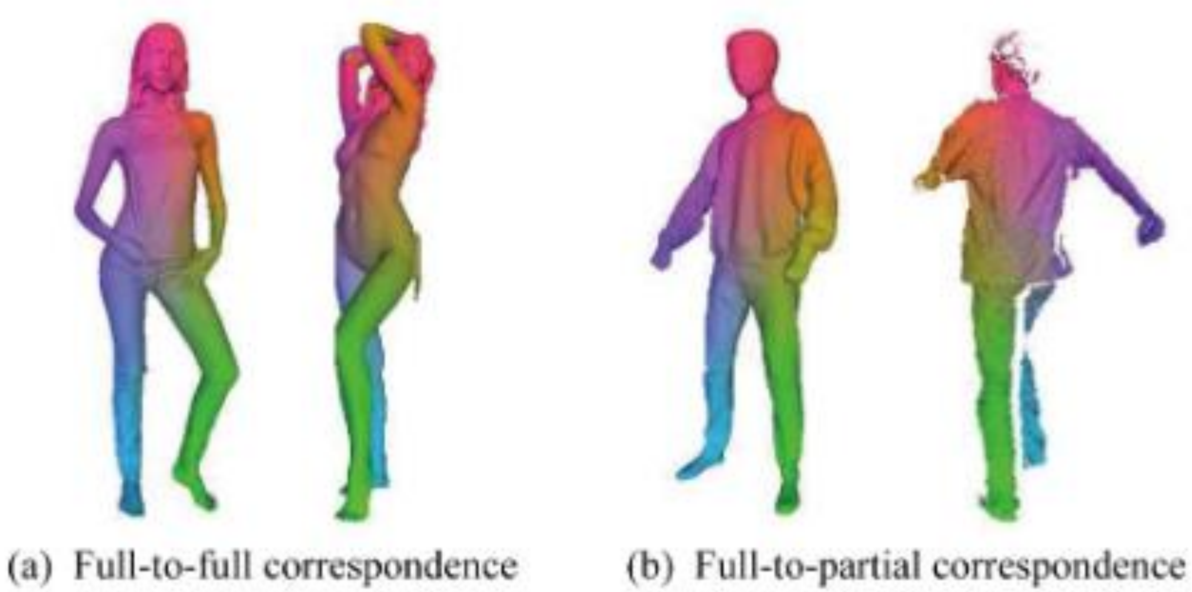
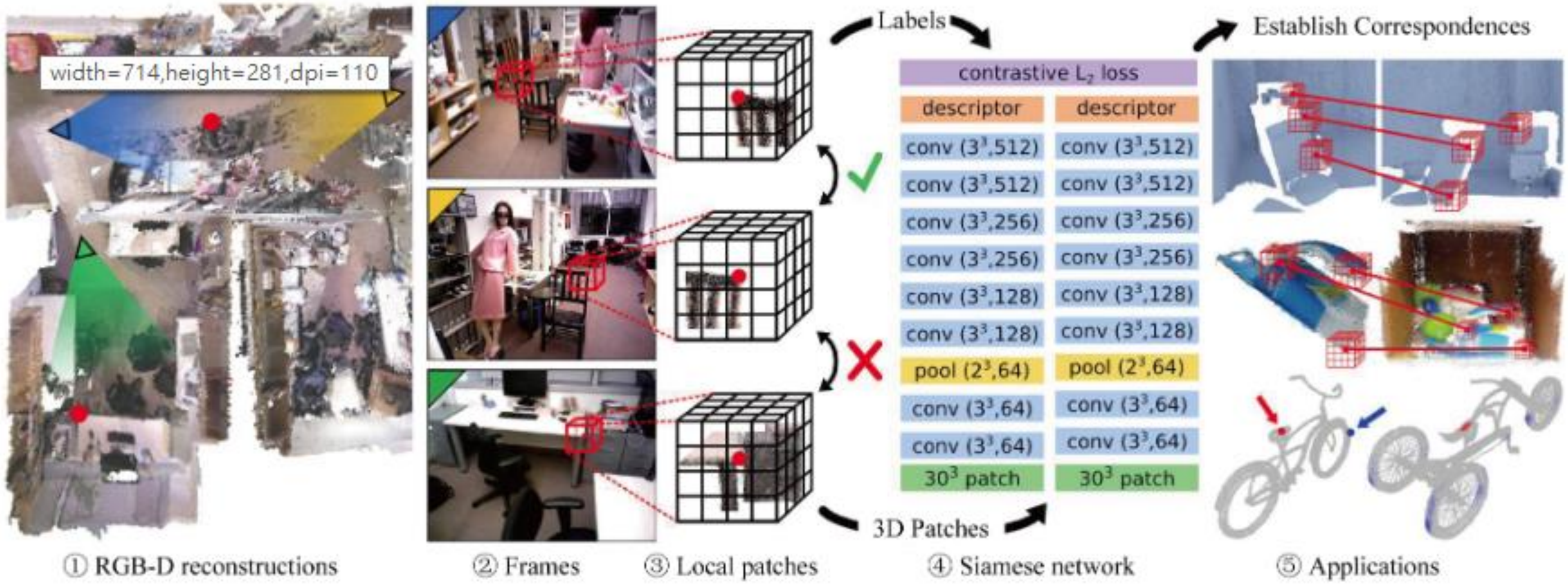


Illustration of shape correspondence

模型匹配與檢索

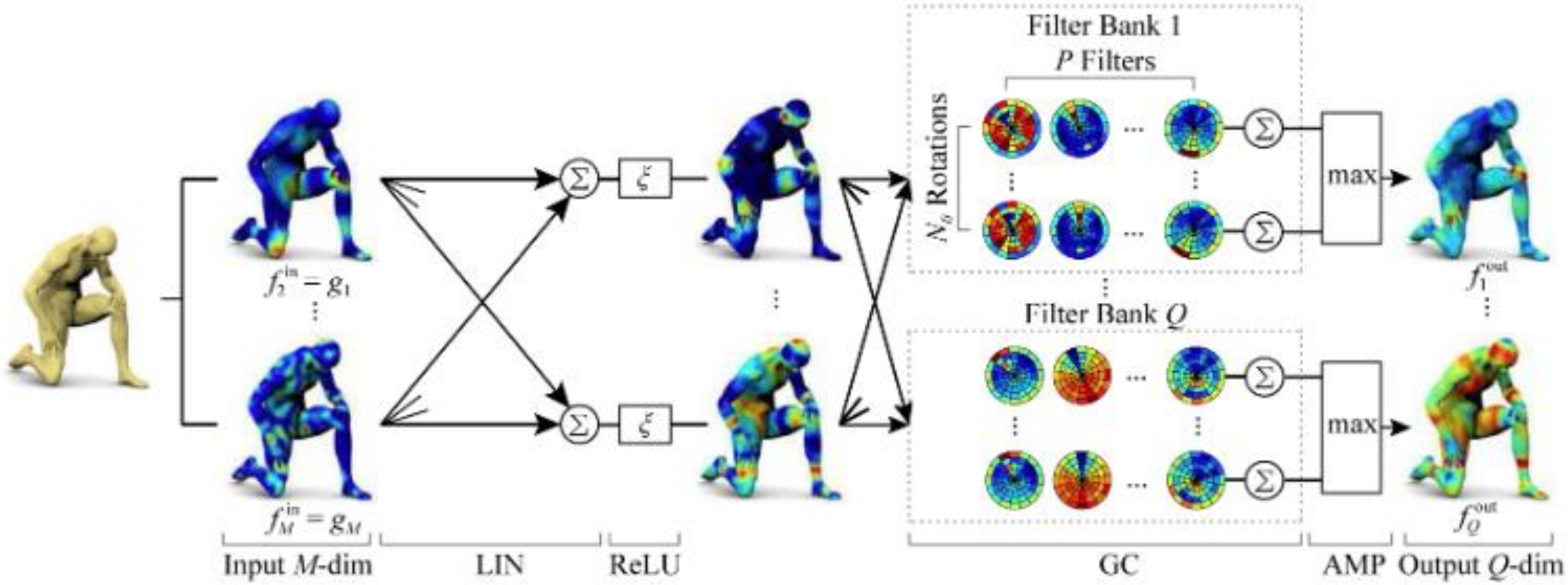
- 3Dmatch: Learning local geometric descriptors from RGB-D reconstructions



