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Embedded ANN-Based Forest Fire Prediction Case Study of Algeria

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ABSTRACT

One of the major environmental challenges is forest fires. Each year millions of hectares of forest are destroyed throughout the world, resulting in economic and ecological damages, as well as the loss of human life. Therefore, predicting forest fires is of great importance for governments. However, there is still limited study on this topic in Algeria. In this paper, the authors present an application of artificial neural networks to predict forest fires in embedded devices. They used meteorological data obtained from wireless sensor networks. In the experimentation, nine machine learning model are compared. The findings from this study make several contributions to the current literature. First, the model is suitable for embedded and real-time training and prediction. Moreover, it should provide better performance and accurate prediction against other models.

KEYWORDS

Embedded Machine Learning, Forest Fires Prediction, Meteorological Data, Neural Networks

INTRODUCTION

Forest fires are among the worst natural catastrophes because of their fast spread and lack of controllability. As a result, forest fire prevention has become a major concern in the disciplines of forestry and ecology. Algeria is a country located on the southern rim of the Mediterranean Basin. It is highly affected by forest fires and each year millions of forest hectares (ha) are destroyed. Forest fires are usually due to a climate favorable to ignition, propagation and the abundance of combustible materials such as shrublands and woods (Curt et al., 2020). The 2020 fire season was especially dramatic, hectares were burnt by 3,493 hot spots, of which 38 percent were forests (representing 16,570 hectares), 32 percent were bushes, and 30 percent were vegetation. Algeria is the fourth most impacted country among those covered by the European Forest Fire Information System (EFFIS) (San-Miguel-Ayanz et al., 2017).

Early fire prediction and detection are critical steps that will greatly decrease the disaster's damage and firefighting efforts. Many techniques have been developed, including approaches that use satellite images, historical weather data and computational fluid dynamics. Although many machine learning models (ML) have been used to predict forest fires (Abid, 2021), to the best of the authors' knowledge, only a few references in the literature systematically describe the effect of using these models on embedded devices. This was the motivation behind the present study.

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Neural Network models that use meteorological data are known to influence forest fires. These data are detected by wireless sensor networks (WSNs). Therefore, they may be collected in real-time at very low costs compared to satellite and scanner data. The adoption of WSNs data can help to eliminate false positives produced by transient changes in a single sensor's output. Furthermore, the multiple data fusion technique reduces communication costs while also conserving energy.

This article makes the following key contributions:

1. The researchers present an overview of state-of-the-art fire prediction techniques based on WSN sensors and machine learning.
2. Using two WSN datasets, they investigate and compare the performance of nine Machine Learning algorithms.
3. The models are compared and evaluated based on Accuracy, F-score, AUC-ROC, memory consumption, training and prediction times.
4. The authors propose an embedded forest fire prediction model based on ANN using the results obtained from comparisons.

The following section discusses the related work. Section 3 primarily covers the proposed work. Section 4 presents the results of the performance evaluation of classification models and their comparative analysis. Finally, Section 5 summarises the conclusion and future scope of this work.

RELATED WORK

In this study, the authors investigated at several approaches proposed for the forest fire prediction. There have been several works in the literature conducted using machine learning models (Abid, 2021). The ML models that have been adopted in this context are Artificial Neural Networks (ANN) (Yan et al.,2016; Liu et al., 2011;Yu et al., 2005; Hefeeda & Bagheri, 2007), logistic regression (Chang et al., 2013; Catry et al., 2009; Chuvieco et al., 2009; Kalabokidis et al., 2002; De Vasconcelos et al., 2001), decision tree (DT) and trees-based models (Giuntini et al., 2017; Pourtaghi et al., 2016; Maksimović et al., 2013; Oliveira et al., 2012; Stojanova et al.,2010; Lozano et al.,2008; Prasad et al., 2006).

Researchers have concentrated their efforts on applying artificial intelligence into forest fire models, particularly in WSN and UAV-based forest fire monitoring systems. Therefore, the intention of the present work is to investigate Neural Network-based approaches for forest fire prediction and approaches using wireless sensor networks (WSNs) data on embedded devices.

Yan et al. (2016) have proposed a real time fire identification using a multilayer ANN with a multi-sensor WSN. A data set of 1160 samples collected from three sensors (smoke, CO2 and temperature) is adopted to train the ANN model. The obtained accuracy was about 82.5%. Liu et al. (2011) have suggested a WSN based forest fires multi-criteria detection system. The authors used a multiple layer back propagation ANN and focused on the impact of the distance between the sensor node and a fire on the model prediction. The results revealed that the accuracy was about 90% for a distance of 10 cm and 40% for a distance of 20 cm. Another fire detection system was introduced in Yu et al. (2005). They have adopted a multilayer perceptron (MLP) model and sensor nodes such as temperature, relative humidity, smoke and wind speed. The model returns The fire weather index (FWI) that estimates the fire occurrence probability. They argue that their proposed approach can save energy and prolong the lifetime of the WSN. Hefeeda and Bagheri (2007) a forest fire detection system was modeled as a k-coverage model. The system computes the Fine Fuel Moisture Code FFMC and FWI values and sent them to the processing center for action.

In addition to the studies previously mentioned, Abid & Nouma (2020) considered the use of the decision tree classifier and WSN technology for forest fire prediction. The study used meteorological