CLOSED: A Dashboard for 3D Point Cloud Segmentation Analysis using Deep Learning

THANASIS ZOUMPEKAS[1,2], GUILLEM MOLINA[1], ANNA PUIG[1] AND MARIA SALAMÓ[1]

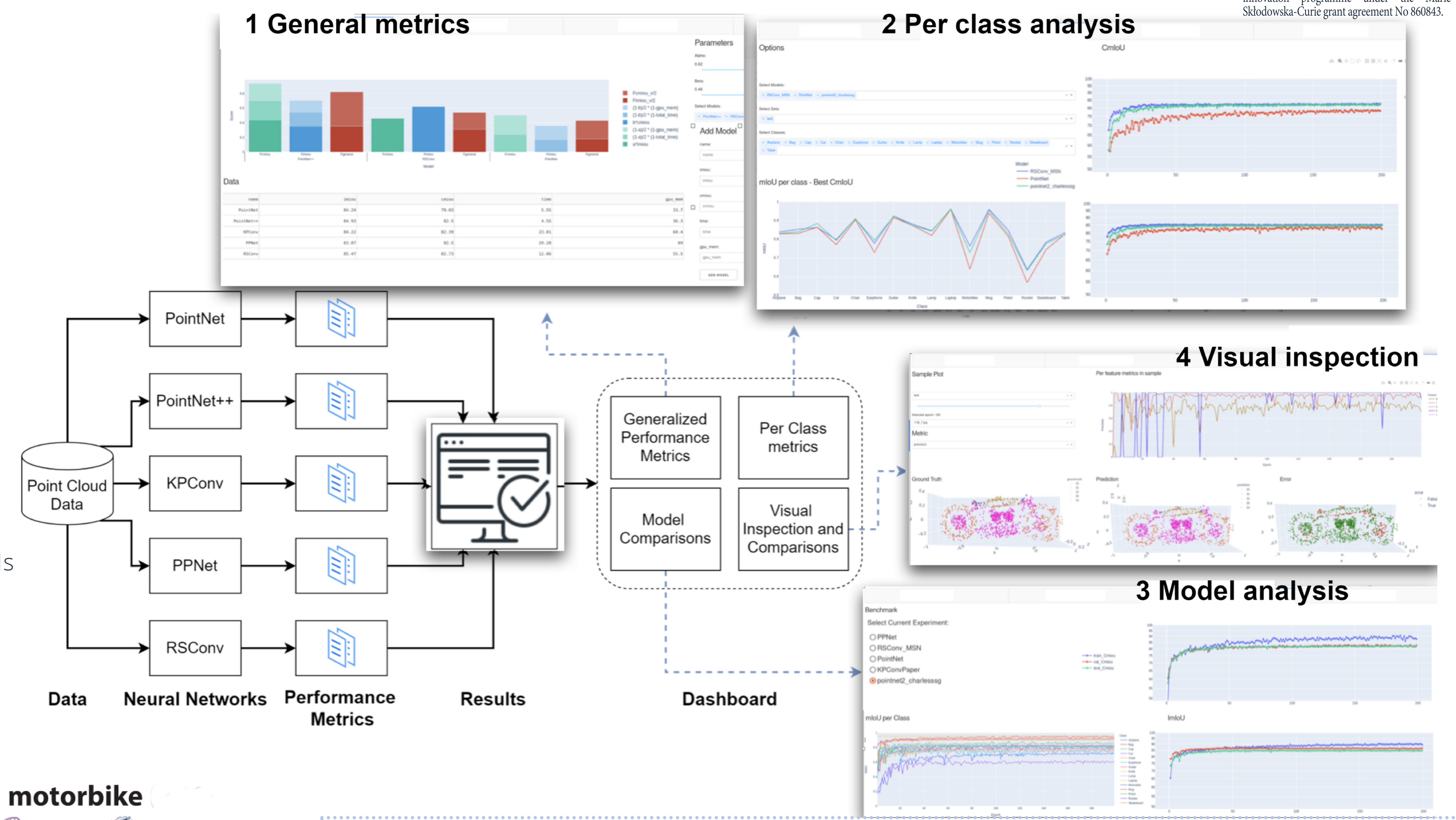
1 DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE, UNIVERSITY OF BARCELONA, BARCELONA, SPAIN
2 UNIT INDUSTRIAL SOFTWARE APPLICATIONS, RISC SOFTWARE GMBH, SOFTWAREPARK 35, HAGENBERG, AUSTRIA

Marie Skłodowska-Curie Actions

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 860843.