Key-point matching based on voxel representation

模型匹配與檢索

- Learning shape correspondence with anisotropic convolutional neural networks

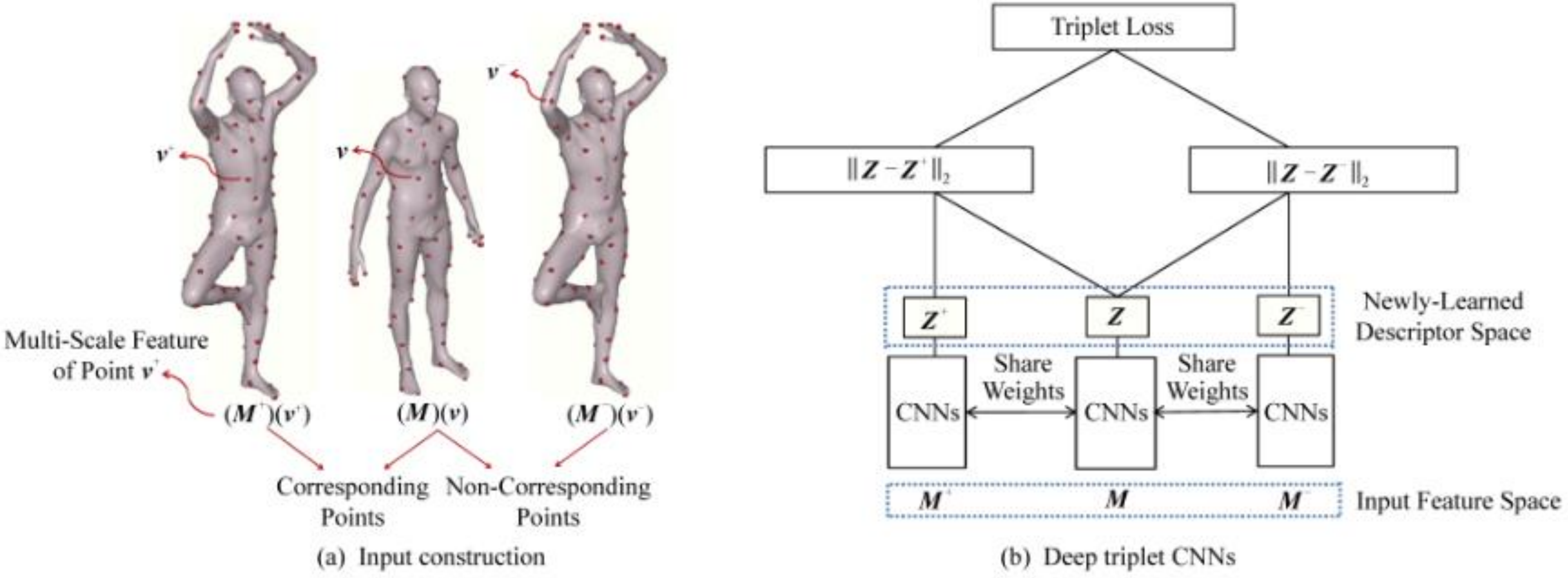


Shape correspondence based on Geodesic CNN

- Deep functional maps: Structured prediction for dense shape correspondence

模型匹配與檢索

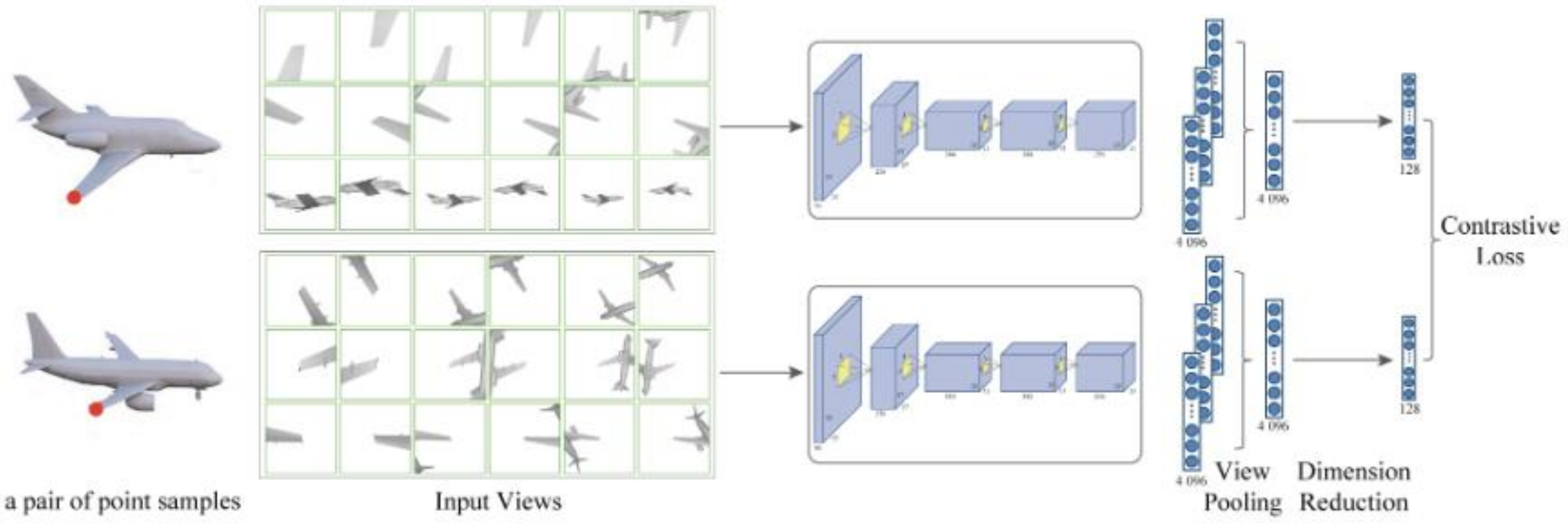
- A method of 3D model retrieval by the spatial distributions of components
- Jointly learning shape descriptors and their correspondence via deep triplet CNNs



