Takeaways: Scan2Mesh

What is this paper about?

1. Making 3d meshes, indexed faces from unstructured 3D data. Our aim is to develop a generative model for such 3D mesh representations; that is, a mesh model described as an indexed face set: a set of vertices as 3D positions, and a set of faces which index into the vertices to describe the 3D surface of the model
2. To generate 3D models similar to the handcrafted content creation process.

- **What problem does the study address?**
    1. If range scans are unstructured and potentially incomplete range, then making mesh from them is not a simple job.
    2. Manual artist efforts gives good results but if the meshes are handcrafted by artists, its an expensive and significantly tedious work.

Abstract:

- Scan2Mesh transforms an unstructured and potentially incomplete range scan into a structured 3D mesh representation.
- The generative loss builds on a series of proxy losses for vertices, edges, and faces.
- A one-to-one discrete mapping is realised between the predicted and ground truth data point with a combination of convolutional and graph neural network architecture.

Introduction:

- Aim is to develop a generative model for 3D mesh representations: that is, a mesh model described as an indexed face set: a set of vertices as 3D positions, and a set of faces which index into the vertices to describe the 3D surface of the model.
- The irregularity of mesh proves to be a significant challenge.
- From an input partial scan, a graph neural network is used to jointly predict mesh vertex positions as well as edge connectivity.
- These vertex and edge positions are treated as graphs, and corresponding dual graph is created. Which has potentially valid mesh faces as dual graph vertices, from which mesh faces are predicted.

What is the author's approach?

1. Rather than generate 3D mesh models extracted from regular volumetric grids, we instead take inspiration from 3D models that have been hand-modeled, that is, compact CAD-like mesh representations. Thus, we propose a novel approach, Scan2Mesh, which constructs a generative formulation for producing a mesh as a lightweight indexed face set, and demonstrate our approach to generate complete 3D mesh models conditioned on noisy, partial range scans.
2. We leverage deep learning to fully generate an explicit 3D mesh structure.

Method Overview:

- The approach is agnostic to the input data and representation.
- A new graph neural network is proposed to predict the vertices, edges and then faces of the mesh graph structure.
- Features from the input TSDF (Truncated Signed Distance Field) scan are computed through a series of 3D convolutions; from this feature space, a set of 3D vertex locations is predicted; then a graph neural network is employed to predict which mesh edges belong to the mesh graph structure.
- Dual graph is constructed from the graph of intermediate predicted vertices and edges to predict the final face structure of the mesh.

Scan2Mesh Network Architecture:

- The architecture has two main components:
    - A 3D convolutional and graph neural network architecture to jointly predict vertex locations and edge connectivity.
    - A graph neural network to predict the final mesh face structure.
- The TSDF is represented as a 5-channel volumetric grid, in which the first two channels store the truncated unsigned distance field values and known/unknown space according to the camera trajectory of the scan, and the last three channels store the (x, y, z) coordinates of the volumetric grid in the coordinate system of the mesh vertex positions.

- **Joint Vertex and Edge Prediction:**
    - TSDF input is used to predict a set of n mesh vertex locations through a series of 3D convolutions.
    - Resulting feature space is used to predict an nx3 tensor of n vertex positions through a series of two fully connected layers.
- **Training:**

Training is performed with supervised input-target pairs, with input scans generated by virtually scanning objects from the ShapeNet dataset