Faculty of Information Engineering, Computer Science and Statistics

Bachelor of Science in Computer Science (L-31)

Academic Year 2021-2022

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Internship report

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Deep Learning based approach for Semantic Segmentation of Aerial Images

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Application domain

Domain of application: motivation

- Natural disasters more and **more frequent** and **more serious**
- **Floods** make up about **43%** of the total of events
- **157 thousand** victims and **2.3** billion people affected (1995-2015)
- **$ 1 billion** in damages (US in 2020)
- The provision of accurate, timely and understandable information is **fundamental** in the management of these events

Domain of application: use of UAVs

- UAVs (Unmanned Aerial Vehicles)
  they can **quickly** access the affected areas

- They can reach areas otherwise **unreachable by humans**
- Quickly deliver low-altitude, **high-resolution** images

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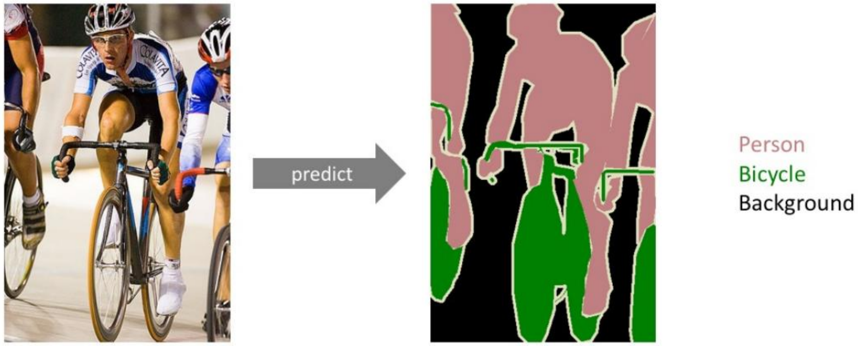
Semantic segmentation

Semantic segmentation: overview

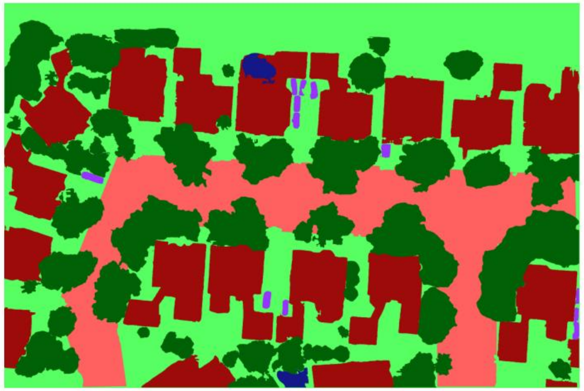
- We can define it as the **classification of each pixel** of the image in a given class
- There are both traditional methods and **methods based on Deep Learning**



FloodNet dataset

FloodNet: overview

- Published following the FloodNet Challenge of the **EARTHVISION 2021** workshop
- Captured between 30 August and 4 September 2017 in Texas (USA) immediately after the disaster caused **by Hurricane Harvey** with a DJI Mavic Pro
- **2343 images** captured at an altitude of 200 feet and with a resolution of 1.5 cm per pixel
- **9 Classes:** Flooded Building, Non-Flooded Building, Flooded Road, Non-flooded Road, Water, Tree, Vehicle, Pool, Lawn



FloodNet: main difficulties and solutions

Presence of errors in the masks → Data cleaning

Strong class imbalance → Data augmentation offline

Objects of different scale → Context-based architecture

Intrinsic difficulty of some classes → Context-based architecture

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Proposed approach

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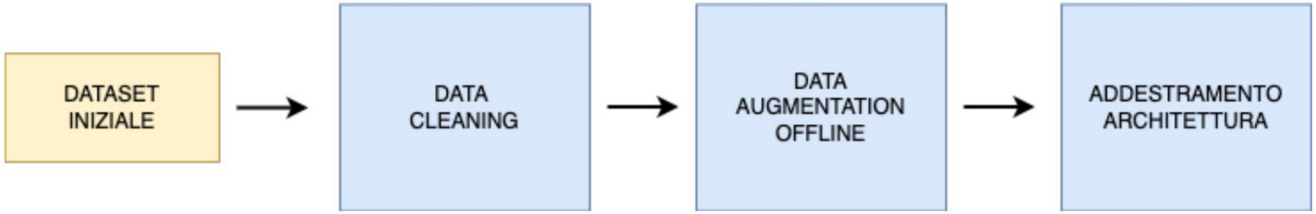
Proposed approach