DESIGN

1. **General metrics**: facilitates the comparisons across different deep learning models based on the generalized metric, Fgeneral. It provides the ability to interactively weigh the segmentation performance between accuracy and time and memory efficiency of the models.
2. **Per class analysis**: compares the segmentation learning-related metrics of CmIoU and ImIoU of all the trained and tested deep learning models in a chart.
3. **Model analysis**: analyses the individual performance of the neural networks among all the learning epochs.
4. **Visual inspection**: facilitates the analysis of the individual segmentation performance of each model in multiple sampled shapes of point clouds during all the learning epochs.

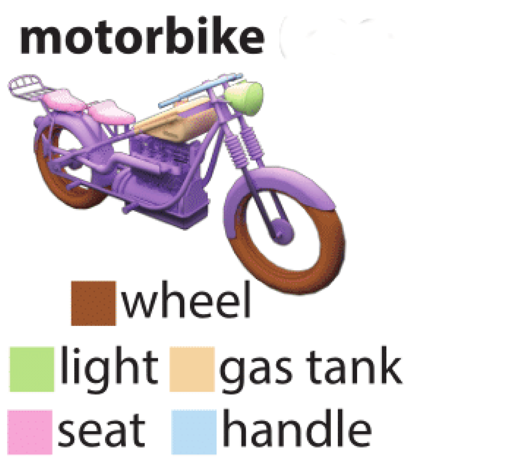


SHOWCASE

Models

Five of the most accurate neural networks for 3D part segmentation analysis:

1. **PointNet**,
2. **PointNet++**
3. Kernel Point Convolution (**KPConv**)
4. Position Pooling Network (**PPNet**)
5. Relation Shape Convolution (**RSConv**).



Data

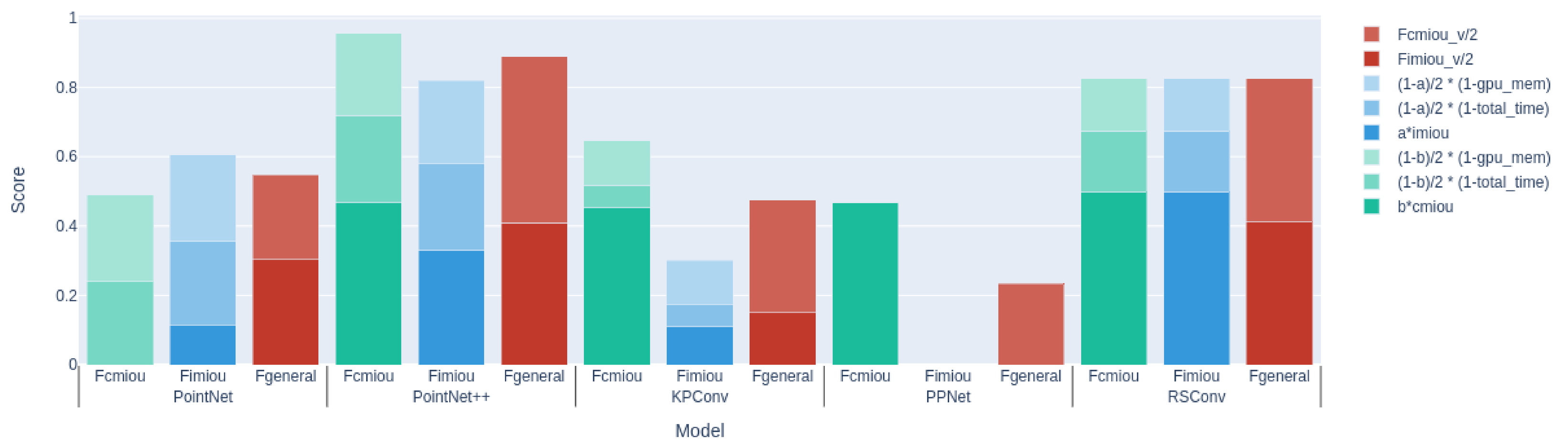
ShapeNet data for part segmentation.

