UNIVERSIDADE D
COIMBRA

Nuno Pires

Intelligent system for localising and monitoring forest fires

Dissertation in the context of the Master in Informatics Engineering, specialization in Information Systems, advised by Professor Alberto Cardoso and Professor Jacinto Estima and presented to the Department of Informatics Engineering of the Faculty of Sciences and Technology of the University of Coimbra.

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SISTEMA INTELIGENTE PARA LOCALIZAÇÃO E MONITORIZAÇÃO DE INCÊNDIOS FLORESTAIS

Dissertação no âmbito do Mestrado em Engenharia Informática, especialização em Sistemas de Informação, orientada pelo Professor Alberto Cardoso e Professor Jacinto Estima e apresentada ao Departamento de Engenharia Informática da Faculdade de Ciências e Tecnologia da Universidade de Coimbra.

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Abstract

Fire can have disastrous consequences. Decision-support systems play a central role in dealing with forest fires. Its early warning capacity and real-world impact help to protect forests, species, and communities from wildfire.

The presented work proposes a system for forecasting and monitoring forest fires using multiple data sources. Data fusion, aggregation, and enhancement techniques are also mentioned.

The main purpose of the system is to provide important information for emergency decision-making, such as the geolocation, severity, and temporal evolution of a wildfire. It will employ statistical and machine learning methodologies to predict and determine fire occurrence, susceptibility, and risk.

Finally, the system, with the help of data visualisation tools, will show findings and insights.

The document also presents current approaches and obstacles to forest fire prediction, as well as the suggested methodology and analysis of risk.

Keywords

Decision support system, Fire management, Fire forecasting, Machine learning, Spatial and temporal prediction

Resumo

Os incêndios podem ter consequências desastrosas. Os sistemas de apoio à decisão desempenham um papel central na luta contra os incêndios florestais. As suas capacidades de alerta e o seu impacto no mundo real ajudam a proteger as florestas, as espécies e as comunidades.

O trabalho apresentado propõe um sistema de previsão e monitorização de incêndios florestais que utiliza fontes diversas de dados. Onde são utilizadas técnicas de fusão, agregação e melhoramento de dados.

O principal objetivo do sistema é fornecer informações importantes para a tomada de decisões de emergência, tais como a geolocalização, a gravidade e a evolução temporal de um incêndio florestal. O sistema empregará metodologias estatísticas e de aprendizagem automática para prever e determinar a ocorrência, a suscetibilidade e o risco de incêndio.

Finalmente, com a ajuda de ferramentas de visualização de dados, o sistema será capaz de apresentar informações e resultados.

No documento também são analisadas as abordagens actuais e os obstáculos à previsão de incêndios florestais, bem como a metodologia sugerida e a análise de risco.

Palavras-Chave

Sistema de apoio à decisão, Gestão de incêndios, Previsão de incêndios, Aprendizagem automática, Previsão espacial e temporal

