Understanding Clouds from Satellite Images

Department of Computer Science
Illinois Institute of Technology
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Jorge Gonzalez - A20474413
Luis Cavanillas - A20474430

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Problem statement

Problem Statement

Build a deep learning to model to detect four types of shallow cloud formations in satellite images (*Sugar*, *Flower*, *Fish* and *Gravel*).

Motivation

Improve the physical understanding of cloud formations and help build better climate models.

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Background materials

Main Source

Rasp, S., Schulz, H., Bony, S., & Stevens, B. (2020). Combining crowdsourcing and deep learning to explore the mesoscale organization of shallow convection. Bulletin of the American Meteorological Society, 101(11). doi:10.1175/bams-d-19-0324.1

Two different approaches for cloud detection:

1. Object detection: draws bounding boxes around the cloud formations.
2. Semantic segmentation: classifies every pixel of the image, assigning them a category depending on the cloud formation.
    - The model used is a U-Net with a ResNet50 backbone.

Secondary source

Ronneberger, O., Fischer, P., & Brox, T. (2015). U-Net: Convolutional networks for biomedical image segmentation. Lecture Notes in Computer Science, 234-241. doi:10.1007/978-3-319-24574-4_28

They design and describe a model network used for semantic segmentation: U-Net.

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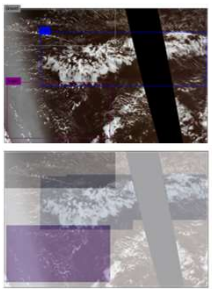
Proposed solution

Semantic segmentation:

It is a form of pixel-level prediction by clustering parts of an image together which belong to the same object class.

A mask is a representation of the target as an image where a specific class is present.

Initially a single mask overlaying all the clouds in an image was designed.



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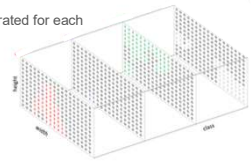
Proposed solution

Due to the poor initial results obtained:

Further research on segmentation models and the development of a mask with a depth of 4 channels, one for each type of cloud.

Therefore, a total of 4 masks are generated for each model.



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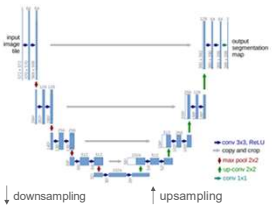
Proposed solution

Network proposed in the paper:

U-Net with a Resnet50 Backbone

1. We have built and trained the original U-Net from scratch.
2. We have trained and used the pretrained U-Net with the Resnet50 Backbone.
3. Multiple results have been obtained and compared.



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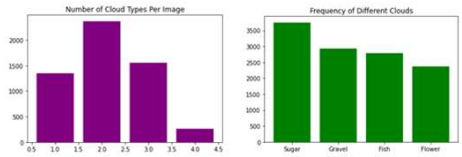
Implementation details

- Initial analysis of the data



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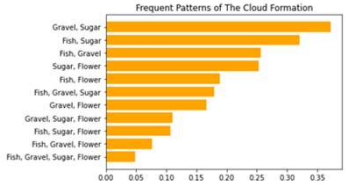
Implementation details

- Initial analysis of the data



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Implementation details

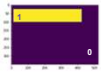
- Pre-processing

Images (and masks) have been resized to 256 x 256 pixels.

Masks have been created for each image as a binary map:

1 : When the pixel contains the cloud formation

0 : When the pixel does not contain the cloud formation.



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Implementation details

- Image Generators and yield functions have been used.

- Results of hyper-parameter tuning:
  - Adam Optimizer
  - Output function: 'Sigmoid' (pixels normalized between 0 and 1)
  - Batch size: 16
  - Loss: binary cross entropy + dice loss (measure of overlap between images)
  - Epochs:
    - Our model: 100 epochs (very long training time)
    - Pretrained model: 20 epochs.

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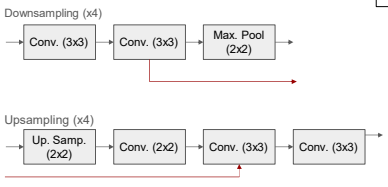
Implementation details

- Network

Number of filters
[64, 128, 256, 512]

Padding: same

Activation: 'ReLu'



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Results

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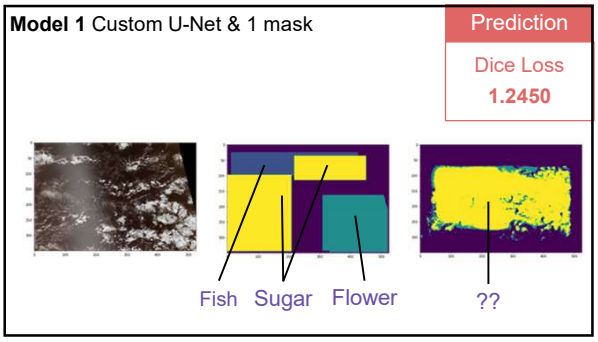
Model 1 Custom U-Net & 1 mask
Prediction
Dice Loss
1.2450
Fish
Sugar
Flower
??