- **16881** 3D objects of point clouds
- **16** different shape categories (or classes), each one annotated with **2** to **6** parts

Analysis Aspects

ASPECT 1

According to specific hardware resources and time constraints which neural network model is more appropriate to use?

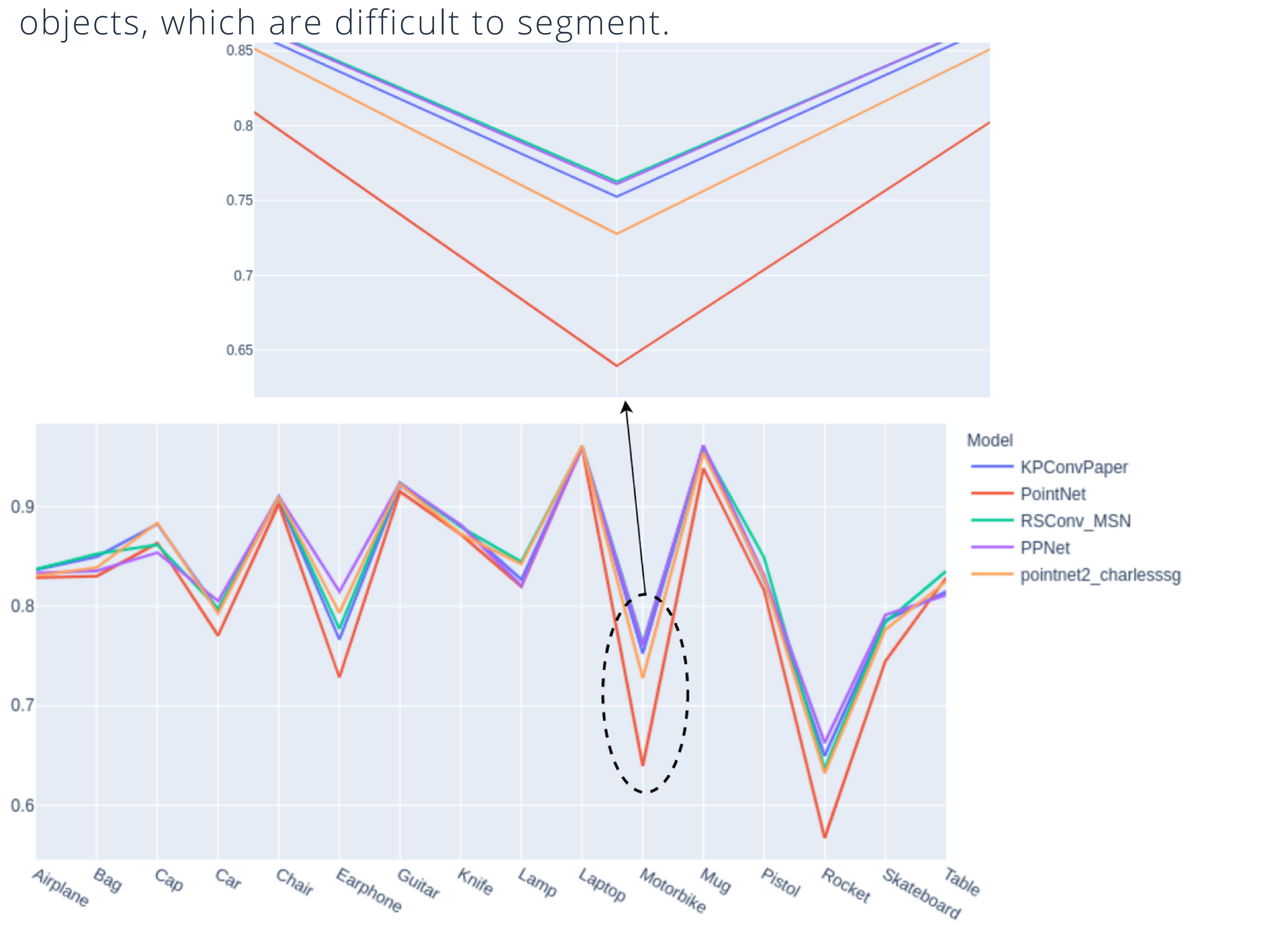


Generalized performance evaluation of the five selected neural networks with parameters α=0.5 and β=0.5, concerning balance between segmentation accuracy and efficiency of the deep learning models. For each model, we can observe the Fgeneral, FCmIoU and FImIoU and visually compare the proportions of each part of their equations.