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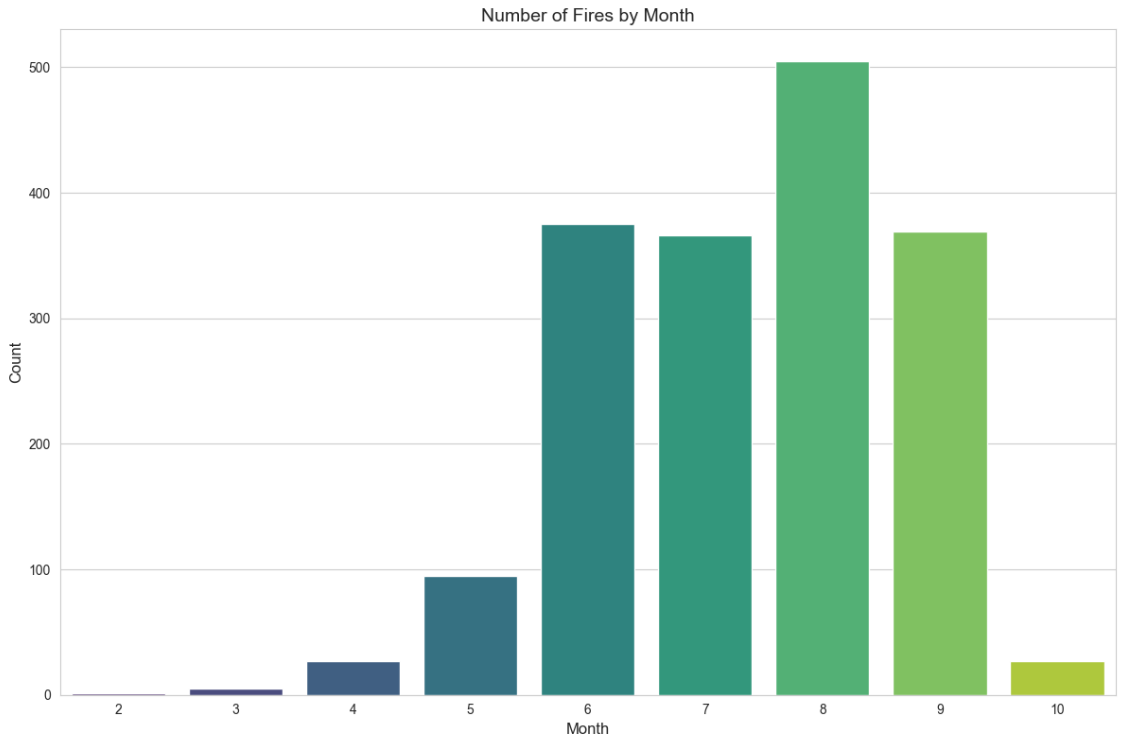
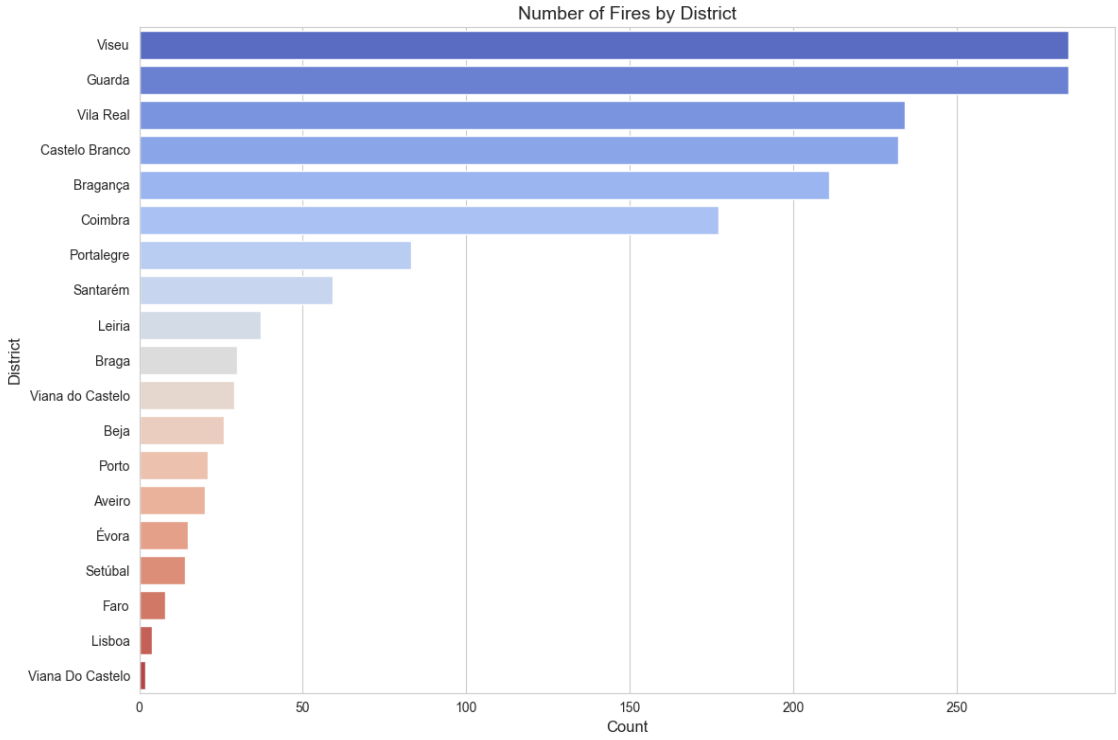


Figure 1.2: The three created datasets



1.1.1 Land types and Tree Species

(**?**)

112 is a discontinuos urban fabric - vegetation and green spaces between buildings (gardens, lawns, flower beds, shrub and tree formations); class is assigned when urban structures and transport networks associated with vegetated areas and bare surfaces are present and occupy significant surfaces in a discontinuous spatial pattern

2 - Agricultural areas

242 - Complex cultivation patterns. Mosaic of small cultivated land parcels with different cultivation types -annual crops, pasture and/or permanent crops-, eventually with scattered houses or gardens.