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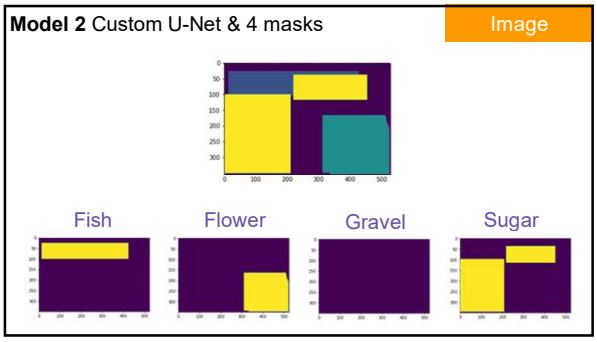
Model 2 Custom U-Net & 4 masks
Image
Fish
Flower
Gravel
Sugar

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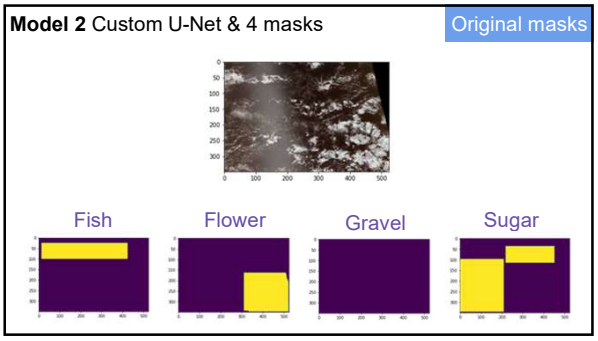
Model 2 Custom U-Net & 4 masks
Original masks
Fish
Flower
Gravel
Sugar

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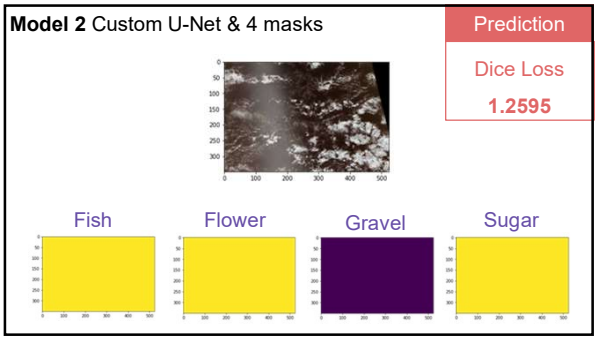
Model 2 Custom U-Net & 4 masks
Prediction
Dice Loss
1.2595
Fish
Flower
Gravel
Sugar

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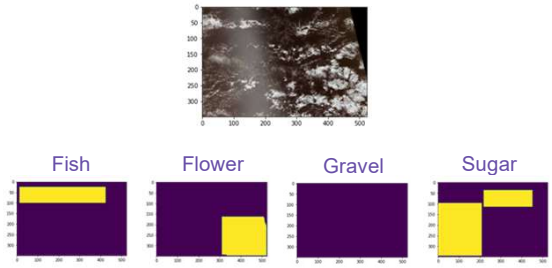
Model 3: Pre-Trained U-Net & 4 masks

Original masks



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Model 3: Pre-Trained U-Net & 4 masks

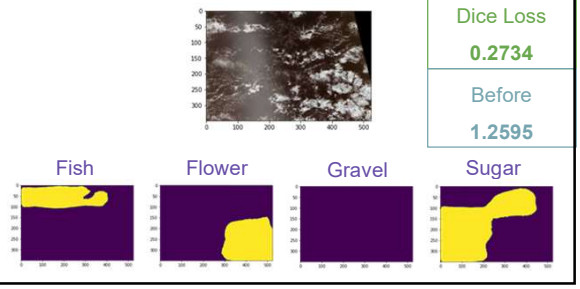
Prediction

Dice Loss

0.2734

Before

1.2595



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Conclusions

- Understand the data before training (pre-processing)!
- Use multiple image masks in semantic segmentation!
- Use generators and yield functions to prevent RAM overflow!
- Transfer learning is a great solution when limited resources are available.

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Q & A

Thank you for your time !

Any questions?

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