shape matching based on deep triplet CNN

模型匹配與檢索

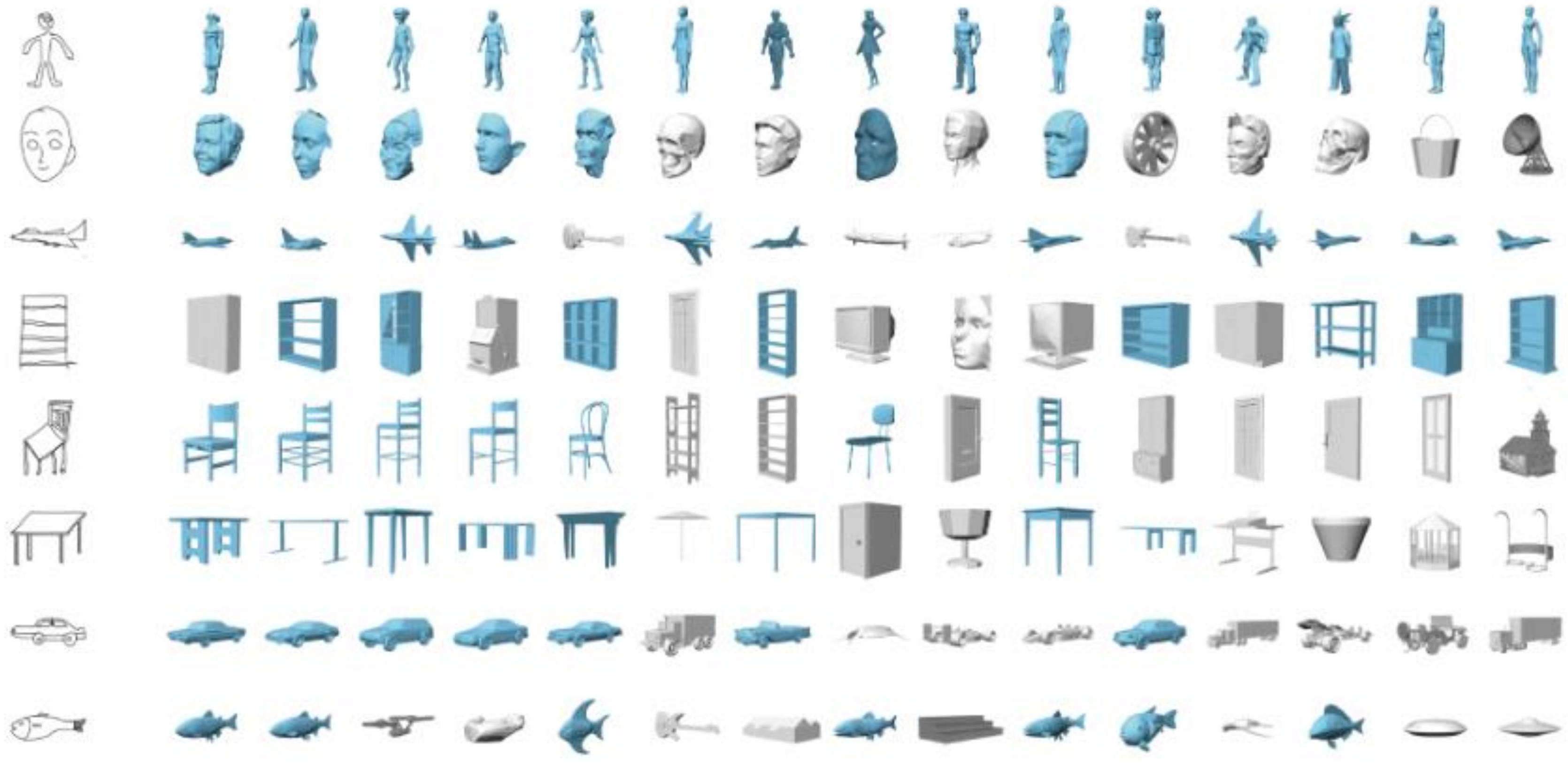
- Learning local shape descriptors from part correspondences with multiview convolutional networks
- Learning part-in-whole relation of 3D shapes for part-based 3D model retrieval



Multi-scale shape matching based on multi-view images

模型匹配與檢索

- Deep correlated metric learning for sketch-based 3D shape retrieval
- Sketch-based 3D shape retrieval using convolutional neural networks



(a) Sketch queries (b) Retrieved examples

模型分類與分割

- Convolutional-recursive deep learning for 3D object classification
- Learning rich features from RGB-D images for object detection and segmentation
- Multimodal deep learning for robust RGB-D object recognition
- A deep representation for volumetric shapes
- VoxNet: A 3D convolutional neural network for real-time object recognition

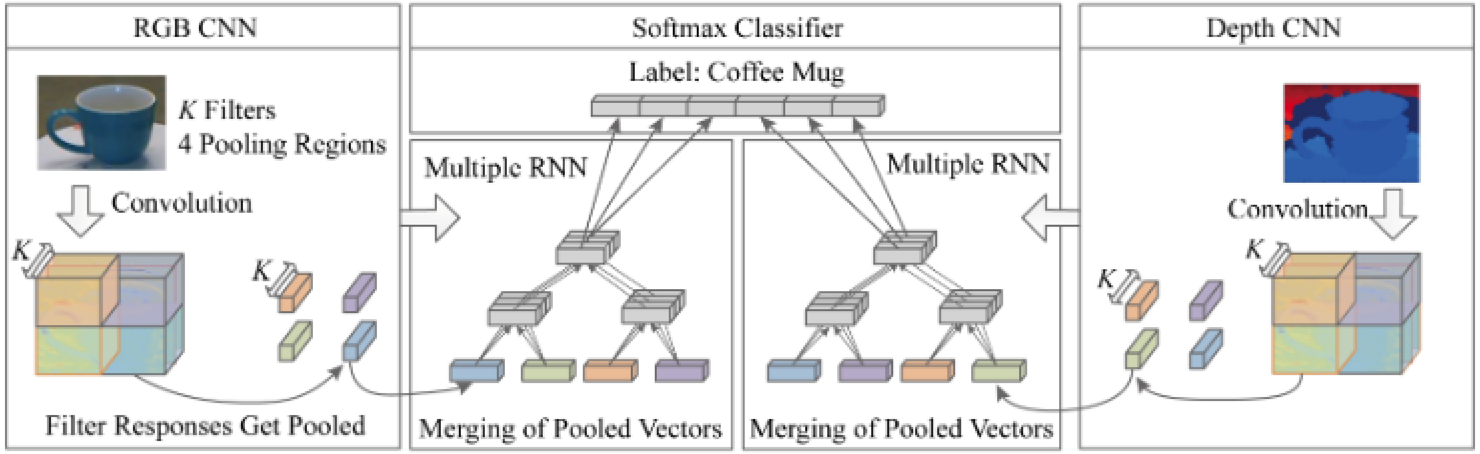
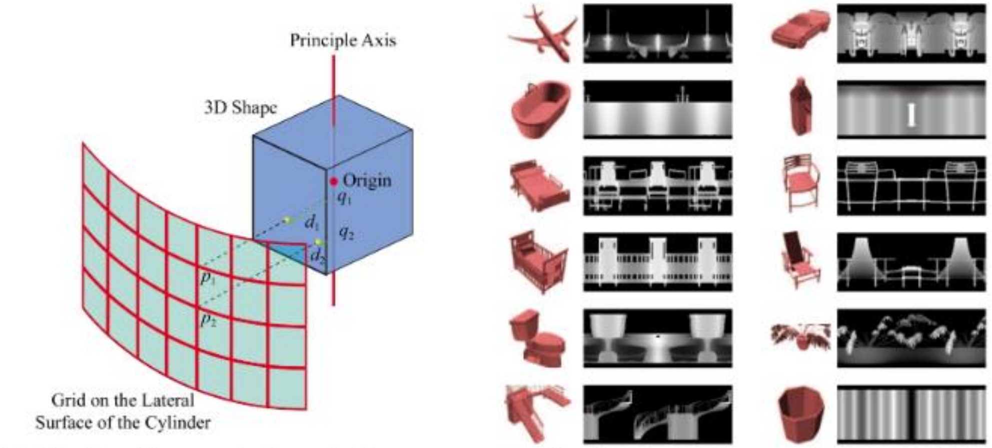


Fig. 30 3D object recognition based on RNN[84]

