

Computer Vision et Nuages de Points 3D

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2ème Journée Aquitaine IA, RO et Data Science

7 Février 2019 - Bordeaux - Kedge Business School



Plan

Computer Vision

Nuages de Points 3D

Reconnaissance d'Objets

Systèmes de Perception

Conclusion



Nos métiers à



Relevé laser 3D,
Modélisation 3D,
BIM



Détection,
géolocalisation et
modélisation des
réseaux



Acquisition
dynamique terrestre



Topographie



Géomètre-expert,
foncier,
copropriété,
division en volume



Maîtrise d'œuvre
VRD, aménagement
du territoire



Bathymétrie et
création de
drones



Impression 3D,
vue immersive



Recherche et
Développement

Computer Vision

Vision par ordinateur :
Extraction de l'information à
partir de médias visuels

Acquisition

Reconnaissance

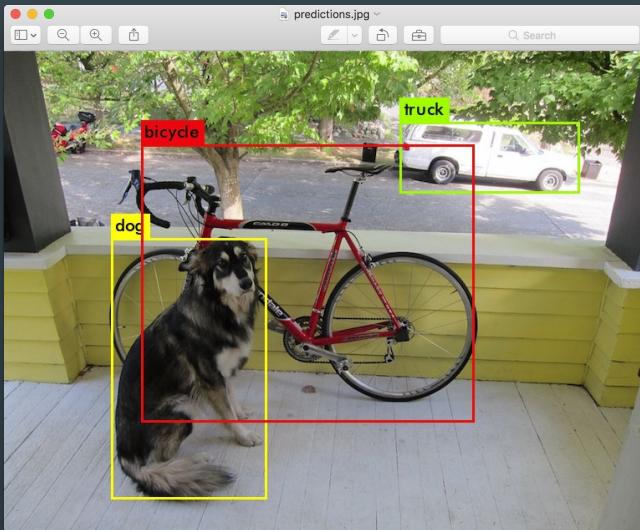
Assemblage (Registration)

Reconstruction

Comprehension



Perception et Compréhension

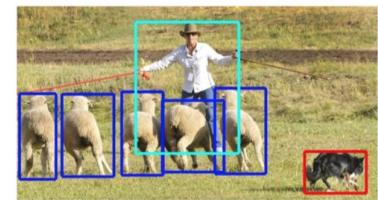


Redmon, J. et A. Farhadi, 2017.
YOLO9000. Better, Stronger, Faster.
CVPR 2017.

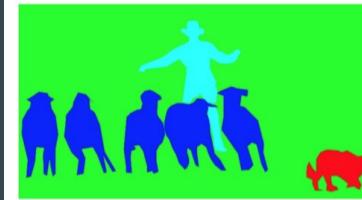
Lin et al., 2015.
Microsoft COCO:
Common Objects
in COnText



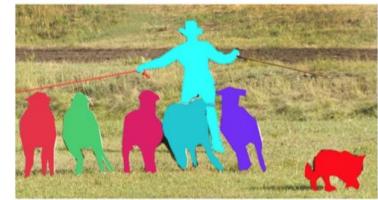
(a) Image classification



(b) Object localization



(c) Semantic segmentation



(d) This work

<p>Who is wearing glasses? man woman</p>  <p>Is the umbrella upside down? yes no</p> 	<p>Where is the child sitting? fridge arms</p>  <p>How many children are in the bed? 2 1</p> 
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Yash, G. et al. 2017.
Making the V in VQA
Matter: Elevating the
Role of Image Understanding
In Visual Question
Answering. CVPR 2017.



