Learning 3D feature embeddings for efficient 3D object segmentation

Doctoral School and University:

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Keywords: 3D scene segmentation, local surface description, local 3D features, multiresolution, cumulative distribution transform, semantic segmentation, graph neural networks, instance-semantic segmentation.

PhD Thesis Subject Summary

In recent years, Machine Learning approaches have revolutionized solutions to longstanding image-based problems such as realistic image generation, semantic segmentation and many others. However, several challenges are still present while handling 3D information in machine learning models [1, 2]. First, it is not clear what is the best 3D representation for machine learning models, e.g., meshes or volumetric grids [1, 3]. Second, 3D representations of real objects from scanners are often made up of a large number of points. When very complex scenes are scanned, an important problem is to **efficiently** subdivide the surfaces into semantic meaningful elements: for example tubes, tanks. motors, valves, etc in the context of a factory. In the case of a mobile robot exploration, the time constraint for object recognition and segmentation is essential.

In this PhD thesis subject, we propose to investigate **lightweight 3D description** approaches in order to obtain efficient 3D scene segmentation algorithms (e.g., a neural network). One

of the main cues to be explored is the cumulative distribution transform [4], which is not computationally expensive and addresses well the problem of high dimensional samples with low description dimension. In addition, the envisaged 3D feature encoding should allow recent deep learning architectures to process different types of scenes or 3D objects with good generalization properties. The problem of on-line processing 3D processing will also be explored in order to benefit from recognition techniques in dynamic situations and embedded algorithms on mobile robotic platforms. The approach should be compatible and of easy adaptation to allow additional feature representations beyond 3D points, such as with surface elements (normal vector, curvature) and also to regular surfaces as in object modeling (CAD). This work will be developed in collaboration with ATS Engineering. This PhD thesis will be co-supervised by Akram Aldroubi, University of Vanderbilt, Nashville, TN, USA.

Desirable skills and ideal candidate profile

The candidate should be motivated to carry out world class research and should have a Master in Computer Vision, Computer Science or Electrical Engineering along with solid skills in mathematics, Python, C/C++, Linux, Git and OpenCV. Experience with Pytorch, TensorFlow or ROS is of added value.

Additional information

Interested candidates please send a detailed CV, Master's results transcripts, thesis report, one coding program sample and the email coordinates of two referees to be contacted for recommendation, to Olivier Laligant (olivier.laligant@u-bourgogne.fr) and Renato Martins (renato.martins@u-bourgogne.fr).

Deadline

We aim to fill this position as soon as possible with the aim to start the PhD in January 2022. Applications will be considered until a suitable candidate has been found and no later than the second week of December 2021.

References

[1] Georgia Gkioxari, Jitendra Malik, Justin Johnson. **Mesh R-CNN.** IEEE/CVF International Conference on Computer Vision (ICCV), 2019

[2] Gege Zhang, Qinghua Ma, Licheng Jiao , Fang Liu and Qigong Sun. **AttAN: Attention Adversarial Networks for 3D Point Cloud Semantic Segmentation**. International Joint Conference on Artificial Intelligence (IJCAI), 2020.

[3] Charles R. Qi, Li Yi, Hao Su, Leonidas J. Guibas. **PointNet++: Deep Hierarchical Feature Learning on Point Sets in a Metric Space**, Conference on Neural Information Processing Systems (NeurIPS), 2017

[4] Akram Aldroubi, Rocio Martin, Ivan Medri, Gustavo K. Rohde, Sumati Thareja: **The Signed Cumulative Distribution Transform for 1-D Signal Analysis and Classification**. arXiv 2021.