3 - Forest and seminatural areas

324 - Transitional woodland/shrub. Transitional bushy and herbaceous vegetation with occasional scattered trees. Areas representing natural development of forest formations, consisting of young plants of broad–leaved and coniferous species, with herbaceous vegetation and dispersed solitary adult trees

Figure 1.3: The three created datasets

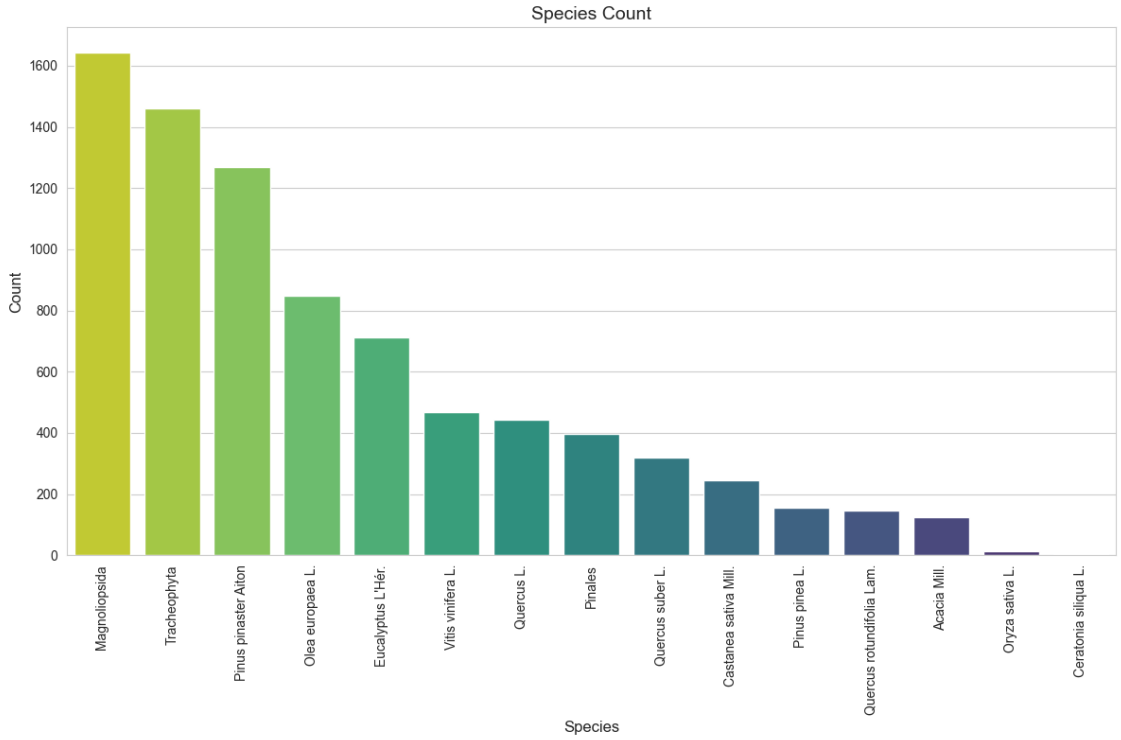
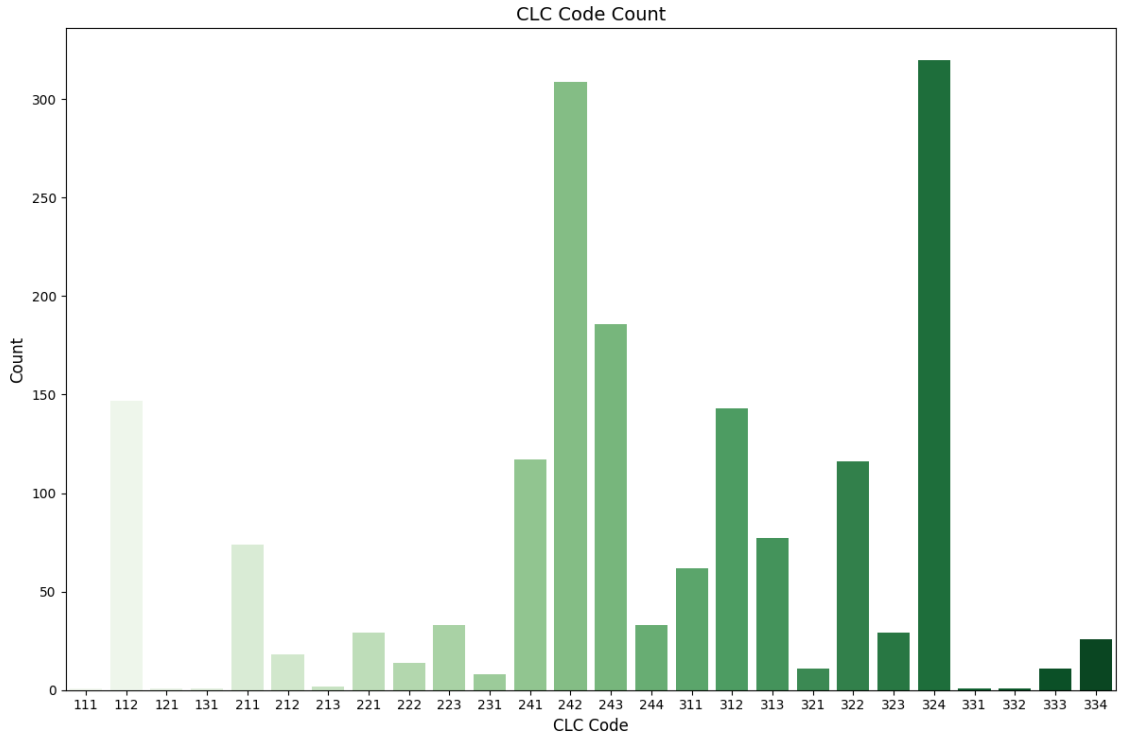


