XSICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

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Events automatic simulation in microgrids for the training and validation of protection devices

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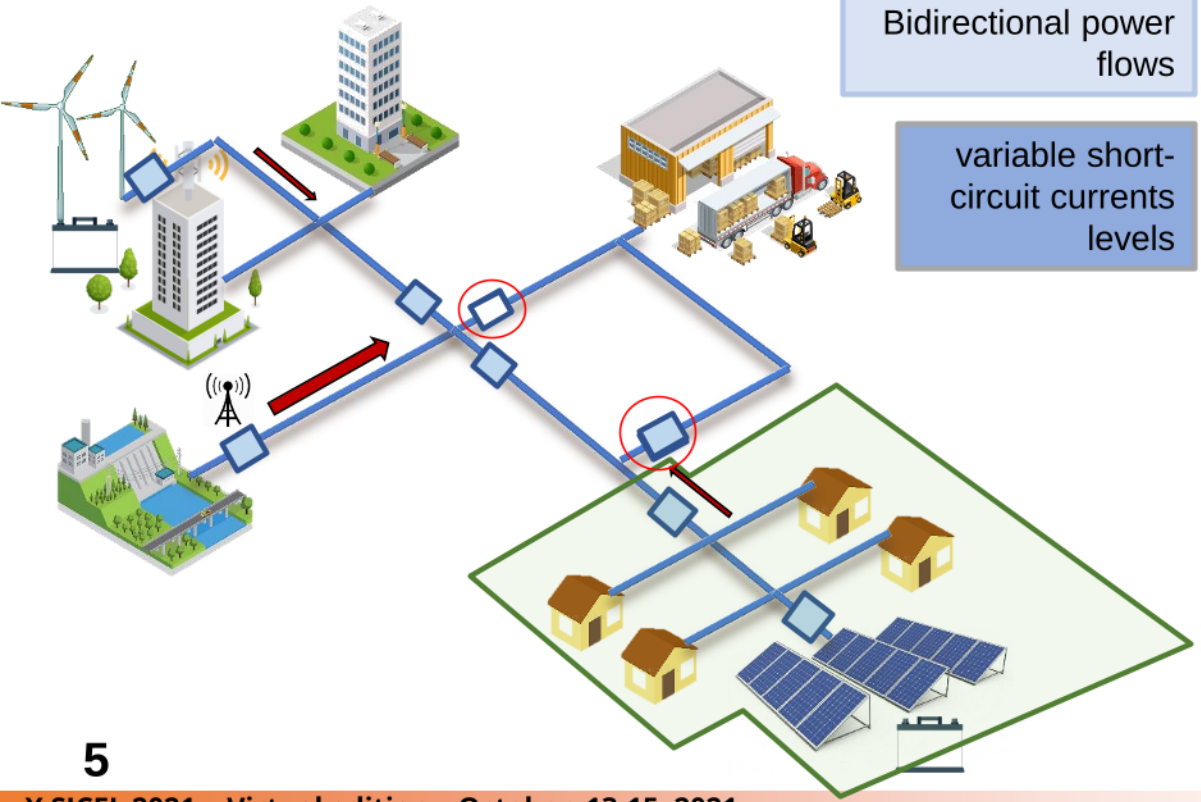


