





Intelligent Monitoring and Management Platform for the Prevention of Olive Pests and Diseases, Including IoT with Sensing, Georeferencing and Image Acquisition Capabilities Through Computer Vision

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Abstract. Climate change affects global temperature and precipitation patterns. These effects, in turn, influence the intensity and, in some cases, the frequency of extreme environmental events, such as forest fires, hurricanes, heat waves, floods, droughts, and storms. In general, these events can be particularly conducive to the appearance of plant pests and diseases. The availability of models and a data collection system is crucial to manage pests and diseases in sustainable agricultural ecosystems. Agricultural ecosystems are known to be complex, multivariable, and unpredictable. It is important to anticipate crop pests and diseases in order to improve its control in a more ecological and economical way (e.g., precision in the use of pesticides). The development of an intelligent monitoring and management platform for the prevention of pests and diseases in olive groves at Trás-os-Montes region will be very beneficial. This platform must: a) integrate data from multiple data sources such as sensory data (e.g., temperature), biological observations (e.g., insect counts), georeferenced data (e.g., altitude) or digital images (e.g., plant images); b) systematize these data into a regional repository; c) provide relevant forecasts for pest and diseases.

Convolutional Neural Networks (CNNs) can be a valuable tool for the identification and classification of images acquired by Internet of Things (IoT).

Keywords: Olives sustainable production · Internet of Things · Convolutional neural network · Deep learning · Computer vision

1 Computer Vision and Deep Learning for Prevention of Olive Pests and Diseases

The project will develop an Intelligent monitoring and management platform for prevention of pests and diseases in olive groves, including IoT with sensing, georeferencing and image acquisition capabilities through computer vision. In recent years computer vision has been, combined with intelligent technology such as deep learning technology, applied to every aspect of agricultural production management.

As already mentioned, this study will focus on olive disease prevention. According to Tian, Wang, Liu, Qiao and Li, "... computer vision technology has been well applied in the prevention and control of agricultural pests and diseases, and its high efficiency, high precision and low cost are its main features" [1]. According to Liu and Wang "Object positioning is one of the most basic tasks in the field of computer vision. It is also the closest task to plant diseases and pests detections in the traditional sense. Its purpose is to obtain accurate location and category information of the object. At present, object detection methods based on deep learning emerge endlessly" [2].

According to Dokic, Blaskovic and Mandusic "The development of artificial intelligence and machine learning in the last decades has led to a significant increase in the number of projects in the field of agriculture" [3]. Specifically for prevention and control of crop diseases, pests and weeds, many papers were published demonstrating the application of computer vision and deep learning on agriculture (e.g. Maharlooei et al. [4], Liu and Chahl [5], Zhong et al. [6]).

2 Deep Learning – Definition and Convolutional Neural Network

According to IBM, "Deep learning is a subset of machine learning, which is essentially a neural network with three or more layers. These neural networks attempt to simulate the behavior of the human brain allowing it to 'learn' from large amounts of data" [7].

According to Alzubaidi L. et al. "In the field of DL, the CNN is the most famous and commonly employed algorithm. The main benefit of CNN compared to its predecessors is that it automatically identifies the relevant features without any human super-vision. CNNs have been extensively applied in a range of different fields, including computer vision (...)" [8]. The CNN with best performance will be sought, taking into account its limitations and the characteristics of the data collected by IoT devices in the olive groves of Trás-os-Montes region.

When deploying DL, several limitations must be taken into consideration:

- DL requires a large amount of data to achieve a good model performance.
- When trained with unbalanced data (classification data with skewed class proportions), DL can produce undesired results.
- DL models may be of "black box" type, that is, the model produces predictions, but it is not known how these predictions are produced and which factors most influence them. This happens in complex models that capture relationships that are not necessarily linear. The interpretability of the data can be important.

- When classifying problems by applying DL, the predicted probabilities (*softmax* output) are assumed to represent the true probability of correctness for the predicted class. The loss of connection between model prediction probabilities and the confidence of model predictions would prevent the application of modern neural network models to real-world problems.
- When a DL model continuously learns over time by incorporating new information, it usually quickly replaces previously learned knowledge, leading to the deterioration of the performance of the DL model (catastrophic forgetting).
- DL models make intensive use of memory and processing resources due to their high complexity and large number of parameters involved.
- DL models have excessively high chances of fitting the data set used in training very well, but resulting in a reduced ability to achieve a good performance on tested data (data overfitting at the training stage).
- The Gradient Dissipation and Gradient Explosion problems occur in artificial neural networks trained using back-propagation and gradient-based learning. In these networks, gradients are used to update the weights. These problems occur, respectively, when the gradient becomes incredibly small or grows exponentially.
- DL models often exhibit poor behavior when tested in the real world due to under-specification. To address this limitation, stress testing can be used.

3 Development of the Intelligent Monitoring and Management Platform

Implementation of platforms to be used by stakeholders of the olive crop implies the following tasks: a) requirements definition; b) system analysis; c) platform development testing and deployment. The platform must be developed according to a rapid prototyping process and the generated prototypes will be iteratively tested by stakeholders (producers, associations of growers, government entities, R&D entities, etc.) and consequently developed.

The platform must be modular with advantages in terms of code reuse, productivity, cost reduction, and increased quality [9].

The platform will be developed in a client/server architecture accessible through the web using PCs or mobile devices.

The database management system (DBMS) used by the platform will be non-relational, also known as NoSQL. According to Amghar *et al.*, “At every moment a large amount of data is generated by connected devices - Internet of Things (IoT). This data is difficult to handle using traditional databases, inducing the use of NoSQL databases. These databases have achieved great popularity, thanks to their good performance, their flexibility and scalability, and their high availability” [10].

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References

1. IBM Cloud Education, Deep Learnig. <https://www.ibm.com/cloud/learn/deep-learning>. Acessado em 9 junho 2021
2. Alzubaidi, L., et al.: Review of deep learning: concepts, CNN architectures, challenges, applications, future directions. *J. Big Data* **8**(53), 1–74 (2021)
3. Amghar, S., Cherdal, S., Mouline, S.: Which NoSQL database for IoT applications. In: *International Conference on Selected Topics in Mobile and Wireless Networking* (2018)
4. Dokic, K., Blaskovic, L., Mandusic, D.: From machine learning to deep learning in agriculture – the quantitative review of trends. In: *ICECAE 2020 – earth and Environmental Sciences* (2020)
5. Sun, H., Ha, W., Teh, P.-L., Huang, J.: A case study on implementing modularity in software development. *J. Comput. Inf. Syst.* (2015). <https://doi.org/10.1080/08874417.2016.1183430>
6. Maharlooei, M., Sivarajan, S., Bajwa, S.G.: Detection of soybean aphids in a greenhouse using an image processing technique. *Comput. Eletron. Agric.* **132**, 63–70 (2017)
7. Liu, H., Chahl, J.S.: A multispectral machine vision system for invertebrate detection on green leaves. *Comput. Electron. Agric.* **150**, 279–288 (2018)
8. Zhong, Y., Gao, J., Lei, Q.: A vision-based counting and recognition system for flying insects in intelligent agriculture. *Sensors* **18**(5), 1489 (2018)
9. Tian, H., Wang, T., Liu, Y., Qiao, X., Li, Y.: Computer vision technology in agricultural automation – a review. *Inf. Process. Agric.* **7**(1), 1–19 (2020)
10. Liu, J., Wang, X.: Plant diseases and pests detection based on deep learning: a review. *Plant Methods* **17**, 17–22 (2021)