The International Workshop on Edge Artificial Intelligence for Industrial Applications (EAI4IA)

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The International Workshop on Edge Artificial Intelligence for Industrial Applications (EAI4IA)

AI-Driven Strategies to Implement a Grapevine Downy Mildew Warning System

Lucas Mohimont, University of Reims, France

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Presentation Outline

- Background
- Existing approaches
- Why using AI?
- Objectives and Experiment Description
- Results
  - 1st infection alert
  - 2nd infection alert
- Discussion and Future Works

Grape Vine Diseases

- Loss in grape yield and/or wine quality
- Common diseases include:

Black rot

Downy Mildew

Powdery Mildew

Grey mold

Identifying Downy Mildew Infection

- Downy Mildew incubation cycle described in 1936
- Simplified representation of the cycle:

oospores → Primary Infection → Dispersion → Secondary Infection

Primary Infection:
- Non destructive

Secondary Infection:
- Appears with favorable humidity, temperatures
- High yield loss

oilspots

Oospores overwinter

Why using AI for Down Mildew detection?

- The main goals:
  - Limiting the yield/quality loss
  - Managing the amount of intrants(pesticides)
- Existing mechanistic models use static rules based on weather conditions
- AI could solve many limitations of these models
  - Adaptation to different parcels and varieties
  - Processing of more variables
  - Generating precise warning with local sensors and on-site analysis (edge)

Objectives and Methodology

- **Goals**
  - Verify if AI algorithms present enough precision to concurrence "mechanical" algorithms
  - Identify AI algorithms better suited to the task

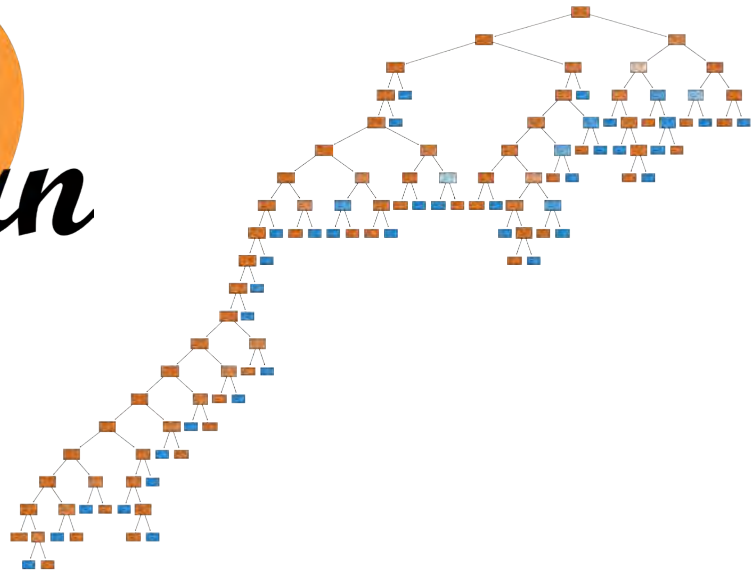
- **Methodology**
  - Use a real dataset from a vineyard in Reims, France
  - Label the dataset using a "mechanical" algorithm for 1st and 2nd infection alerts
  - Train different machine learning algorithms for binary classification
  - Cross-validation between different years

Dataset description

- Data obtained from a Promété 300 agri-meteorological station installed in a Vranken-Pommery vineyard at Reims, France
- Hourly readings from January 2019 to December 2021
- Available sensor variables :
  - **Wind speed** [Km/h] (max, **average**)
  - Wind gust [Km/h] (max)
  - **Relative humidity** [%] (max, **min**, average)
  - **Pluviometry** [l/m^2]
  - **Leaf wetting duration** [min] (only available from 2019 to 2020)
  - Dew point [C] (min, average)
  - **Solar radiation** [W/m^2] (average) -> **used to determine "nighttime"**
  - **Air temperature** [C] (max, **min**, average)
  - Vapor press deficit [kPa] (min, average)
- Total of 16 variables
- **Binary labels are generated with mechanistic models for primary and secondary infections (True or False).**

ML Algorithms Compared in this Work

- Input data: 16 features x 48 hourly readings (768)
- Models are trained twice for primary and secondary infections
- Decision Trees
- Random Forest (1000 iterators)
- Support Vector Machine (SVM)
- Feed Forward Neural Network (7 layers, relu)
- Convolutional Neural Networks(CNN)
  - 2 conv2D layers, dropout, relu activation
  - 2 fully connected layers



