Application of UAVs for Real-Time Detection and Monitoring of Forest Fires

Next steps: Qu’est-ce qui n’existe pas ?

* Improve accuracy on image detection : change the model?
* Test the algorithm on video
* Evaluate the camera-fire distance
* Map hot spots (2D)
* Implement fire propagation model
* Use an algorithm to deploy a squad of 2 drones
* Additional research: data augmentation (most efficiency for a 50% augmentation)

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1. Introduction

1.1 Présentation du contexte des feux de forêt et de leur impact sur l'environnement et les ressources forestières

1.2 Limites des systèmes traditionnels de lutte contre les incendies

1.3 Introduction des technologies de drones comme solution potentielle

2. State of the art

2.1 History of the use of drones in environmental monitoring

2.1.1 Satellite Detection

Satellites are considered the most used remote sensing technology for many forestry applications. Several studies have adopted satellite imagery to detect wildfires and fire smoke in forest regions, which could help to reduce their risks. However, satellite-based images are not the best solution for early forest fire detection due to the low spatial resolution making small fire spot detection very difficult or impossible in most cases. The satellites’ temporal resolution is another major limitation that restricts forest monitoring efficacity, where they are not always available to provide continuous information about the forest state. Moreover, cloudy and bad weather conditions prevent satellites to collect clear data of the forests.

2.1.2 UAVs Detection

Optical cameras still facing several issues, where it is impossible to detect wildfire smoke at nighttime and very hard to detect wildfire flames in dense forests that could be hidden by high trees. Moreover, visible camera sensors are very sensitive to environmental conditions, such as sunlight angle, clouds, and shadows.

However, thermal cameras mounted on UAV platforms could solve several limitations of optical cameras, but they come with their challenges and limitations, including thermal distance problems and low spatial resolution. Nevertheless, thermal cameras turn UAVs into an impressive tool that is independent of light and able of detecting covered wildfire flames through the thermal radiation emitted by the fire within Middle Wavelength InfraRed (MWIR) and Long Wavelength InfraRed (LWIR) spectral ranges.

Combining data gathered from thermal and optical, or other types of sensors, is another solution for accurate early wildfire detection. Recently, sensor fusion has emerged as one of the most important topics that are widely used in different fields, including autonomous vehicles, agriculture applications, and even wildfire detection from UAV platforms. This discipline can improve the early wildfire detection accuracy by combining the information collected through multiple types of sensors.

Research found difficulties in implementing efficient detection with Supervised Learning (SL) because these techniques need field experts to select the valuable features. On the other hand, Deep Learning (DL) algorithms can extract relevant and strong features automatically (especially CNN, Tensorflow, PyTorch).  
  
Deep Learning Algorithms:

* Wildfire image classification
* Wildfires detection based on object detection algorithms
* Semantic segmentation-based wildfires detection

However, these techniques need a very large amount of data and high processing power in the training process.

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| --- | --- |
| **Image Classification** | **Principle** |
| AlexNet |  |
| GoogLeNet |  |
| VGG-13 |  |
| SVM-RAW |  |
| SWM-Pool5 |  |
| CNN-RAW |  |
| DenseNet |  |

|  |  |
| --- | --- |
| **Object Detection** | **Principle** |
| YOLO |  |
| SSD (ResNext) |  |
| R-CNN |  |
| Color |  |
| Multi-space Local Binary Pattern (LBP) |  |
| (SVM) |  |
| Bayes classifier |  |
| CS-ResNext50-Panet-SPP |  |
| Haar |  |

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| --- | --- |
| **Semantic Segmentation** | **Principle** |
| DeepLabV3+ |  |
| FireNet |  |
| U-Net |  |

Generative Adversarial Network (GAN)

Deep Belief Network (DBN)

2.2 Examples of successful applications in forest wildfire detection

2.3 Technological advances in drones and their potential impact

3. Méthodologie

3.1 Description du type de drone et de ses caractéristiques techniques.

3.2 Protocole de déploiement des drones pour la détection des feux.

3.3 Méthodes de collecte et d'analyse des données.

4. Étude de Cas et Résultats Expérimentaux

4.1 Présentation d'une étude de cas spécifique où les drones ont été utilisés.

4.2 Analyse des données recueillies et résultats obtenus.

4.3 Comparaison avec les méthodes traditionnelles de détection.

5. Discussion

5.1 Avantages et limites de l’utilisation des drones.

5.2 Implications pour la gestion et la prévention des feux de forêt.

5.3 Suggestions pour des recherches futures.

6. Conclusion

6.1 Résumé des découvertes principales.

6.2 Réflexion sur l'impact de ces technologies.

6.3 Perspectives d’avenir pour l’utilisation des drones.

7. Vocabulary

* VTOL : A Vertical Take-Off and Landing aircraft is one that can take off and land vertically without relying on a runway

8. References