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PROPOSITION DE SUJET DE THÈSE

Title : Neural Networks for Multi-temporal 3D Data Semantic Segmentation

Référence : TIS-**DTIS-2019-xxxx**
(à rappeler dans toute correspondance)

Laboratoire d'accueil à l'ONERA :

Domain : Computer Vision, Pattern Recognition (TIS) — Location (ONERA) : Palaiseau

Département : Department of Information Processing and Systems (DTIS)

Unité : Image, Vision and Machine Learning (IVA) — Tél. : +33180386573

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Directeur de thèse envisagé (PhD Supervisor) :

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Sujet : Neural Networks for Multi-temporal 3D data Semantic Segmentation

Keywords: Computer vision, Deep Learning, 3D, 3D classification, 3D for robotics

Context

3D data are now becoming the common standard for environment perception and analysis. They even replace images in many usecases: autonomous vehicles, robotics, urban cartography, forensics, etc. They usually come as point clouds (coordinates in the usual 3D space) associated with a color information. With the uprising of low-cost sensors (Kinect, Iphone-X 3D sensor…), professional devices (laser scanners) and robust photogrammetric techniques (3D reconstruction from multiple images), point clouds are commonly used as inputs of algorithms for surface reconstruction, semantic segmentation or 3D graphics. Furthermore, the high acquisition framerate of these devices allow to get multi-temporal 3D point clouds as precise as videos.

Thanks to machine learning techniques, including deep neural networks, vision based robotics have made tremendous progress. In the field of 3D scene analysis, we developed SnapNet which is among the leading state-of-the-art approaches for urban semantic segmentation (Semantic 3D benchmark http://semantic3d.net , [Boulch et al. 2017]) and robotics (NYUv2 and SUNRGBD benchmarks [Guerry et al. 2017]). New applications also emerged from these radical technical changes, such as 2D and 3D imagery mixed with virtual reality where object recognition must be robust to the different locations (and motion) of the sensor.

Objectives

This thesis aims at improving 3D scene understanding techniques for robotics. It will tackle the case of dynamic 3D data, either as a mean for adding consistency to the semantics or a proxy to detect changes. More formally, it raises several scientific issues:

1. How to improve 3D semantic segmentation of point clouds ?

3D scene understanding from point clouds, in particular at object detection level, is a crucial step of navigation and decision-making for autonomous agents. While image processing neural networks have converged towards a common, standard approach, 3D processing is still an open and active research field. Current state-of-the-art techniques include image segmentation [Su et al. 2015], voxel processing [Maturana & Scherer 2015], unstructured data processing [Qi et al. 2017] or scene segmentation followed by a segment labelling step [Landrieu et al. 2018]. Therefore, designing and developing new algorithms and neural network architectures for segmentation and detection in 3D data, in particular in a robotic context (autonomous robot), will be the underlying theme of the thesis.

2. How to benefit from temporal redundancy for semantic and geometric reconstruction?

In robotics, including autonomous vehicles, data acquisition produces a data stream (on-board LIDAR, RGB-D camera, stereo cameras…) [Guerry 2017]. Frame by frame processing of these 3D data do not ensure temporal consistency and do not exploit the complementary information of the different points of view of the scene. The objective is to create joint semantic and reconstruction algorithms from multi-frame 3D data. Such an algorithm should be able to exploit the small point of view changes for simultaneously improving the semantic reconstruction and dealing with object occlusions.

3. How to identify and characterize changes in data acquired at different dates?

While 3D data interpretation is usually done on static point clouds, the game is changing with dynamic 3D data. Between two distant dates, structural changes can occur (e.g. during building site monitoring) and must be detected and characterized. The problem is that data which includes structural changes also vary a lot even in unchanged area (due to acquisition noise and a varying surface sampling). How to get rid of these meaningless differences, and focus on relevant changes? Various approaches will be investigated, including direct 3D data matching or object-level change detection.

Practical Informations

This thesis is part of a collaboration between the IVA team at ONERA/DTIS (Bertrand Le Saux and Alexandre Boulch) and the IMAGINE team at École des Ponts ParisTech (Renaud Marlet). It will take place at the ONERA center of Palaiseau near Paris.

Brief Bibliography

[Boulch et al. 2013] Boulch, Alexandre and Houiller, Simon and Marlet, Renaud and Tournaire, Olivier, Semantizing Complex 3D Scenes using Constrained Attribute Grammars, Computer Graphics Forum 2013

[Boulch & Marlet 2016] Boulch, Alexandre and Marlet, Renaud, Deep Learning for Robust Normal Estimation in unstructured Point Clouds, Computer Graphics Forum 2016

[Boulch et al. 2017] Boulch, Alexandre and Guerry, Joris and Le Saux, Bertrand and Audebert, Nicolas, SnapNet: 3D point cloud semantic labeling with 2D deep segmentation networks, Computer and Graphics 2017

[Guerry et al. 2017] Guerry, Joris and Boulch, Alexandre and Le Saux, Bertrand and Moras, Julien and Plyer, Aurélien and Filliat, David, SnapNet-R: Consistent 3D Multi-View Semantic Labeling for

Robotics, ICCV/3DRMS 2017

[Guerry 2017] Guerry, Joris, Reconnaissance visuelle robuste par réseaux de neurones dans des scénarios d'exploration robotique. Détecte-moi si tu peux!, Manuscrit de Thèse, 2017

[Landrieu et al. 2018], Landrieu, Loic and Simonovsky, Martin, Large-scale Point Cloud Semantic Segmentation with Superpoint Graphs, CVPR, 2018

[Maturana & Scherer 2015] Maturana, D. and Scherer, S., VoxNet: A 3D Convolutional Neural Network for Real-Time Object Recognition, IROS, 2015.