Figure 1.4: Class 1.1.2 - Discontinuous urban fabric example (Kosztra, 2007)

Figure 1.5: Class 2.4.2 - Complex cultivation patterns example (Hazeu, 2017)

Figure 1.6: Class 3.2.4 - Transitional woodland/shrub example (Kosztra, 2005)

Figure 1.7: The three created datasets



Portugal's vegetation is a blend of Atlantic, European, Mediterranean, and African species (Encyclopædia Britannica, Inc., 2024), and four tree species account for 80% of all the forest area: *Pinus pinaster*, *Eucalyptus globulus*, *Quercus suber*, and *Quercus rotundifolia* (Marques et al., 2011).

1.1.2 Weather variables distribution at the time of ignition

removed variables: 'hourly.weather_code' 'hourly.sunshine_duration' 'hourly.is_day' 'hourly.snowfall', 'hourly.snow_depth',

Figure 1.8: The three created datasets

Figure 1.9: The three created datasets

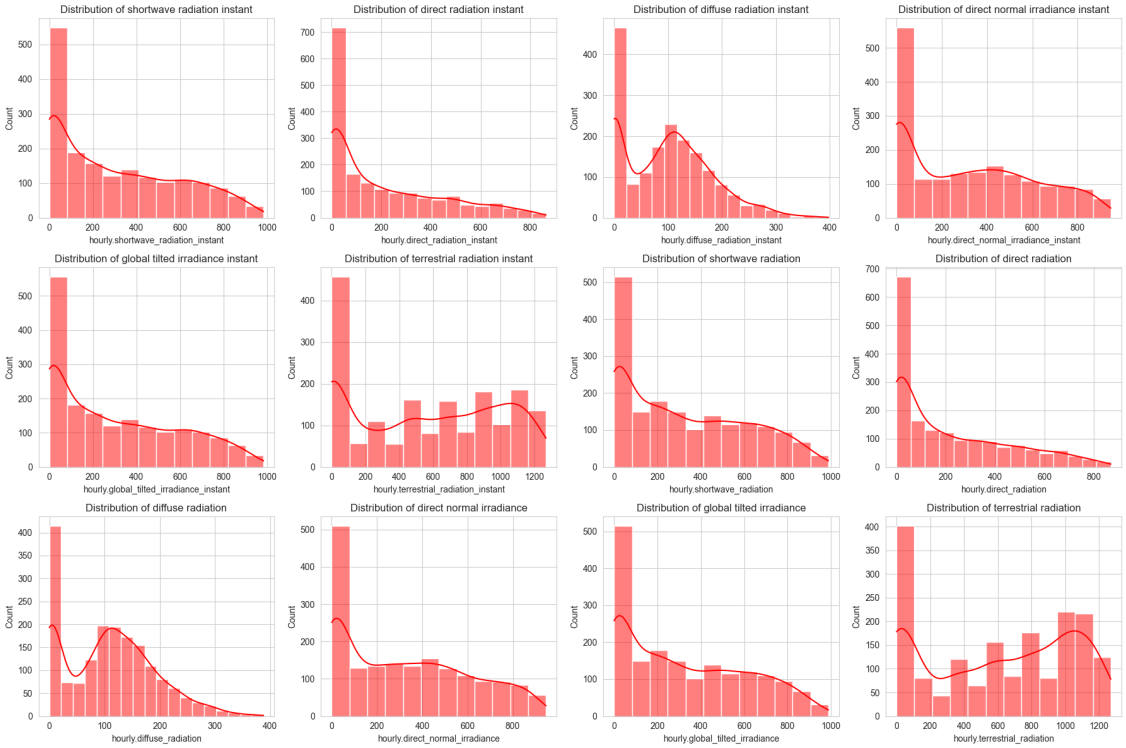
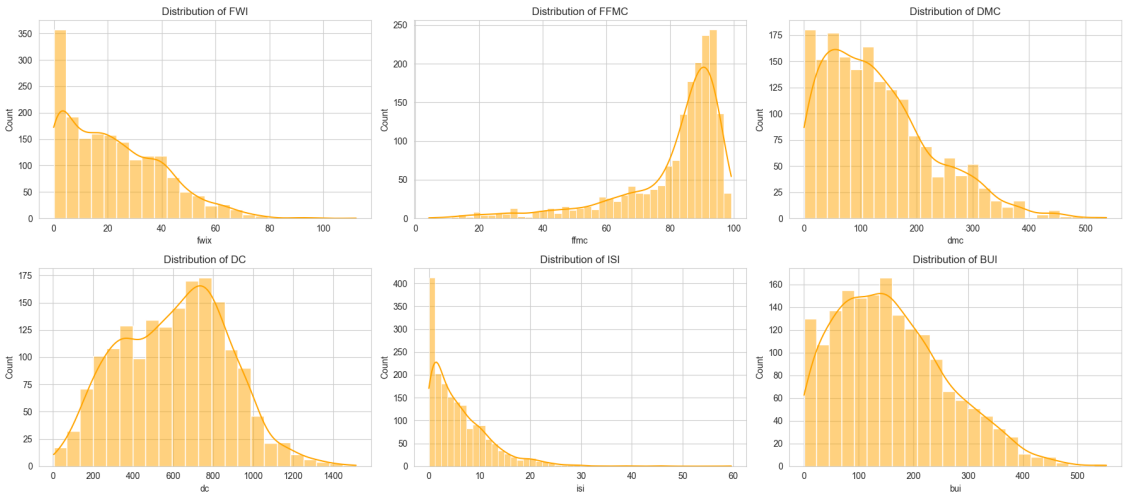