Image Benchmark Datasets for Object Recognition

ImageNet	2010	http://www.image-net.org
Microsoft Common Objects in COntext (COCO)	2015	http://cocodataset.org/#home
Pascal Visual Object Classes	2005	http://host.robots.ox.ac.uk/pascal/VOC/
VisualQA	2015	https://visualqa.org
CIFAR-10, CIFAR-100	2009	https://www.cs.toronto.edu/~kriz/cifar.html
MNIST	1995	http://yann.lecun.com/exdb/mnist/



Nuages de Points 3D

(x,y,z)

parfois : intensité, temps,
classification, couleurs RGB

Acquisition

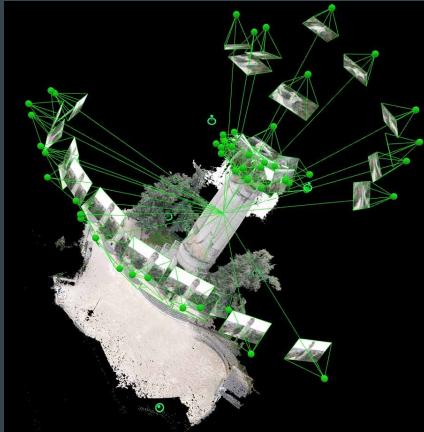
Applications

Data Structures

Algorithms



Comment créer un nuage de points 3D ?



Assemblage des images
Reconstruction d'un modèle en 3D



Upper image: <https://www.studioflytechnologie.fr/modelisation-3d-et-photogrammetrie-lutilisation/>
Lower image: <http://blog.synosystems.de/photogrammetrie-chdk/>

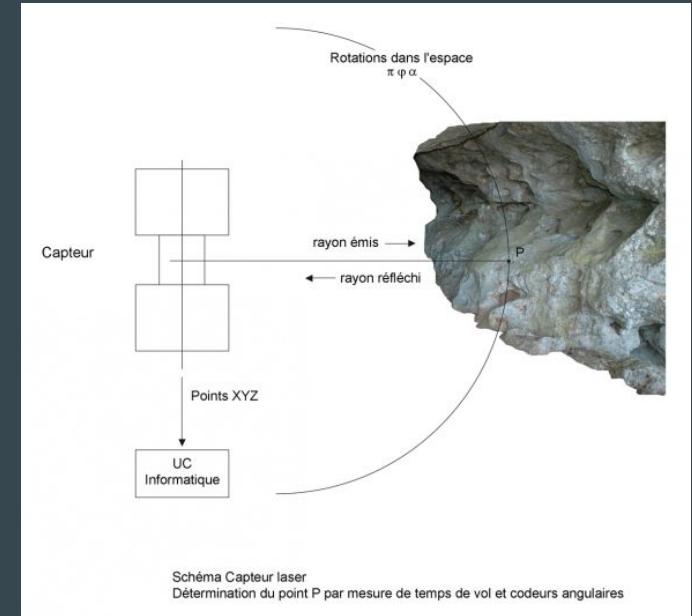


RGB-D (couleur et profondeur)

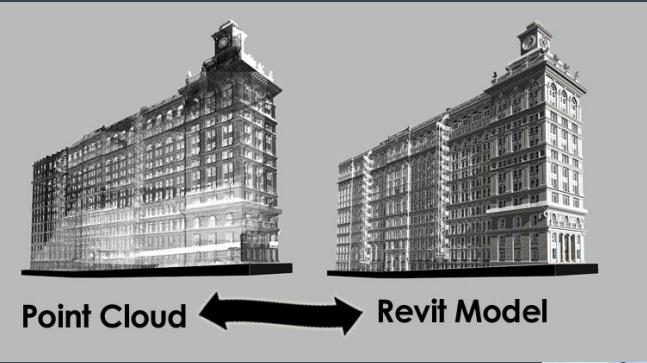
Source. https://vision.in.tum.de/research/rgb-d_sensors_kinect

LiDAR (Light Detection and Ranging).
Un rayon de lumière est émis et réfléchi.
Balayage de l'environnement en 3D.

Source: <https://journals.openedition.org/insitu/6413>



Applications pour Nuages de Points 3D



Point Cloud ← → Revit Model

Mesures en 3D haute-fidélité

Source:

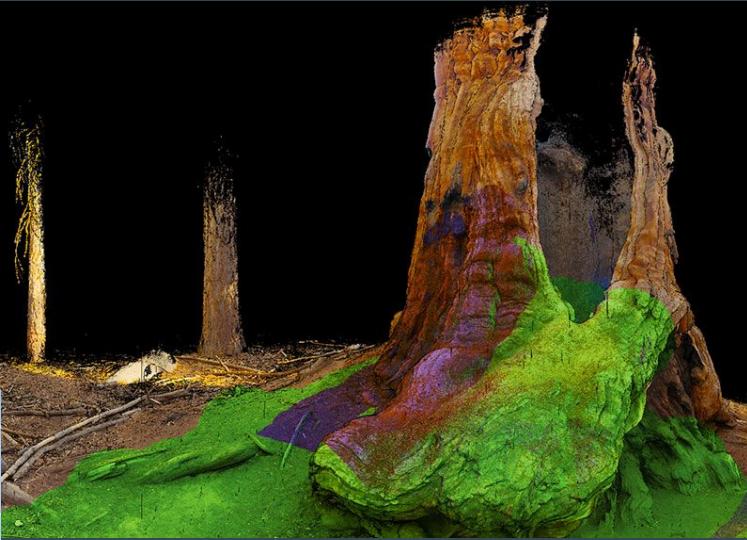
<http://blog.bimengus.com/3d-point-cloud-survey-with-laser-scanning/>



Mobile Mapping

Source:

<https://www.geo-sat.com/en/job/mobile-cartography>



Effets spéciaux numériques réalité virtuelle,
Jeux vidéos, films

Source: Nurulize Atom View <http://nurulize.com/atom-view/>



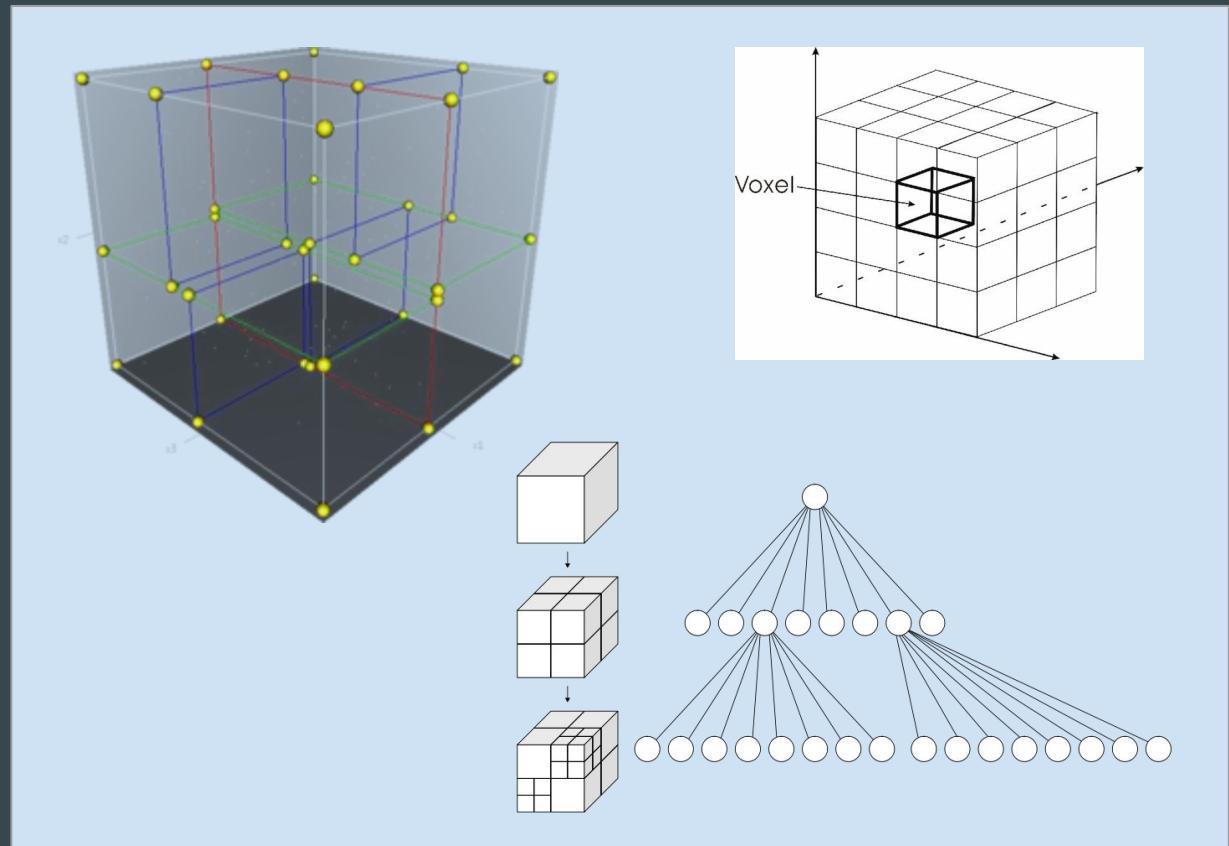
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3D Point Cloud Data Structures