- Based on three main parts:
  - **Data cleaning**
  - **Offline data augmentation**
  - **Context-based architecture**



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Proposed approach: Data cleaning

- **Cleaning** and **correction** phase of the

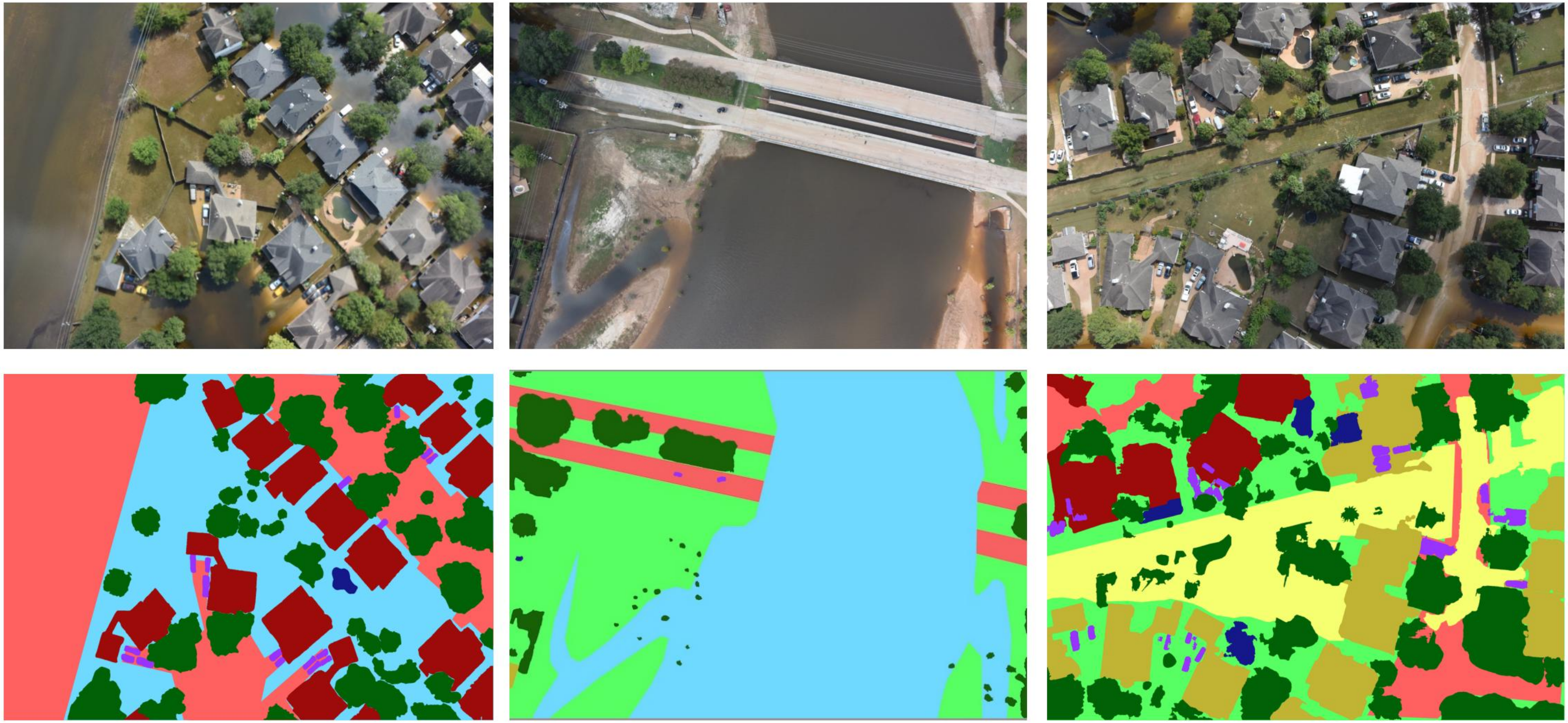
dataset • **Manual** scanning of all images and their corresponding ones masks

- **182** masks found with errors
- Three **main types** of errors found:

  - incorrect classification of pixels -

  non-occurrence of objects in the masks - presence

  of inconsistency and confusion



Proposed approach: Offline data augmentation

- **Purpose:** to **specifically** increase the number of images to cope with the imbalance of the classes
- 4 types of **transformation:** Rotation, Horizontal Flip, Vertical Flip and variation of brightness and contrast
- From each of the **140 selected images ,** three other images were produced with the corresponding mask **(+420 images)**

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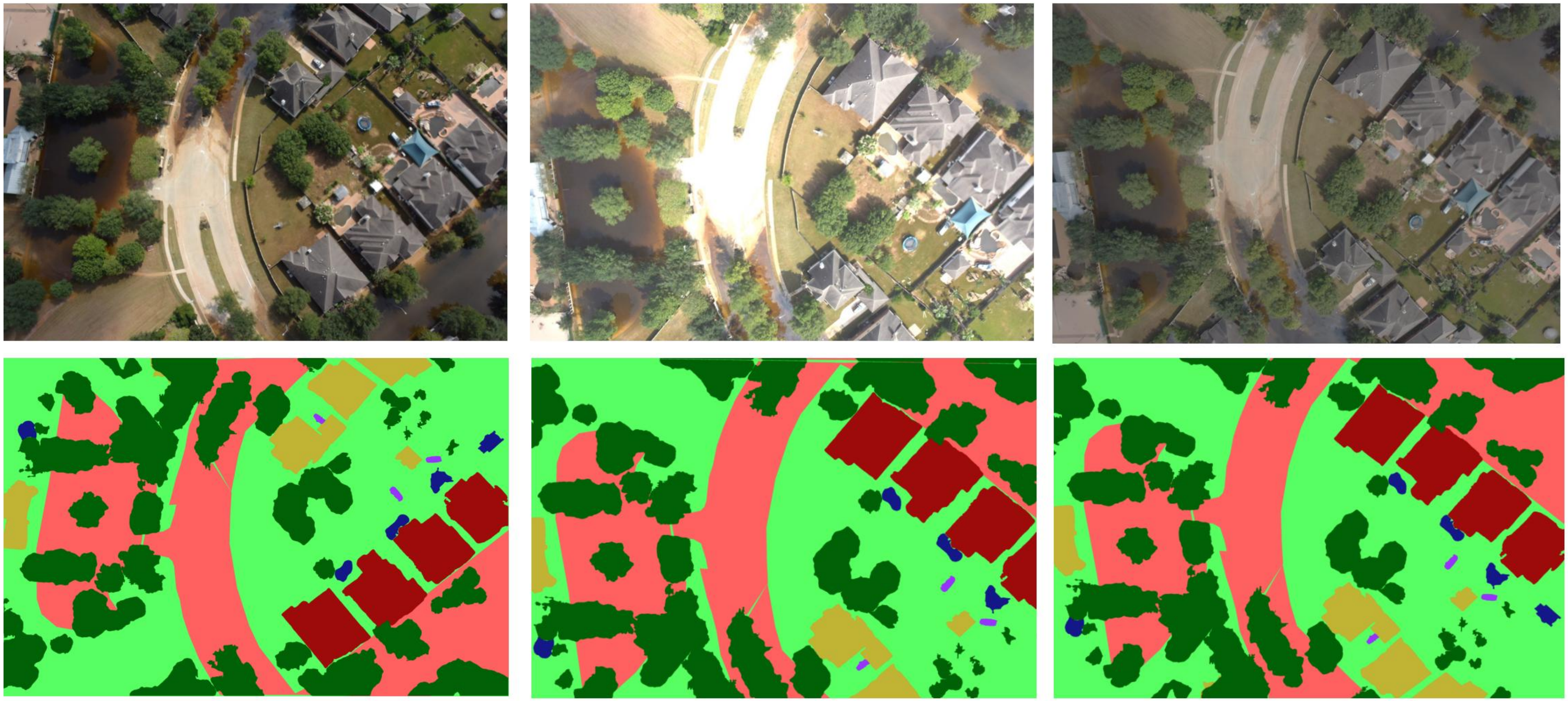
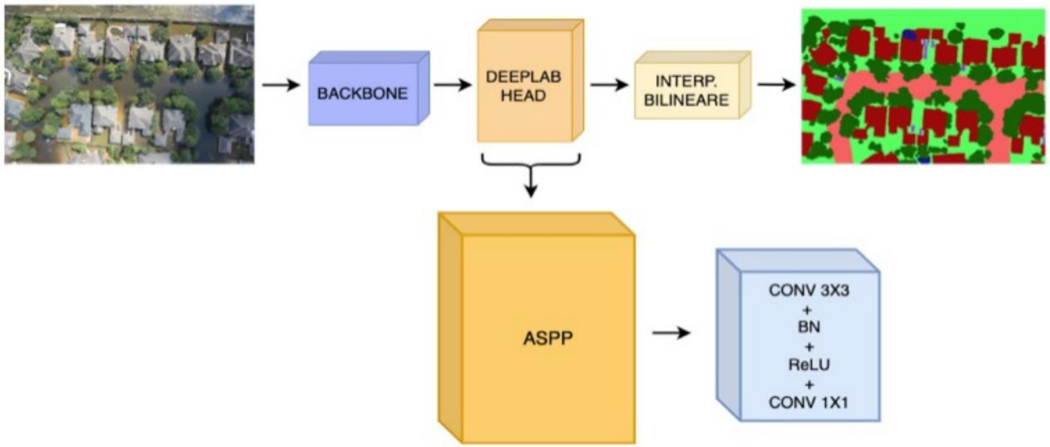
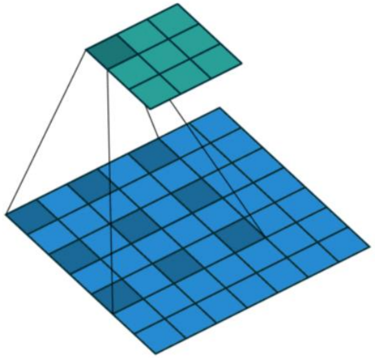