[Qi et al. 2017] Qi, Charles R and Su, Hao and Mo, Kaichun and Guibas, Leonidas J, PointNet: Deep Learning on Point Sets for 3D Classification and Segmentation, CVPR, 2017.

[Su et al. 2015] Su, Hang and Maji, Subhransu and Kalogerakis, Evangelos and Learned-Miller, Erik, Multi-view Convolutional Neural Networks for 3D Shape Recognition, CVPR 2015

Collaborations extérieures :

Requested Profile

Requested Educational Background :
Master of Science or “Grande École d'ingénieur” with outstanding transcript in applied mathematics or computer science.

Preferred qualification:

Data processing and Machine learning

Computer Vision

For application, please send a CV and a cover letter to the thesis director and all advisors.

PARTIE DESTINÉE EXCLUSIVEMENT À LA DSG

ANNEXE À LA PROPOSITION DE SUJET DE THÈSE

Les rubriques suivantes doivent être dûment renseignées :

1. Titre de la thèse

Réseaux de neurones pour la segmentation sémantique de données 3D temporelles.

2. Domaine et thématique scientifique principale

Perception et traitement de l'information

Secondaire : Intelligence Artificielle et Décision

3. Contexte de l'étude (en 1 à 2 pages)

a. à l'ONERA (préciser notamment les personnes participant à l'encadrement en plus du responsable ONERA)

Bertrand Le Saux
Alexandre Boulch

Cette thèse viendra nourrir les travaux du PRF Delta, tant pour le lot 1 (technques de machine learning fondamentales) que pour le lot 2 (applications à la robotique)

b. à l'extérieur

Renaud Marlet (Équipe IMAGINE à École des Ponts ParisTech)

c. bibliographie succincte

[Boulch et al. 2013] Boulch, Alexandre and Houiller, Simon and Marlet, Renaud and Tournaire, Olivier, Semantizing Complex 3D Scenes using Constrained Attribute Grammars, Computer Graphics Forum 2013

[Boulch & Marlet 2016] Boulch, Alexandre and Marlet, Renaud, Deep Learning for Robust Normal Estimation in unstructured Point Clouds, Computer Graphics Forum 2016.

[Boulch et al. 2017] Boulch, Alexandre and Guerry, Joris and Le Saux, Bertrand and Audebert, Nicolas, SnapNet: 3D point cloud semantic labeling with 2D deep segmentation networks, Computer and Graphics 2017

[Guerry et al. 2017] Guerry, Joris and Boulch, Alexandre and Le Saux, Bertrand and Moras, Julien and Plyer, Aurélien and Filliat, David, SnapNet-R: Consistent 3D Multi-View Semantic Labeling for Robotics, ICCV/3DRMS 2017

[Maturana & Scherer 2015] Maturana, D. and Scherer, S., VoxNet: A 3D Convolutional Neural Network for Real-Time Object Recognition, IROS, 2015.

[Landrieu et al. 2018], Landrieu, Loic and Simonovsky, Martin, Large-scale Point Cloud Semantic Segmentation with Superpoint Graphs, CVPR, 2018

[Qi et al. 2017] Qi, Charles R and Su, Hao and Mo, Kaichun and Guibas, Leonidas J, PointNet: Deep Learning on Point Sets for 3D Classification and Segmentation, CVPR, 2017.

[Su et al. 2015] Su, Hang and Maji, Subhransu and Kalogerakis, Evangelos and Learned-Miller, Erik, Multi-view Convolutional Neural Networks for 3D Shape Recognition, CVPR 2015

4. Description des travaux (en 1 à 2 pages)

a. plan de thèse prévisionnel

Le sujet traite de 3 problématiques :

La segmentation sémantique de nuages de points 3D est le cœur de la thèse, c'est l'axe directeur des 3 années de thèse. Il s'appuiera sur les travaux de l'équipe IVA, actuellement en tête de plusieurs benchmarks de sémantisation 3D en robotique et reconnaissance urbaine.

Pour y arriver le doctorant s'appuiera sur les deux axes induits par l'étude de données 3D muti-temporelles (dynamiques) : l'apport de la redondance temporelle entre captures 3D

rapprochées (traitement des occlusions, robustification…) et la détection de changements de la scène en captures 3D éloignées.

b. techniques à mettre en œuvre

Apprentissage automatique dont deep learning

Traitement d'image avancé

Computer Graphics

c. résultats attendus

Publications dans des journaux et des conférences de références en vision par ordinateur et en computer graphics

Boîte à outils logicielle.

5. Financement envisagé

Cocher dans la colonne de droite

Type de bourse	
ONERA	☒
DGA	☒
Région	☐
Contrat doctoral	☐
CIFRE	☐
CNES	☐
Autre	☐

Commentaire éventuel :

Ce sujet pourra faire l'objet d'un co-financement École des Ponts ParisTech / Onéra

6. Avis de l'Adjoint Scientifique du Département