- Binary Space Partitioning Trees (K-D Tree)
- Octree
- Voxel Grid
- Potree
(Octree/WebGL Point Cloud Renderer)



Voxel. [Source](#): Du et al, 2008. [Visual Data Mining of Raster Data A Volume-Rendering-Based Hierarchical Approach](#). DOI: 10.1111/12.815718
KDTree. Source: https://en.wikipedia.org/wiki/K-d_tree
Octree. Source: <https://en.wikipedia.org/wiki/Octree>



Algorithmes : Boîte à outils

- Clustering pour Segmentation
 - Recherche des plus proches voisins
 - Composantes connexes
- Analyses en composantes principales:
 - Droite normale des surfaces
 - Morphologie d'objets
- Dilatation, Erosion, Ouverture, Fermeture
- Transformée de Hough (Formes Géométriques)
- Graphes



Reconnaissance d'Objets

Dans nuages de points 3D

Benchmark Datasets

Models and Algorithms



Point Cloud Benchmark Datasets

KITTI Vision Benchmark Suite pour conduite autonome

<http://www.cvlabs.net/datasets/kitti/>, 14 Jan 2019

- **Easy:** Min. bounding box height: 40 Px, Max. occlusion level: Fully visible, Max. truncation: 15 %
- **Moderate:** Min. bounding box height: 25 Px, Max. occlusion level: Partly occluded, Max. truncation: 30 %
- **Hard:** Min. bounding box height: 25 Px, Max. occlusion level: Difficult to see, Max. truncation: 50 %

Car

All methods are ranked based on the moderately difficult results.

	Method	Setting	Code	Moderate	Easy	Hard	Runtime	Environment	Compare
1	MMF			76.75 %	86.81 %	68.41 %	0.08 s	GPU @ 2.5 Ghz (Python)	<input type="checkbox"/>
2	Patches			76.56 %	87.07 %	68.65 %	0.15 s	GPU @ 2.0 Ghz	<input type="checkbox"/>
3	PointRCNN			75.42 %	84.32 %	67.86 %	0.2 s	GPU @ 2.5 Ghz (Python + C/C++)	<input type="checkbox"/>

S. Shi, X. Wang and H. Li: [PointRCNN: 3D Object Proposal Generation and Detection from Point Cloud](#). arXiv preprint arXiv:1812.04244 2018.

Pedestrian

	Method	Setting	Code	Moderate	Easy	Hard	Runtime	Environment	Compare
1	F-PointNet		code	44.89 %	51.21 %	40.23 %	0.17 s	GPU @ 3.0 Ghz (Python)	<input type="checkbox"/>
C. Qi, W. Liu, C. Wu, H. Su and L. Guibas: Frustum PointNets for 3D Object Detection from RGB-D Data . arXiv preprint arXiv:1711.08488 2017.									
2	IPOD			44.68 %	56.92 %	42.39 %	0.2 s	GPU @ 2.5 Ghz (Python + C/C++)	<input type="checkbox"/>
Z. Yang, Y. Sun, S. Liu, X. Shen and J. Jia: IPOD: Intensive Point-based Object Detector for Point Cloud . arXiv preprint arXiv:1812.05276 2018.									
3	PointPillars			43.53 %	52.08 %	41.49 %	16 ms	1080ti GPU and Intel i7 CPU	<input type="checkbox"/>

semantic-8 results

We use Intersection over Union (IoU) and Overall Accuracy (OA) as [metrics](#). For more details hover the cursor over the symbols or click on a classifier. In order to sort the results differently click on a symbol.

