Semantic Segmentation of Jet Fire Temperature Zones using Deep Learning

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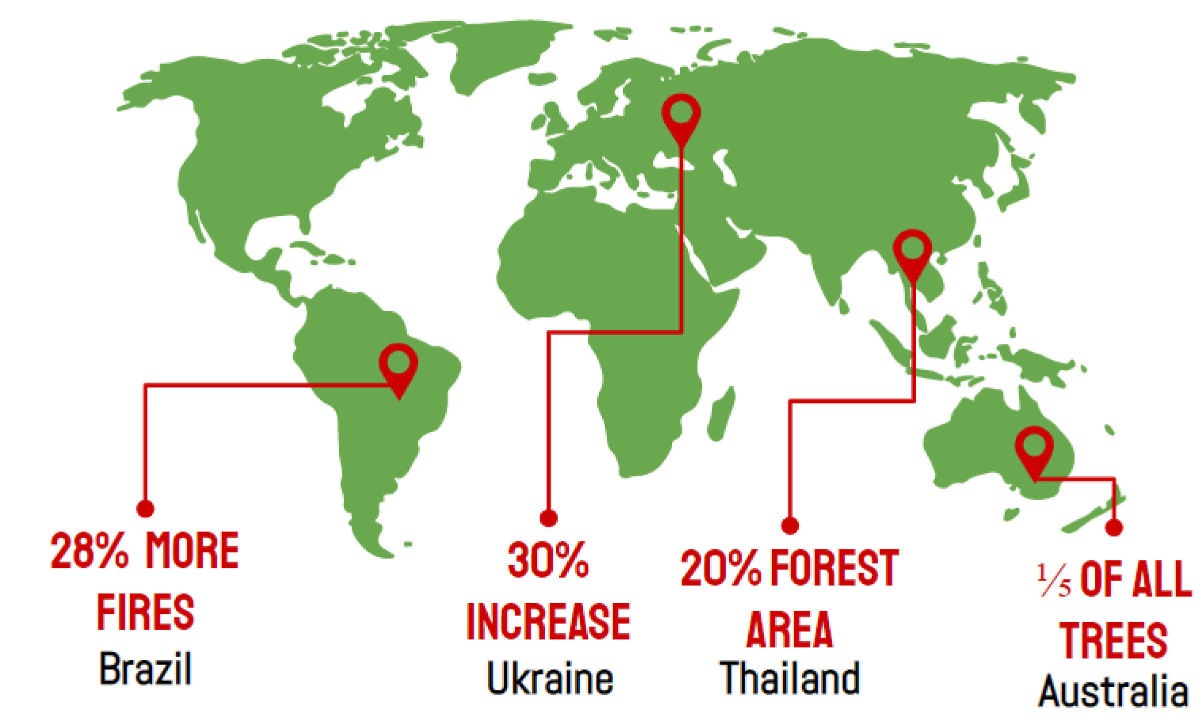
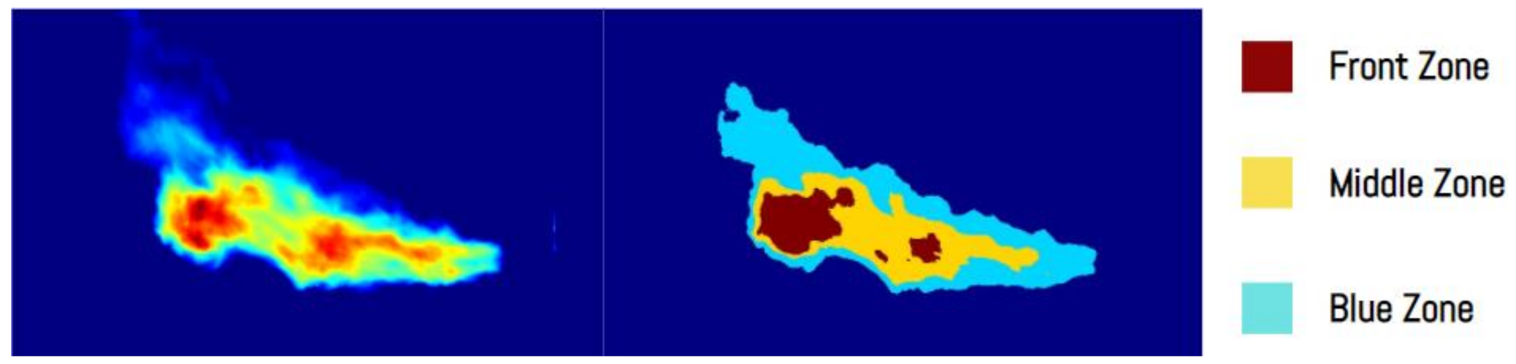
1. Context and Motivation



With the increase in both the occurrence and severity of wildfires, this work is meant to be a part of a developing project to create **an Internet of Things and Artificial Intelligence-based system for the detection of wildfires**, which will be implemented in a local forest.

One task that the system must be able to perform is the **segmentation of infrared images of fire into three zones delimited by temperature** illustrated in this image.



Recently, **Deep Learning** architectures, such as **Convolutional Neural Networks (CNNs)**, have been surpassing other approaches in the area of image semantic segmentation. However, their use in the extraction of fire's geometric characteristics is an application yet to be explored and, in consequence, presents a lack of information about the performance for these kinds of tasks.