Figure 1.10: The three created datasets



1.2 Average conditions at ignition time

Parameter	Value	Unit
hour	14.6	hours
temperature_2m	25.06678	°C
relative_humidity_2m	50.342373	%
dew_point_2m	12.720565	°C
apparent_temperature	24.98887	°C
precipitation	0.180847	mm
rain	0.180847	mm
snowfall	0.0	cm
snow_depth	0.0	meters
pressure_msl	1014.581243	hPa
surface_pressure	956.793955	hPa
cloud_cover	32.822599	%
cloud_cover_low	5.60904	%
cloud_cover_mid	23.429379	%
cloud_cover_high	47.100565	%
et0_fao_evapotranspiration	0.271921	mm
vapour_pressure_deficit	1.831282	kPa
wind_speed_10m	8.881864	km/h
wind_speed_100m	13.092881	km/h
wind_direction_10m	212.215254	°
wind_direction_100m	209.636158	°
wind_gusts_10m	25.422655	km/h
soil_temperature_0_to_7cm	27.828192	°C
soil_temperature_7_to_28cm	24.509492	°C
soil_temperature_28_to_100cm	21.176949	°C
soil_temperature_100_to_255cm	17.014124	°C
soil_moisture_0_to_7cm	0.148219	m^3/m^3
soil_moisture_7_to_28cm	0.171308	m^3/m^3
soil_moisture_28_to_100cm	0.216619	m^3/m^3
soil_moisture_100_to_255cm	0.310751	m^3/m^3

Table 1.1: Hourly Weather Data with Units

Parameter	Value	Unit
shortwave_radiation_instant	308.195706	W/m^2
direct_radiation_instant	209.089096	W/m^2
diffuse_radiation_instant	99.105367	W/m^2
direct_normal_irradiance_instant	324.071525	W/m^2
global_tilted_irradiance_instant	307.808701	W/m^2
terrestrial_radiation_instant	563.058305	W/m^2
shortwave_radiation	328.19435	W/m^2
direct_radiation	220.187006	W/m^2
diffuse_radiation	108.007345	W/m^2
direct_normal_irradiance	330.480113	W/m^2
global_tilted_irradiance	328.19435	W/m^2
terrestrial_radiation	610.627627	W/m^2
roughness	178.799333	-
aspect	178.957915	°
slope	8.162517	°
mean_elev	36.125026	meters
fwix	22.317299	-
ffmc	81.146887	-
dmc	130.720423	-
dc	606.997705	-
isi	6.064164	-
bui	158.466257	-

Table 1.2: Hourly Weather Data with Units

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