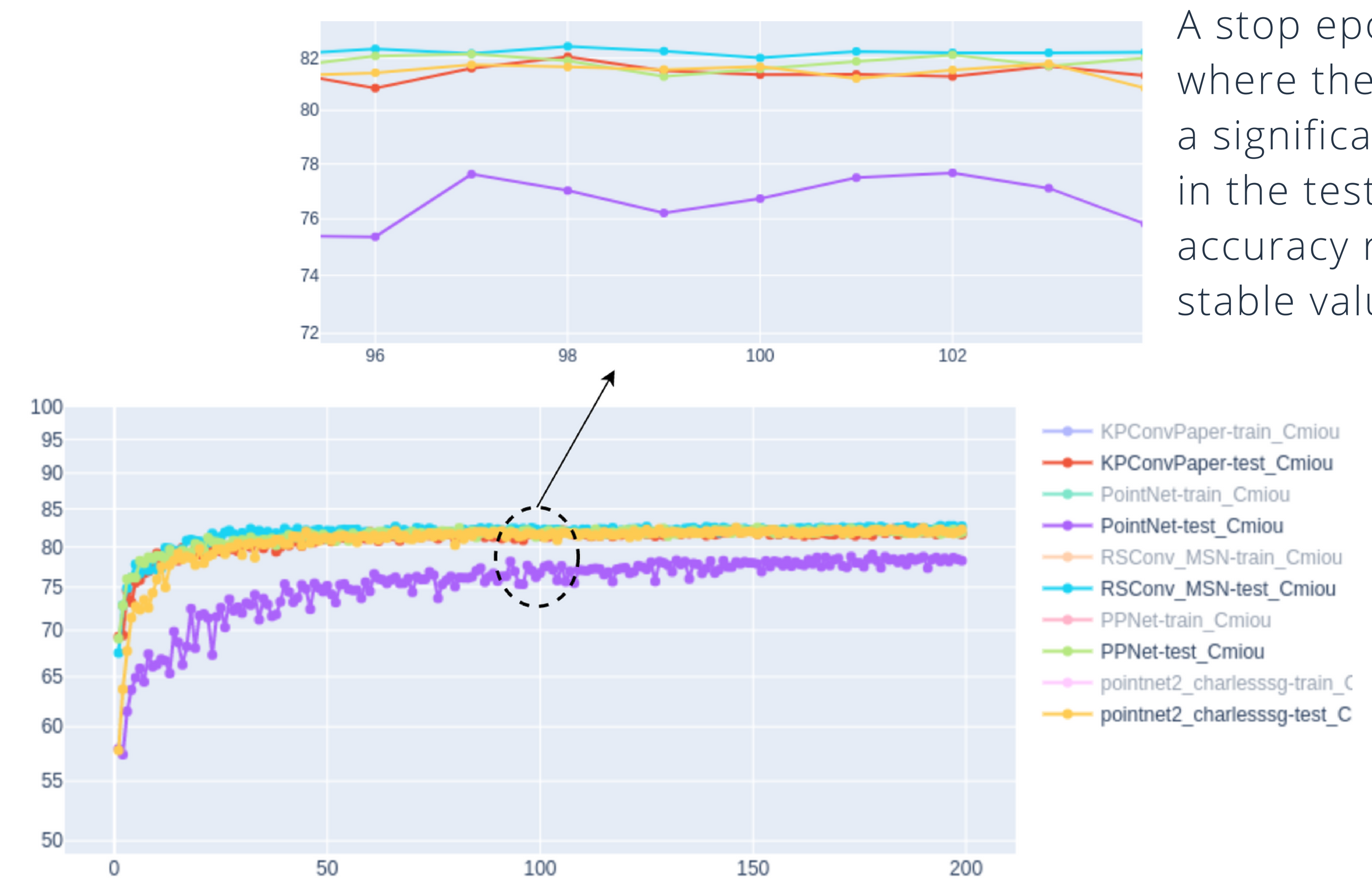
ASPECT 3

Which are the most difficult (and easiest) point cloud object classes to learn? Do all the learning models have the same learning behaviour in all classes?

It is somehow expected that each one of the deep learning models will perform better than the others in specific classes, due to differences in design characteristics. In the Figure on the right, for instance, RSConv performed better than the PointNet and PointNet++ by far in "Motorbike" class. This fact indicates