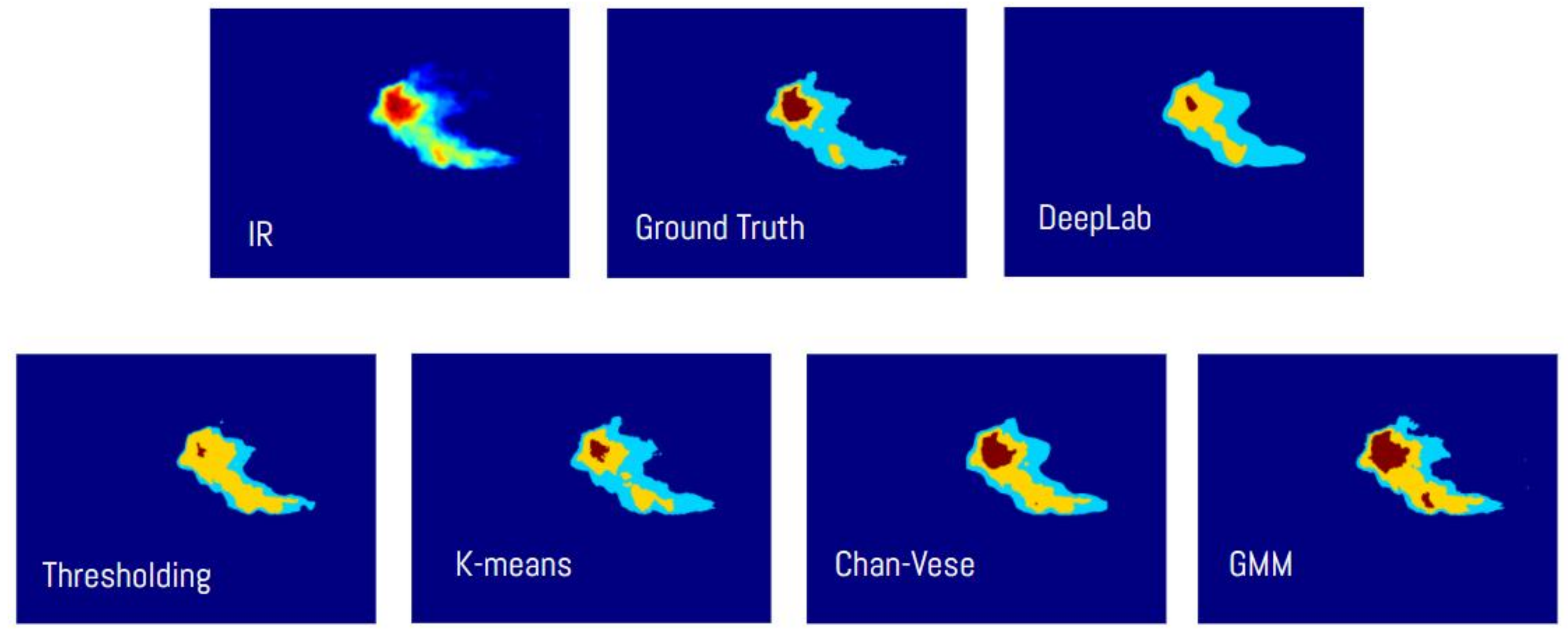
2. Testing Method

Considering this area of opportunity, we employed a CNN model, called **DeepLab**, for this segmentation task and compared its performance with other traditional segmentation approaches.

The data used for testing is from a data set of jet fire images provided by **Universitat Politécnica de Catalunya**. The data sample has 201 infrared images of jet fire, along with their respective temperature zones, segmented by experts to serve as ground truth.

We also implemented four image processing methods for the comparison against the DeepLab model. The four implemented methods are **Thresholding**, **K-Means segmentation**, **Chan-Vese algorithm**, and the **Gaussian Mixture Model**, abbreviated as GMM.

This is a sample visualization for each method.



To evaluate the resulting segmentation, we used the metrics of **Jaccard Index**, also known as Intersection Over Union (IoU), where a value **closer to 1 is better**, and the **Hausdorff distance**, where a **smaller value is better**. The table in this slide shows the average results for the 201 images, as well as the **time** each method took to generate all 201 segmentation masks.

3 Results and Discussion

The preliminary results show good performance in the Jaccard Index, more than in the Hausdorff distance, with the image processing methods showing better results than the DeepLab model.

It is relevant to note, however, that **the accuracy of Convolutional Neural Networks is highly dependant on the amount of labeled data** available. With the small quantity of 201 images, the results given by the DeepLab model show an impressive potential for the segmentation of the desired temperature zones.

Method	Hausdorff distance	Jaccard index	Time (s)
Thresholding	1055.1144	0.9227	30.68
K-means	981.8209	0.9180	3035.14
Chan-Vese	1053.8230	0.9162	18177.50
GMM	1253.0706	0.9218	2723.80
DeepLab	1632.5507	0.8836	568

Further testing is currently being done to improve on these results, with a focus on finding the best **feature extraction model** and **loss function** for this problem, performing different class **weight initializations**, **normalizing the images**, and enlarging the dataset with **data augmentation**.

DeepLab 2° Test	1022.7906	0.9645	38