	Name	↑A_IoU	OA	[s]	IoU 1	IoU 2	IoU 3	IoU 4	IoU 5	IoU 6	IoU 7	IoU 8
1	SPGraph_	0.762	0.929	10000.00	0.915	0.756	0.783	0.717	0.944	0.568	0.529	0.884
Large-scale Point cloud segmentation with superpoint graphs, Loic Landrieu and Martin Simonovsky, CVPR2018												
2	SnapNet	0.674	0.910	0.00	0.896	0.795	0.748	0.561	0.909	0.365	0.343	0.772
Unstructured point cloud semantic labeling using deep segmentation networks. A. Boulch, B. Le Saux and N. Audebert, Eurographics 3DOR 2017												
3	PointNet2_Demo	0.631	0.857	10000.00	0.819	0.781	0.643	0.517	0.759	0.364	0.437	0.726
https://github.com/IntelVCL/Open3D-PointNet2-Semantic3D , Yixing Lao												

1=man-made terrain
2=natural terrain
3=high vegetation
4=low vegetation

5=buildings
6=hardscape
7=noise/scanning artefacts
8=cars



Systèmes de Perception

Mobile Mapping

- Géolocalisation
- Sensors



Perception Systems of the Autonomous Vehicle

LIDAR UNIT

Constantly spinning, it uses laser beams to generate a 360-degree image of the car's surroundings.

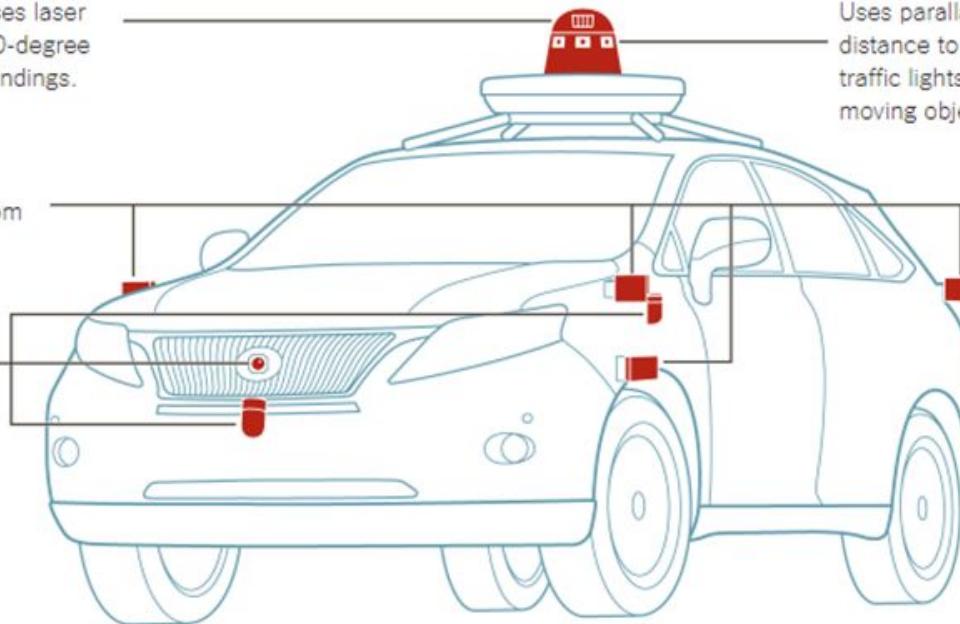
CAMERAS

Uses parallax from multiple images to find the distance to various objects. Cameras also detect traffic lights and signs, and help recognize moving objects like pedestrians and bicyclists.

RADAR SENSORS

Measure the distance from the car to obstacles.

ADDITIONAL LIDAR UNITS



MAIN COMPUTER (LOCATED IN TRUNK)

Analyzes data from the sensors, and compares its stored maps to assess current conditions.

By Guibert Gates | Source: Google | Note: Car is a Lexus model modified by Google.