模型分類與分割

- Deeppano: Deep panoramic representation for 3-D shape recognition

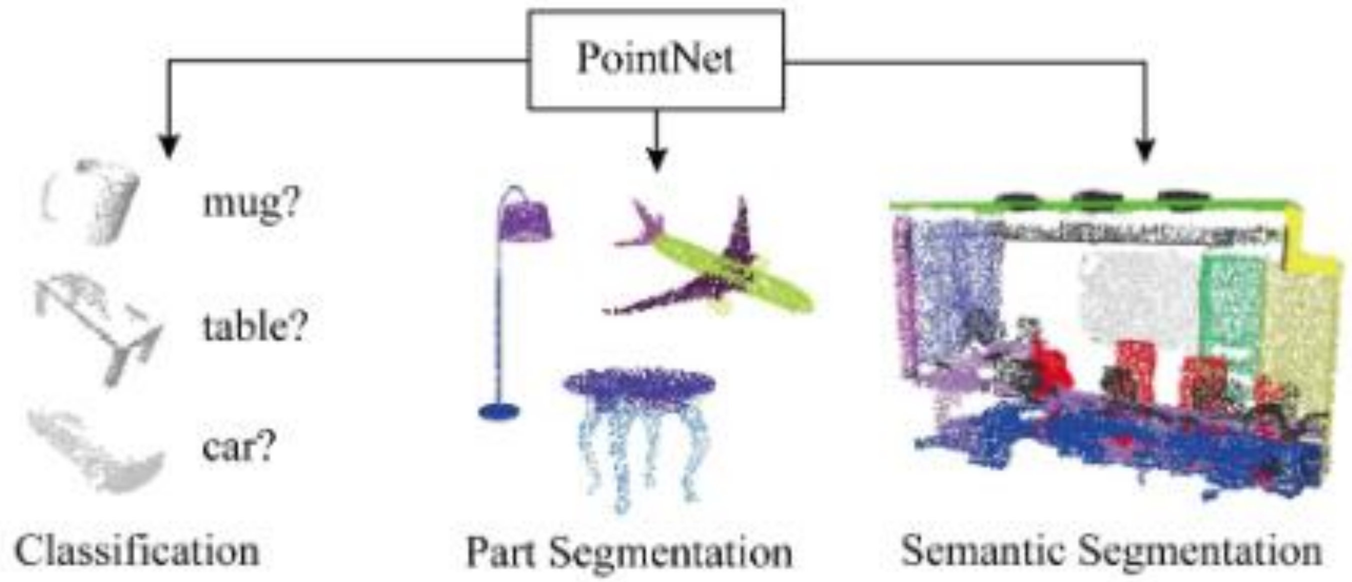


(a) Illustration of the panoramic view construction process   (b) 3D shapes and their corresponding panoramic views

- Predictive and generative neural networks for object functionality

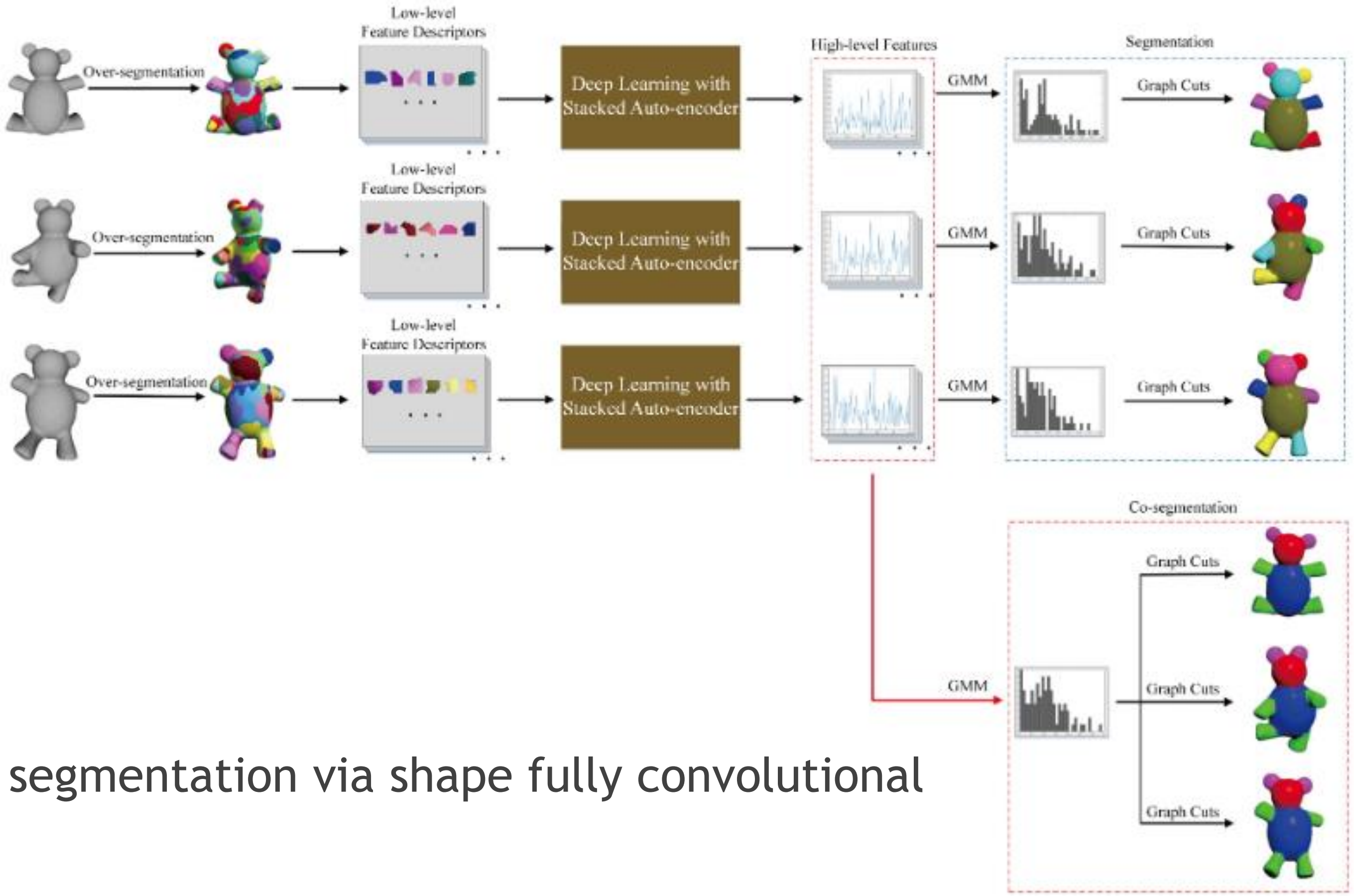
模型分類與分割

- PointNet: Deep learning on point sets for 3D classification and segmentation
- PointNet++: Deep hierarchical feature learning on point sets in a metric space



模型分類與分割

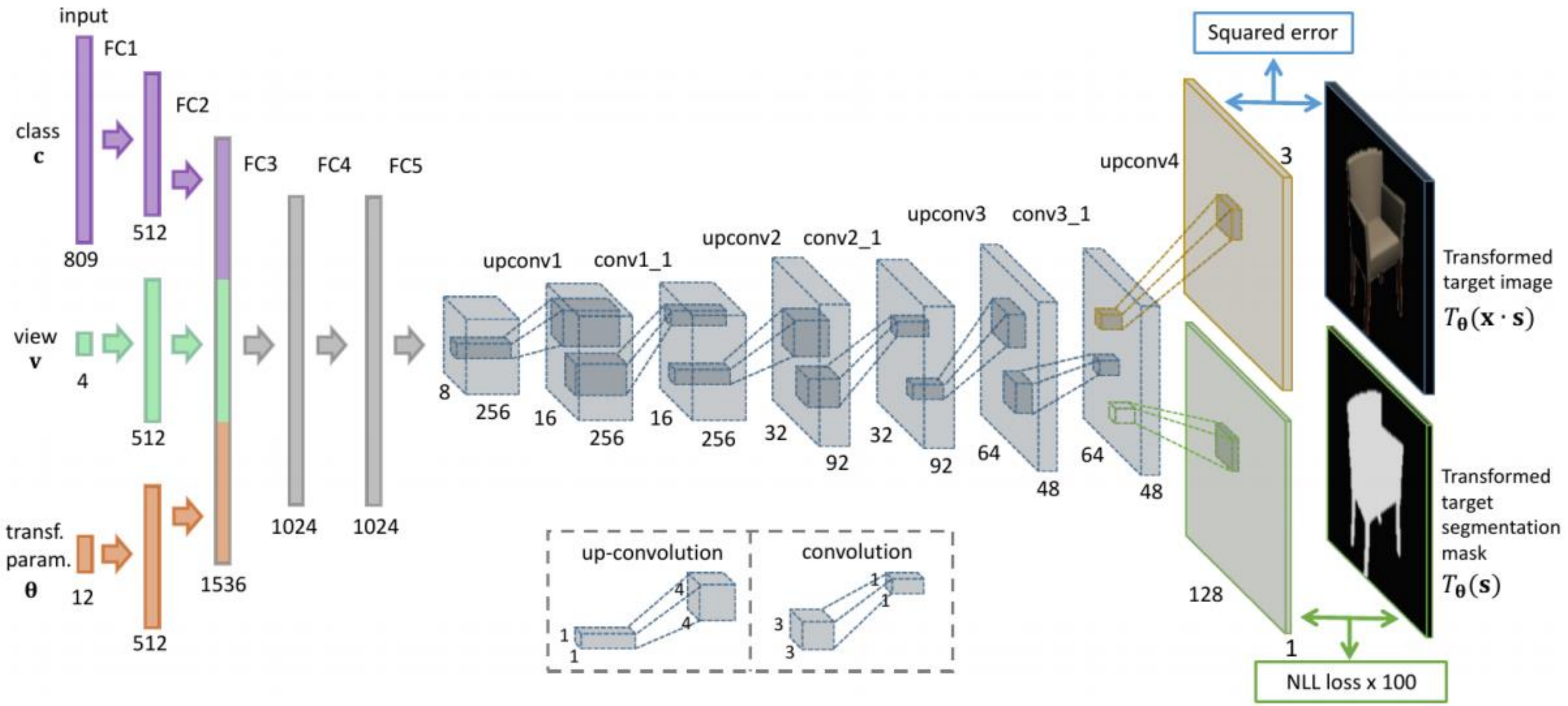
- 3D mesh labeling via deep convolutional neural networks
- Unsupervised 3D shape segmentation and co-segmentation via deep learning



