Project Title: Mesh Deformation with Neural Networks to Form a Target Mesh

Project Description: In this project I propose a method to perform fast mesh deformation with neural networks to form a target mesh. Deforming a source mesh to fit a target shape is performed by finding an offset vector to each vertex in the source mesh so that by offsetting the vertices, a new mesh is obtained which is closer to the target mesh. Currently, this can be achieved by converting the target mesh and the deformed mesh (source mesh after adding the offset vector) to a point cloud representation by sampling points from the meshes and then minimizing the chamfer distance between the point clouds in an optimization loop. At each step, gradients are calculated to update the deform parameters. In order to prevent non-smooth deformation, smoothness can be enforced by adding shape regularizers to the objective function. This can be done by minimizing the length of the edges in the predicted mesh, enforcing consistency across the normals of neighboring faces, and by adding Laplacian regularizer. An example for this method to deform a primitive shape (e.g. a sphere) to a tree mesh is given in Figure 1.

![Figure 1: Deformation of an initial shape to fit a target shape](image)

However this method requires an optimization loop for each of the source and target mesh pairs and each optimization can take several minutes. Instead of this slow process, a new method is proposed to perform fast deformation. In this project a neural network that takes an input point cloud (obtained from the target mesh) to output the predicted offset vector will be trained. The source mesh will be fixed to a generic shape such as a sphere. In order to train the network, target mesh and offset vector pairs will be collected by applying the aforementioned method to various meshes. After that, these target meshes and offset vectors will be used as ground truth to train the network. After training, the network can effectively learn the deform parameters for various meshes and for a new unseen mesh, the offset vector for the deformation can be obtained from the neural network without requiring an optimization loop. In this project, PyTorch3D will be used to implement the proposed method [1].

References