Géolocalisation

Satellite GPS/GNSS

24 GPS Satellites,

72 - 80 GNSS Satellites

Accuracy:

5 - 100 cm for professional grade,

1 – 10 m recreational grade

Base Stations (SBAS/RTK)

Differential correction of

GPS/GNSS signals

Accuracy: < 1 m professional grade;

2-5 m recreational grade

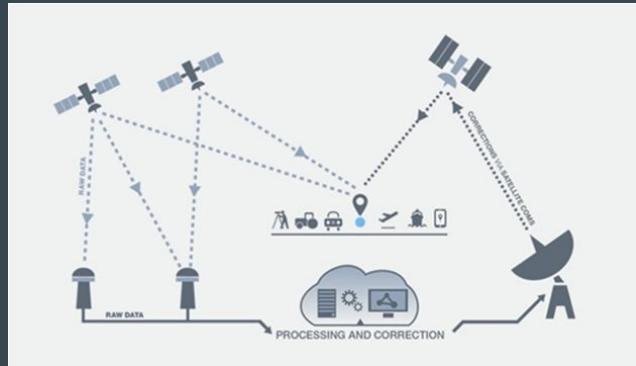
Inertial Measurement Unit/Odometer

No GPS/GNSS; Track

movements relative to reference point

Simultaneous Localization And Mapping

SLAM : Localization relative to a
reference (point or map)



Source: <http://www.ga.gov.au/scientific-topics/positioning-navigation/positioning-for-the-future>



Point Cloud Colorization



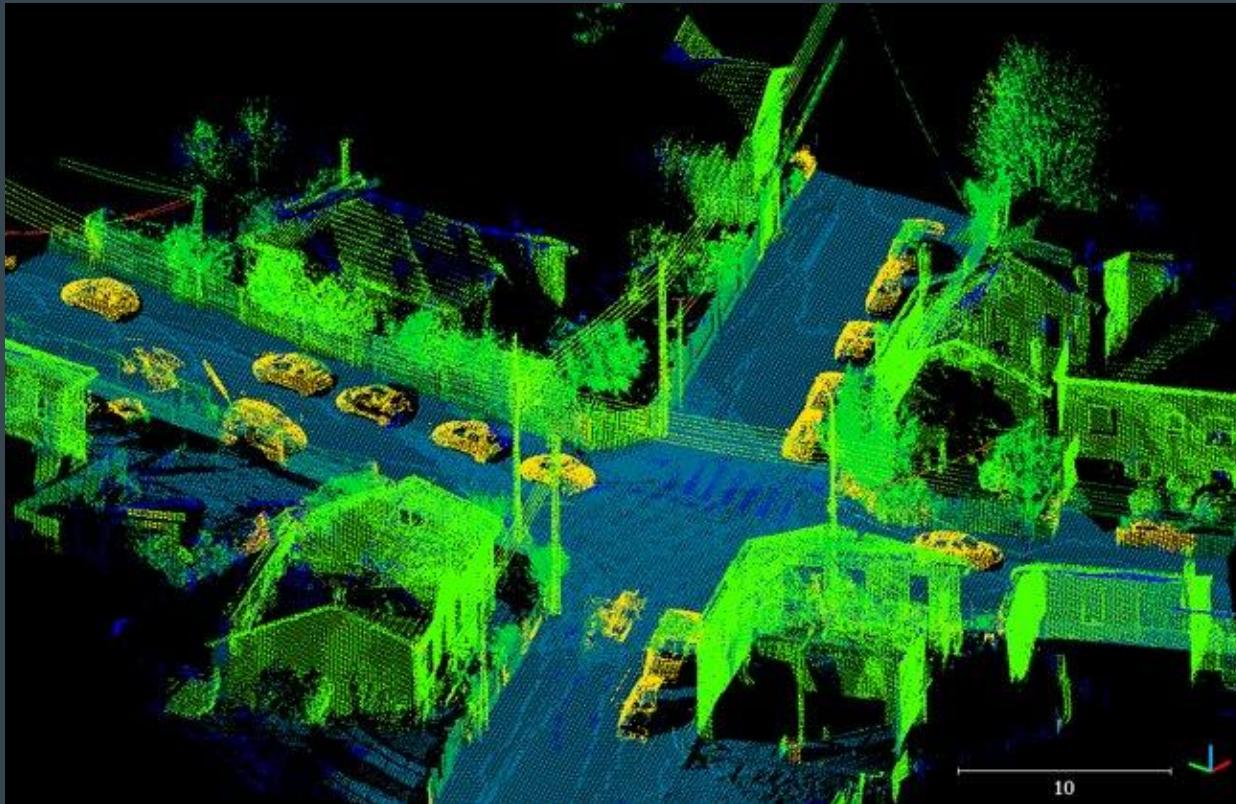
Assemblage des textures à partir des images panoramiques et du nuage de points 3D LiDAR