- 3D shape segmentation via shape fully convolutional networks

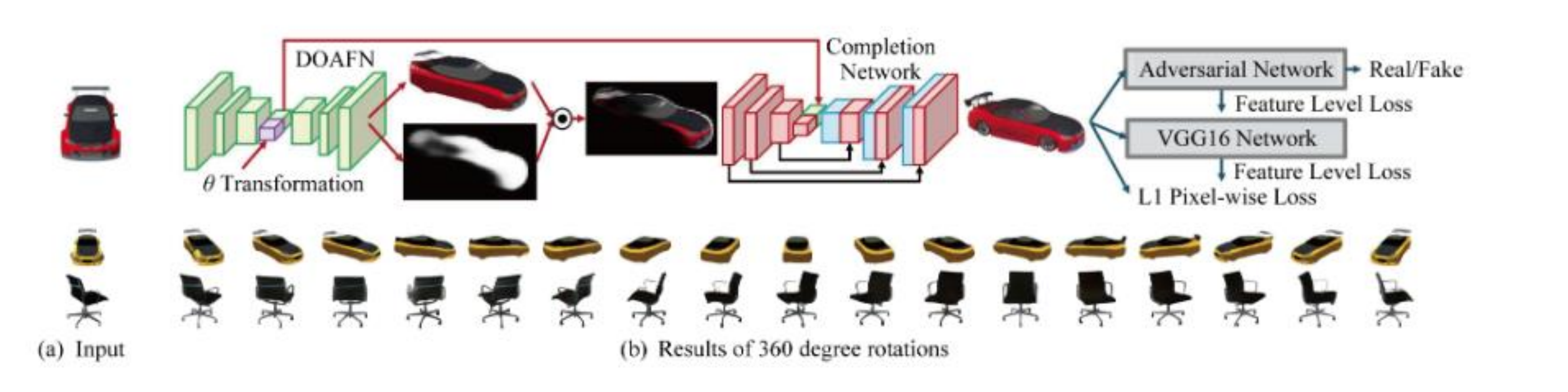
模型生成

- Transforming auto-encoders
- Deepstereo: Learning to predict new views from the world's imagery
- Learning to generate chairs, tables and cars with convolutional networks



模型生成

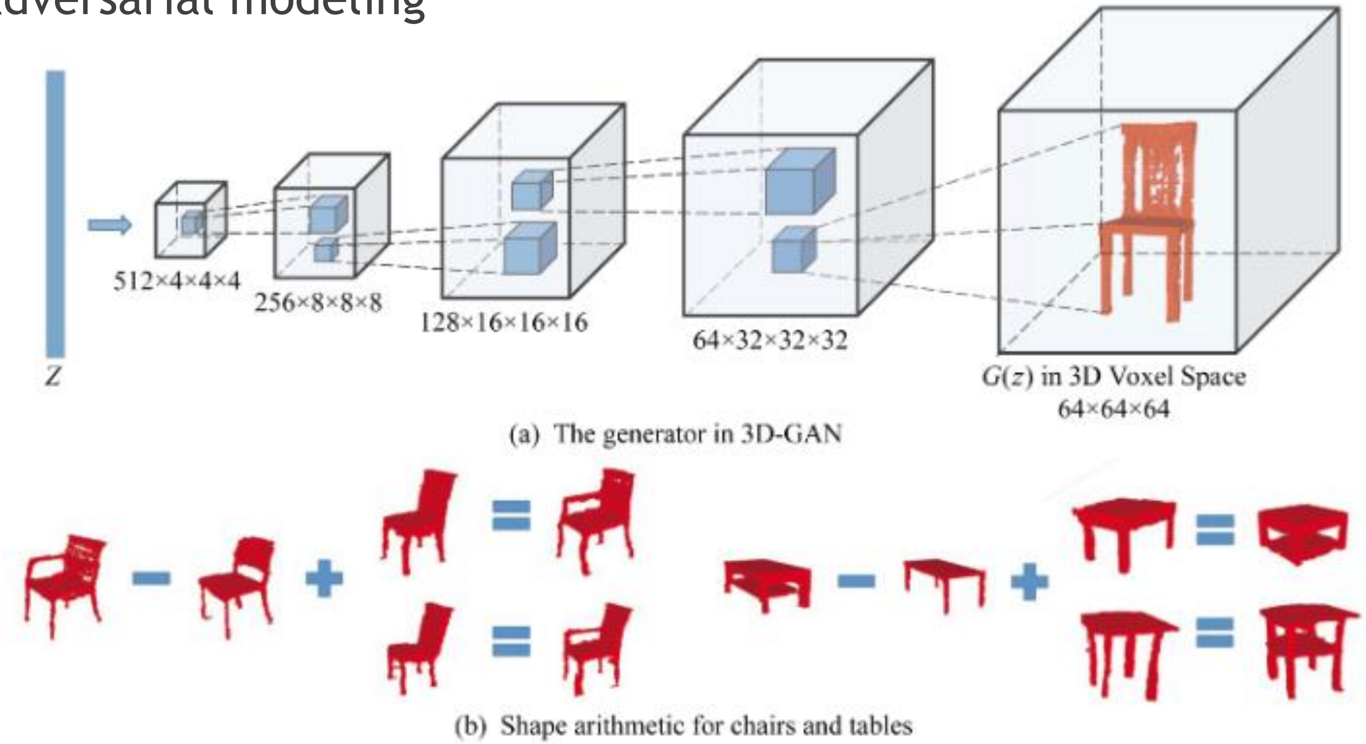
- Spatial transformer networks（STN）
- View synthesis by appearance flow
- Transformation-grounded image generation network for novel 3D view synthesis