Proposed approach: Architecture

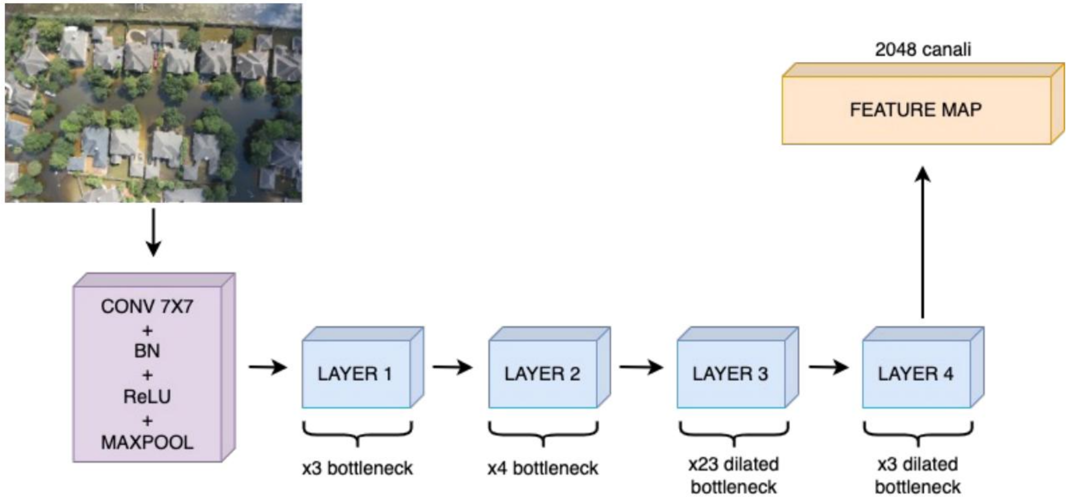
- Inspired by **DeepLabV3,** architecture proposed in 2017
- Consisting of 3 parts:
  - **Backbone**
  - **DeepLabHead (ASPP)**
  - **Bilinear interpolation**