the presence of "ill" data classes of point cloud objects, which are difficult to segment.



ASPECT 2 In which learning epoch we could stop the training process?



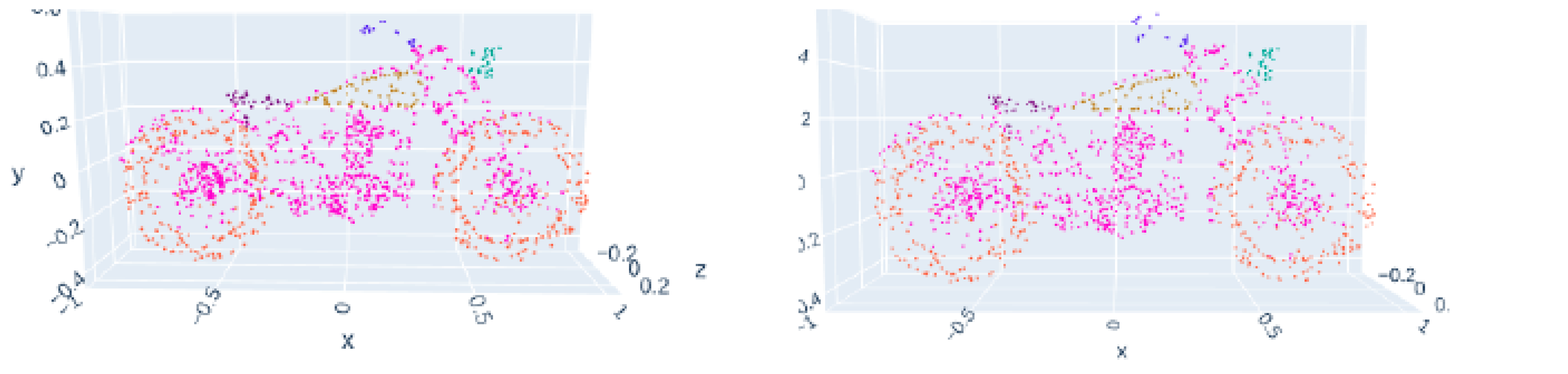
A stop epoch could be the point, where the neural network achieved a significantly high accuracy value in the test data and then its accuracy remains in more or less stable values.

A user can extract meaningful information on the detection of the exact epoch to stop the learning process of a neural network.