Multi-view images generated from a single view image

模型生成

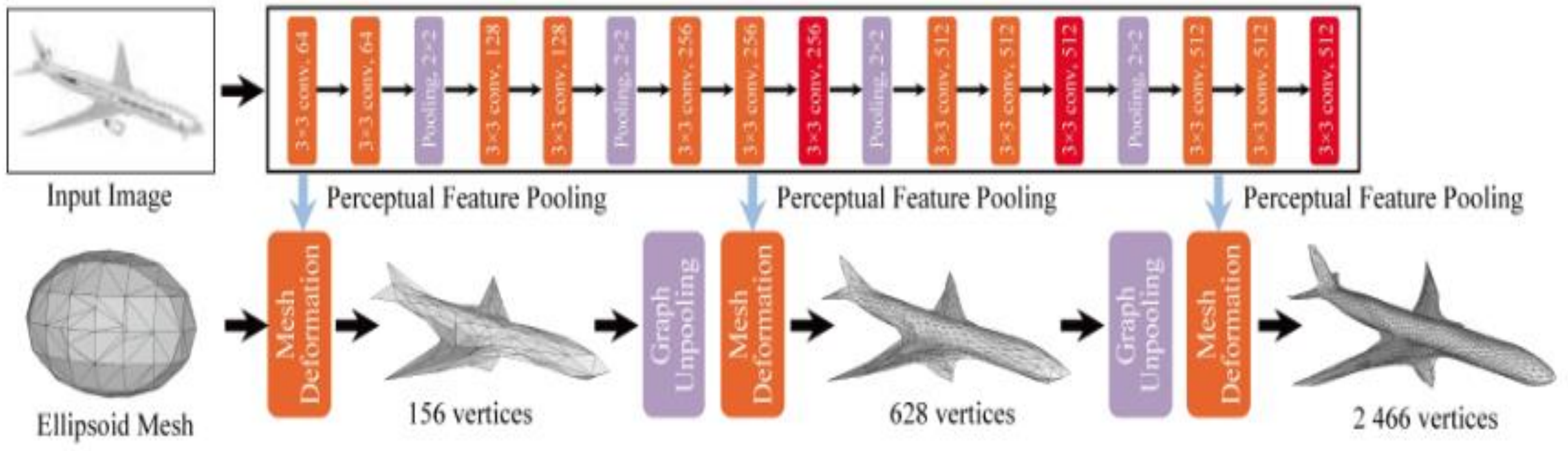
- Learning a predictable and generative vector representation for objects
- Learning a probabilistic latent space of object shapes via 3D generative-adversarial modeling



Shape synthesis using GAN

模 型 生 成

- Pixel2Mesh: Generating 3D mesh models from single RGB images



Deform an coarse ellipsoid mesh into a refined mesh using CNN

模型生成

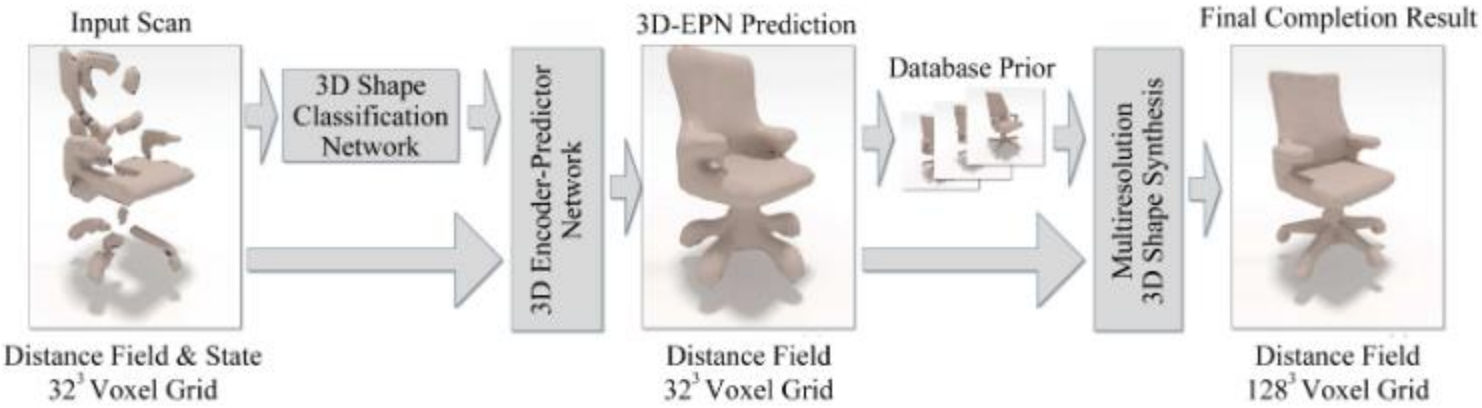
- Transforming auto-encoders
- Deepstereo: Learning to predict new views from the world’s imagery
- Learning to generate chairs, tables and cars with convolutional networks

模型生成

- Transforming auto-encoders
- Deepstereo: Learning to predict new views from the world’s imagery
- Learning to generate chairs, tables and cars with convolutional networks

模型修復與重建

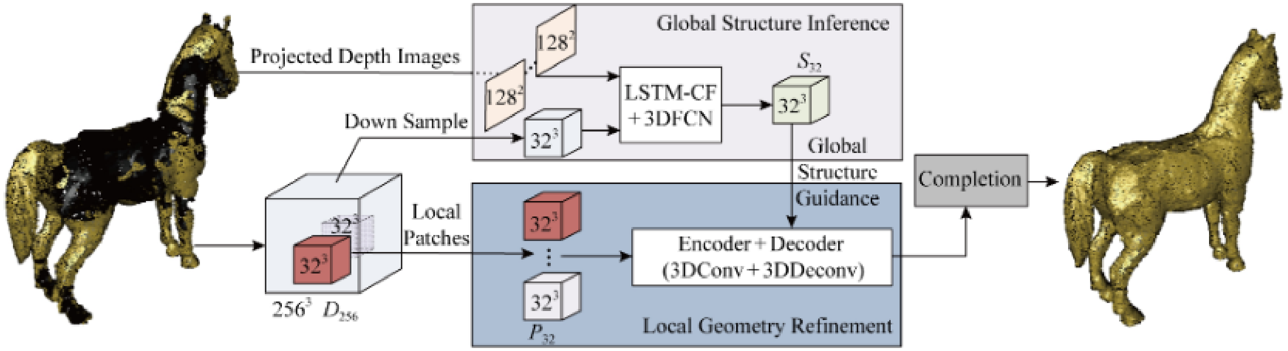
- Shape completion using 3D-encoder-predictor CNNs and shape synthesis



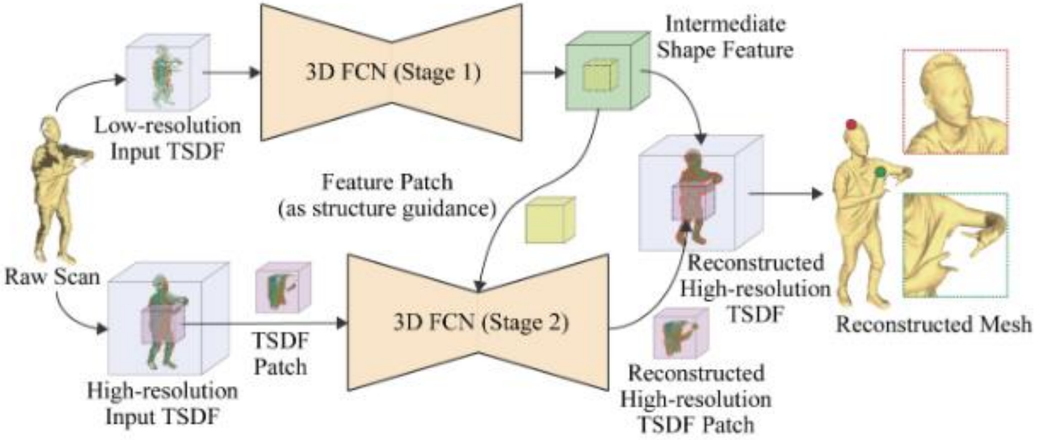
- Shape inpainting using 3D generative adversarial network and recurrent convolutional networks

模型修復與重建

- High-resolution shape completion using deep neural networks for global structure and local geometry inference