Backbone

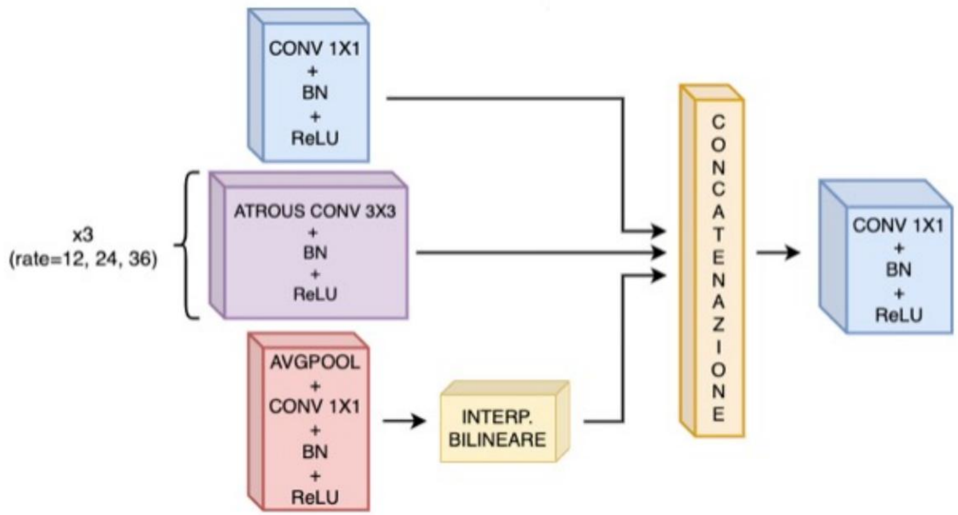


- Responsible for **feature extraction**
- Convolutional network consisting of approximately **101 layers** (inspired to **ResNet101)**
- Uses **dilated convolutions**



DeepLabHead and ASPP

- Mainly composed of **ASPP (Atrous Spatial Pyramid Pooling)**
- Inspired by SPP (Spatial Pyramid Pooling)
- The main idea is to capture **contexts at different scales** using different convolutions **in parallel**



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Hardware resources

Hardware limitations

- Hardware resources have been a major **obstacle** to work
- The Google Colab platform was used
- Very **limited** availability : 3/5 hours a day

Experiments and Results

Experiments

- **Hyperparameters** in common between all experiments:
  - Adam
  - Batch size = 2
  - Learning Rate = 0.01 (except for the last experiment)
  - Split dataset: 60% for training, 20% for validation and 20% for testing

- **1 ^ exp:** baseline (600 * 800)

Classe 1	Classe 2	**Classe 3**	Classe 4	Classe 5	Classe 6	**Classe 7**	**Classe 8**	Classe 9	**mIoU**
0.0018	0.087	**0.0002**	0.28	0.14	0.339	**0.006**	**0.0**	0.309	**0.129**

- **2 ^ exp:** + Data augmentation online (600 * 800)

Classe 1	Classe 2	**Classe 3**	Classe 4	Classe 5	Classe 6	**Classe 7**	**Classe 8**	Classe 9	**mIoU**
0.0003	0.12	**0.001**	0.27	0.23	0.38	**0.0**	**0.03**	0.52	**0.175**

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Experiments

- **3 ^ exp:** + Data cleaning (750 * 1000)

Classe 1	Classe 2	**Classe 3**	Classe 4	Classe 5	Classe 6	**Classe 7**	**Classe 8**	Classe 9	**mIoU**
0.14	0.47	**0.06**	0.48	0.46	0.55	**0.34**	**0.26**	0.81	**0.402**

- **4 ^ exp:** + Data augmentation offline (750 * 1000)

Classe 1	Classe 2	**Classe 3**	Classe 4	Classe 5	Classe 6	**Classe 7**	**Classe 8**	Classe 9	**mIoU**
0.32	0.51	**0.24**	0.55	0.55	0.6	**0.4**	**0.44**	0.84	**0.5**

- **5th exp:** + Dynamic learning rate

Classe 1	Classe 2	**Classe 3**	Classe 4	Classe 5	Classe 6	**Classe 7**	**Classe 8**	Classe 9	**mIoU**
0.41	0.60	**0.32**	0.6	0.57	0.65	**0.49**	**0.52**	0.86	**0.564**

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Results and comparison with other works of the State of the Art

- **Comparison:**

  - their version of the dataset has **857** more images **(+ 36%)**

  - Continuous availability of computational resources

Modello	**Classe 1**	Classe 2	Classe 3	Classe 4	Classe 5	Classe 6	**Classe 7**	**Classe 8**	**Classe 9**	mIoU
ENet	**0.069**	0.473	0.124	0.484	0.489	0.683	**0.322**	**0.424**	**0.762**	0.426
DeepLabV3+	**0.327**	0.728	0.52	0.7	0.75	0.77	**0.42**	**0.47**	**0.84**	0.61
Approccio proposto	**0.41**	0.60	0.32	0.6	0.57	0.65	**0.49**	**0.52**	**0.86**	0.564

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Thanks for your attention!

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