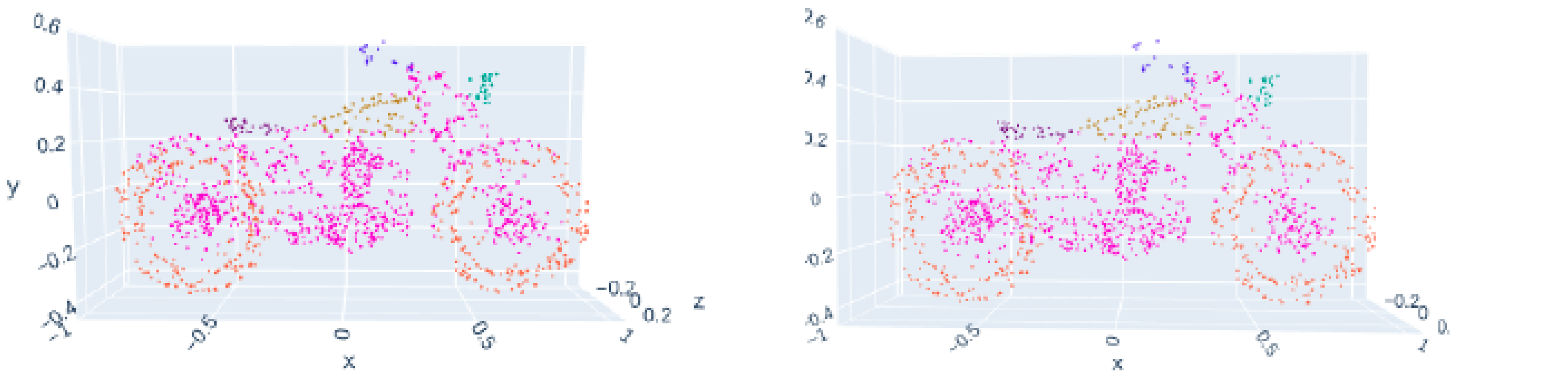
ASPECT 4

To what extent the segmentation accuracy metric values are related to the visual representation of the results?

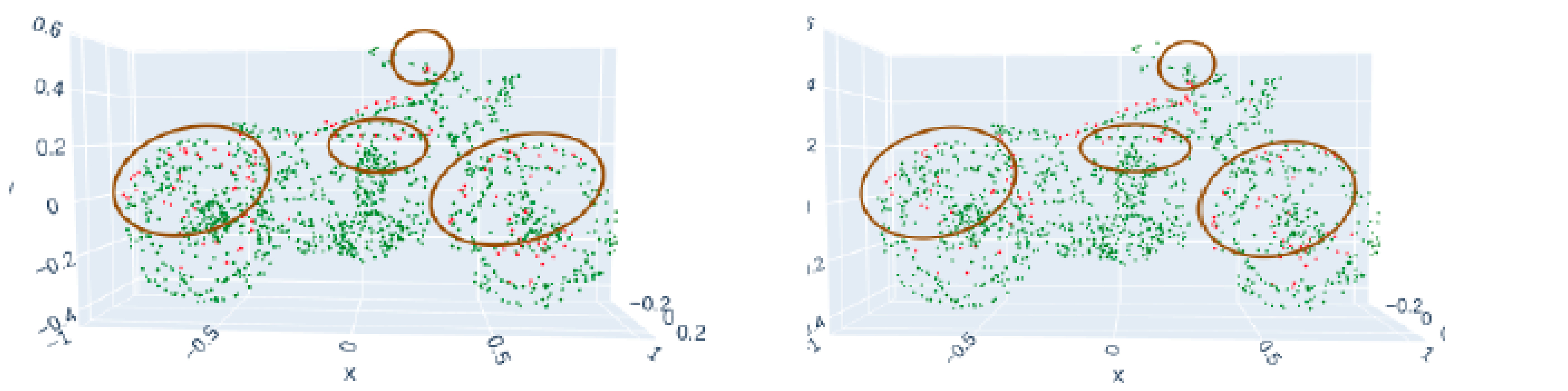
The different colours in (a), (b), (c), (d) denote the distinct parts of the point cloud. The colours green and red in (e) and (f) denote the correctly and incorrectly predicted points respectively. Also, in (e) and (f), the brown circles highlight example areas that appear to have differences between the two neural networks.



(a) Ground truth - PointNet. (b) Ground truth - RSConv.



(c) Predicted - PointNet. (d) Predicted - RSConv.



(e) Prediction error - PointNet. (f) Prediction error - RSConv.