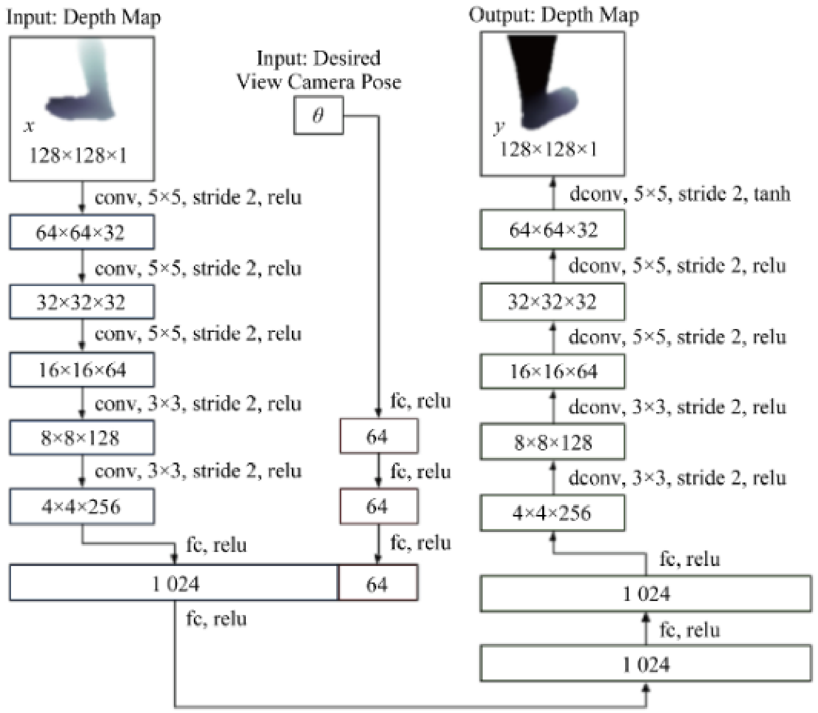


- Learning to reconstruct high-quality 3D shapes with cascaded fully convolutional networks



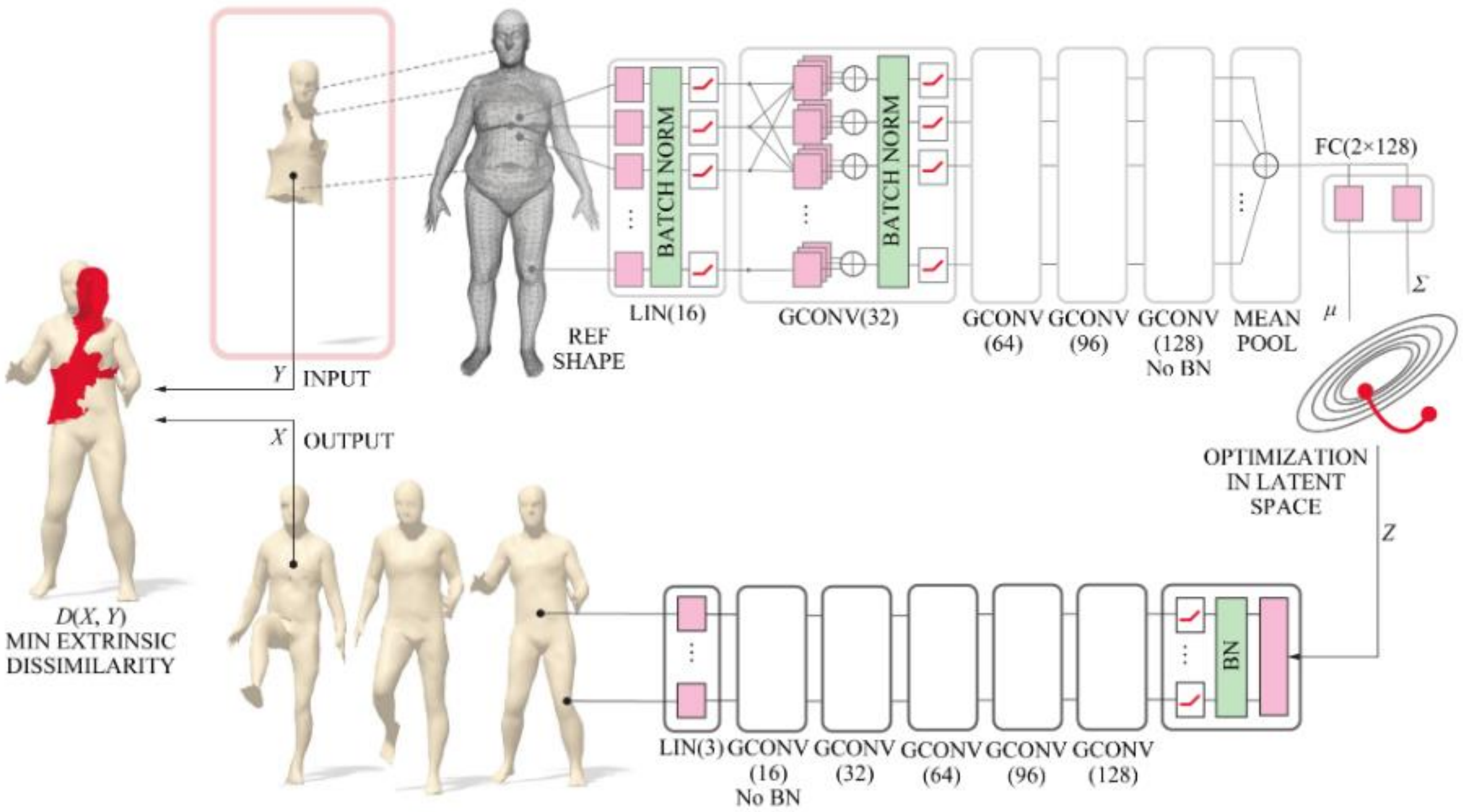
模型修復與重建

- Point cloud completion of foot shape from a single depth map for fit matching using deep learning view synthesis
- Deep learning anthropomorphic 3D point clouds from a single depth map camera viewpoint



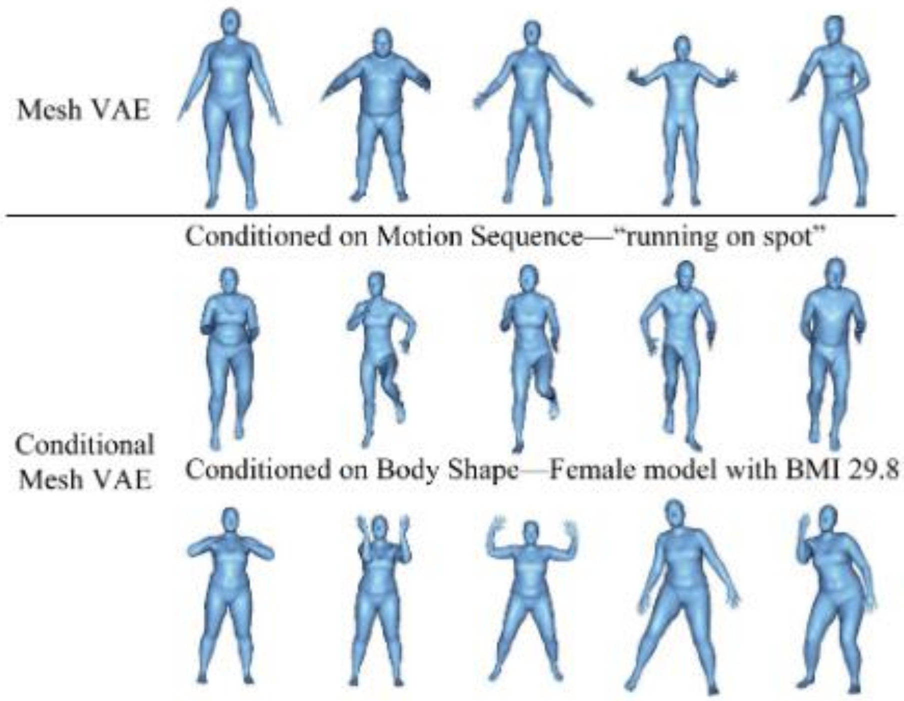
模型修復與重建

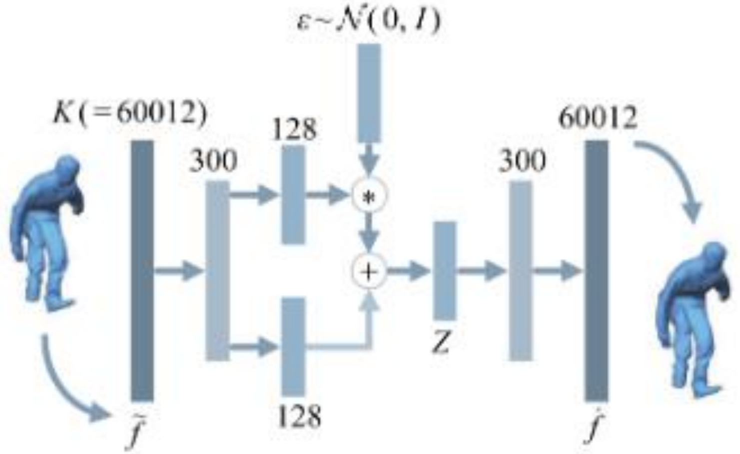
- Deformable shape completion with graph convolutional autoencoders