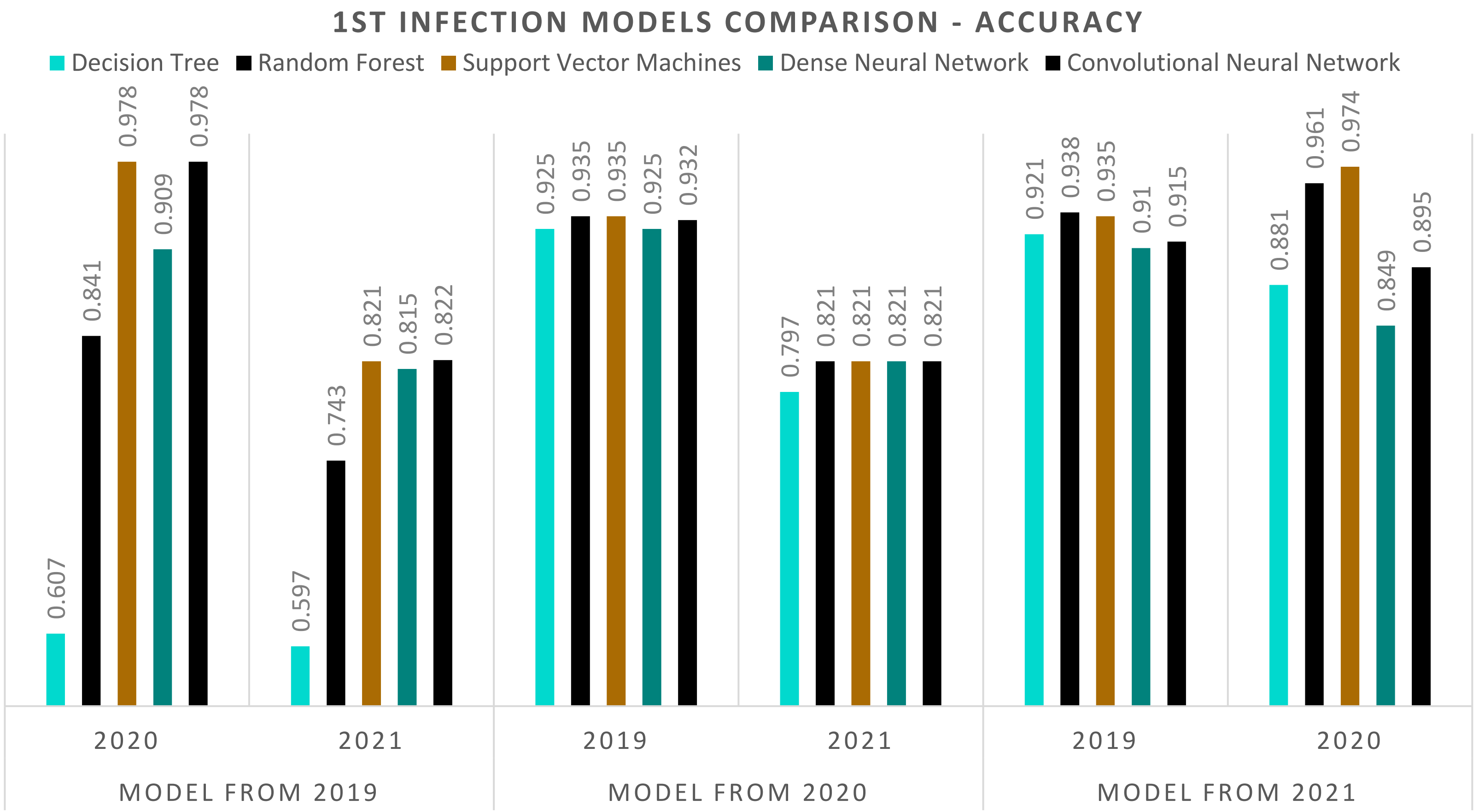
Example of decision tree for 2020 data

Training the models

- Generating several models
  - For each algorithm, a different model was generated for each year
    - 2019, 2020 and 2021 for 1st infection alerts
    - 2019 and 2020 for 2nd infection alerts (lack of data from 2021)
  - A 90/10 split between training/testing was used as alerts are not frequent
- Having different models for each year allows
  - To foresee specific conditions from each year (e.g. 2021 was a wet year)
  - To check the model's robustness via cross-validation