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Point Cloud Classification

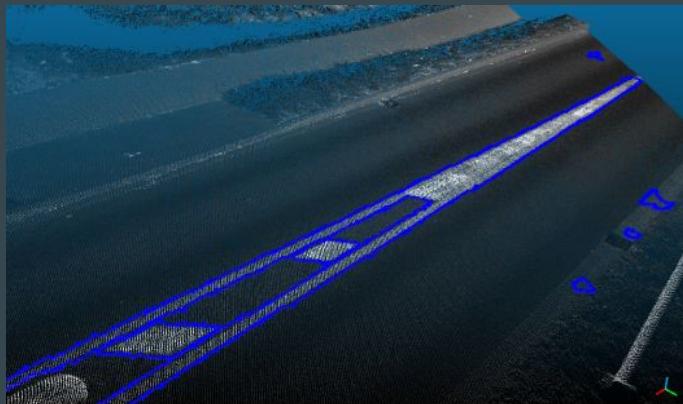
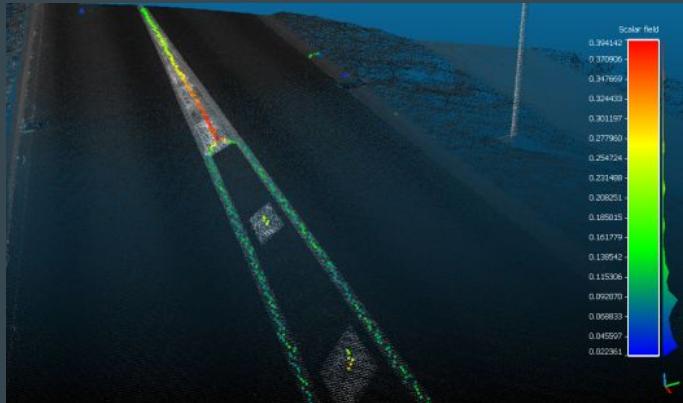
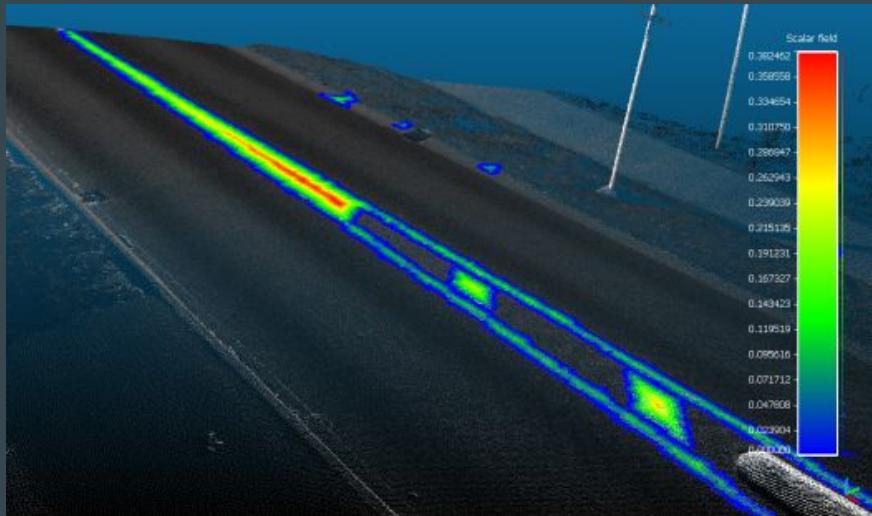


Modèle du réseau neuronal
pour segmentation et
classification



Vectorisation de Haute-Précision

De 3D à vecteur : extraction de formes



Conclusions

Computer Vision avec Nuages de Points 3D

1/ Une technologie de pointe en plein développement.

2/ Défis:

- Non-structurés => Traitements complexes
- Volumineux
- Visualisation en 3D lourde

3/ Applications en robotique, cartographie, navigation autonome, jeux vidéo, réalité virtuelle, cinéma





Thank You

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