模型變形與編輯

- Variational autoencoders for deforming 3D mesh models





模型變形與編輯

- Biharmonic deformation transfer with automatic key point selection

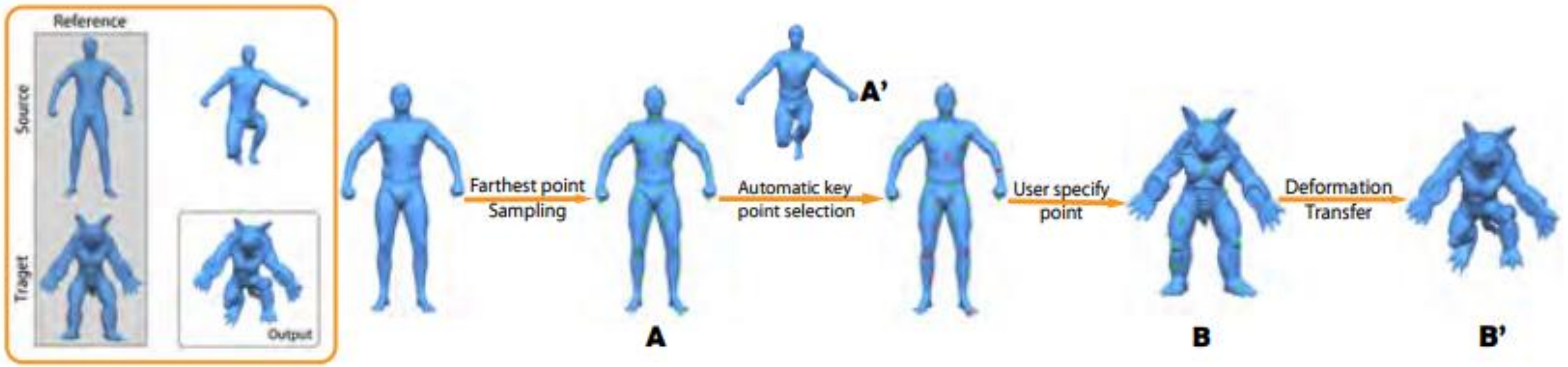
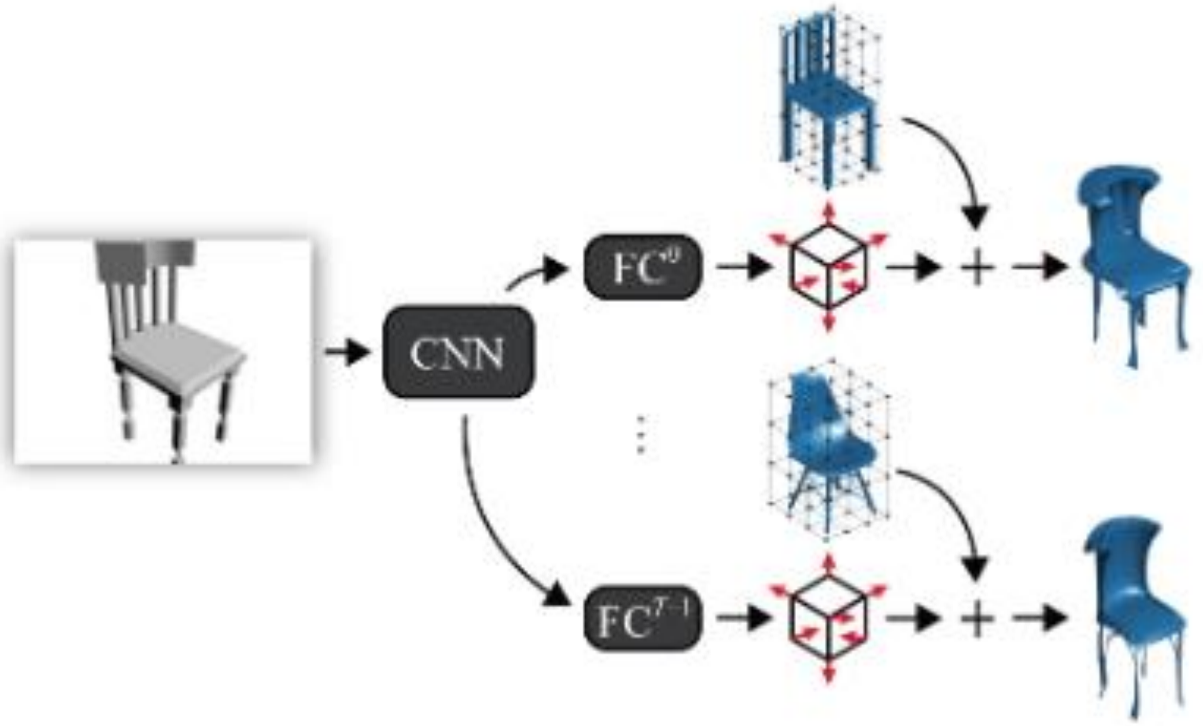


Figure 1: The pipeline of our algorithm.

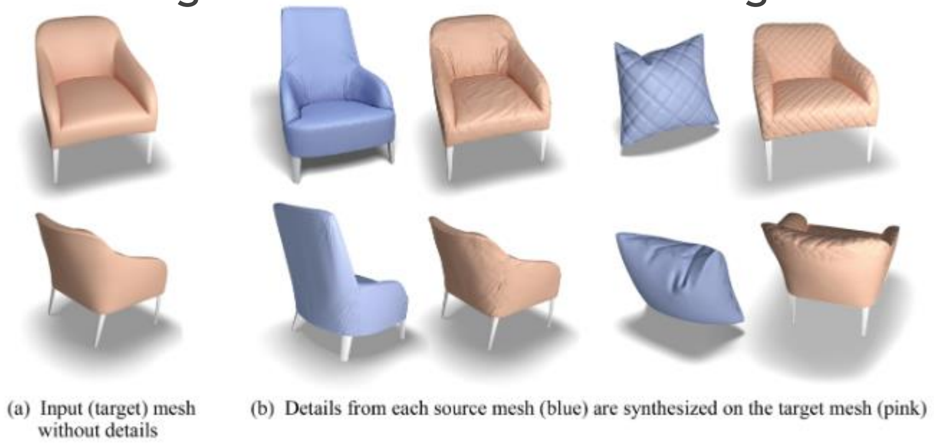
模型變形與編輯

- Learning free-form deformations for 3D object reconstruction



模型變形與編輯

- Analogy-driven 3D style transfer
- Learning detail transfer based on geometric features



- Functionality preserving shape style transfer

總結與展望

- 優勢
  - 相比于傳統的分析和處理方法，具有強大的資料抽象特徵提取能力
  - 極大地提高了模型的各方面應用上性能和效率

- 不足
  - 沒有統一的資料表示
  - 缺乏大規模公開資料集
  - 網路結構缺乏針對性