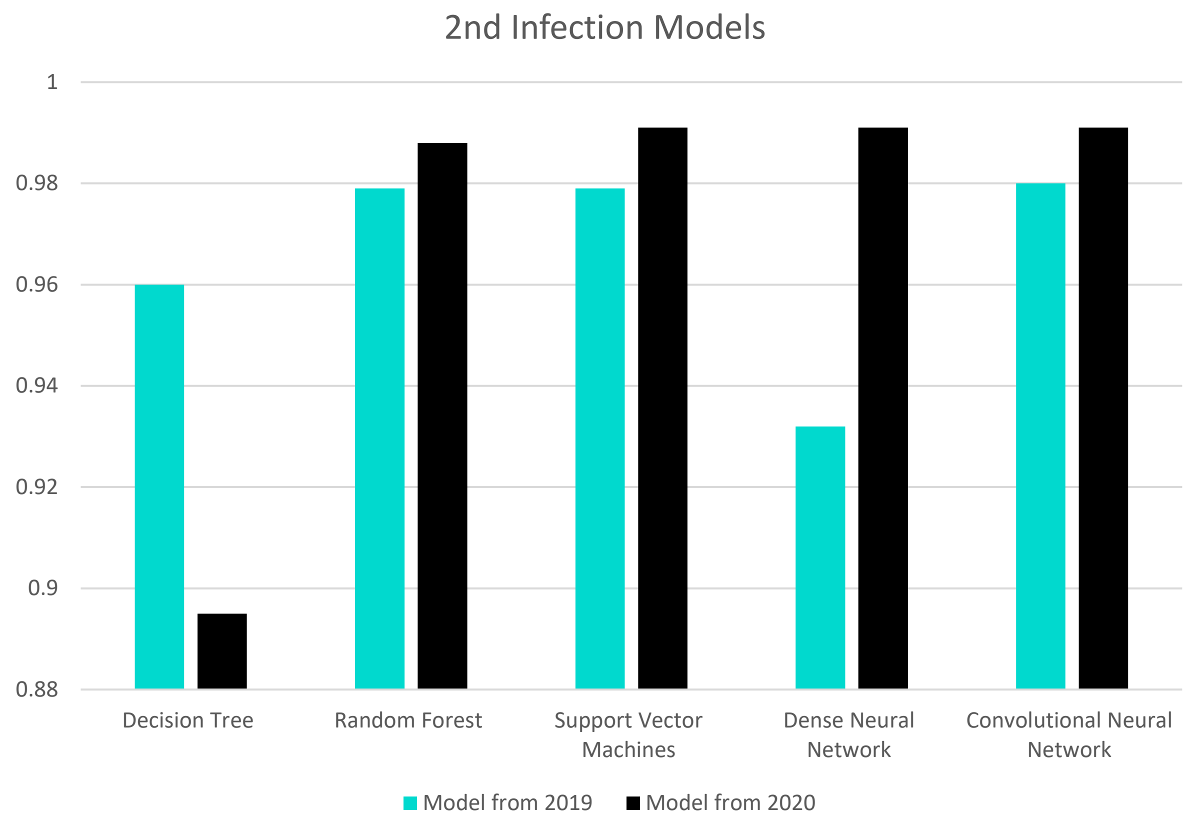
Some Results: 1st infection alerts

- 2021 was a "weird" year due to excessive wetness
  - Hard to predict with other models
  - Robust to detect 1st infections on other years
- SVM and CNN show good performances in most cases



Some Results: 2nd infection alerts

- Only two years available due to leaf wetness sensor failure
  - Cross-validation between 2019 and 2020 models
- High accuracy for RF, SVM and CNN, especially from the model trained with 2020 data



Discussion and Future works

- This preliminary work only compares machine learning models with the synthetic output of a known "mechanical" algorithm
  - Good performances (>>90% accuracy) to reproduce the labeled results
- Future works include
  - Evaluation against real infections identified on the vineyards
  - Training models with subsets of the data variables
    - Search for important or alternative variables not considered in traditional works
- Algorithm deployment at the deep-Edge
  - Explore the capabilities of STM32
    - SVM and CNN are both supported
  - Several agricultural sensors have been deployed in Reims as part of the AI4DI project

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Thank You

For your attention

angelo.steffenel@univ-reims.fr
lucas.mohimont@univ-reims.fr