Protection system

Bidirectional power flows

variable short-circuit currents levels

Active Distribution Networks

Power distribution networks

DER

DG

ESS

Operation challenges

Control functionalities

Reliability, flexibility and efficiency

I. Introduction

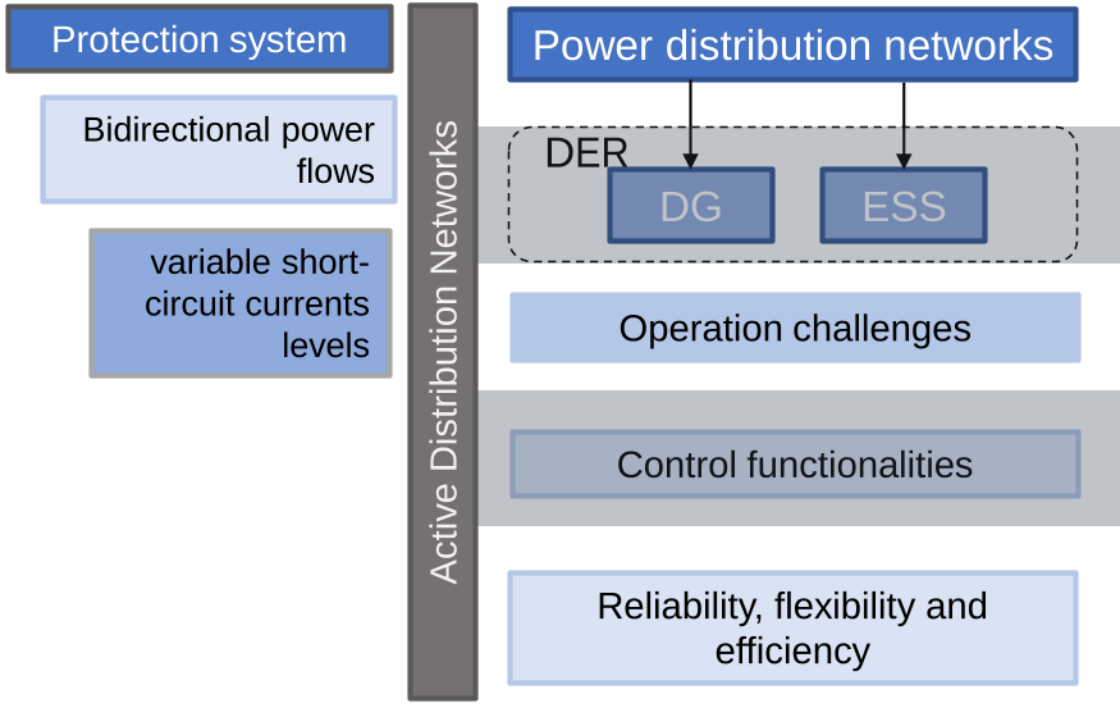
How to protect an ADN/MG considering All their operational condition?

↓

Development of adaptive protection strategies

↓

It requires exhaustive simulations in the MG of faults and normal operation conditions, that include topological changes, load variation, DER connection/disconnection, among others.



Events automatic simulation in microgrids for the training and validation of protection devices

Contents

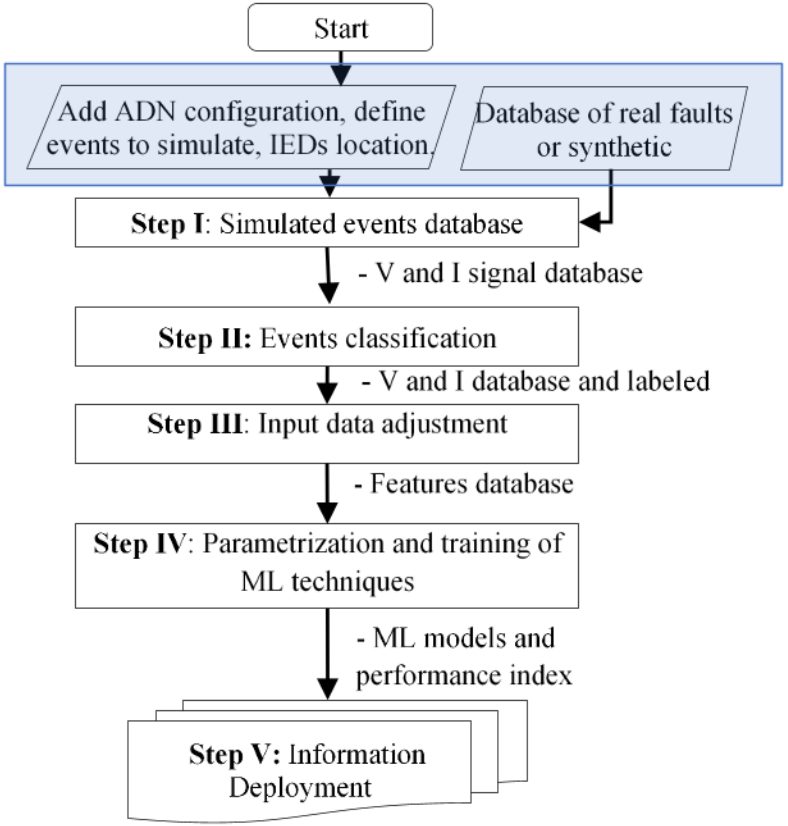
II. Events automatic system structure in microgrids

Step 0: Initial settings

- Simulation time (t_T)
- Sampling frequency (f_m)
- EMT simulation file of the ADN under study
- Equipment to connect / disconnect

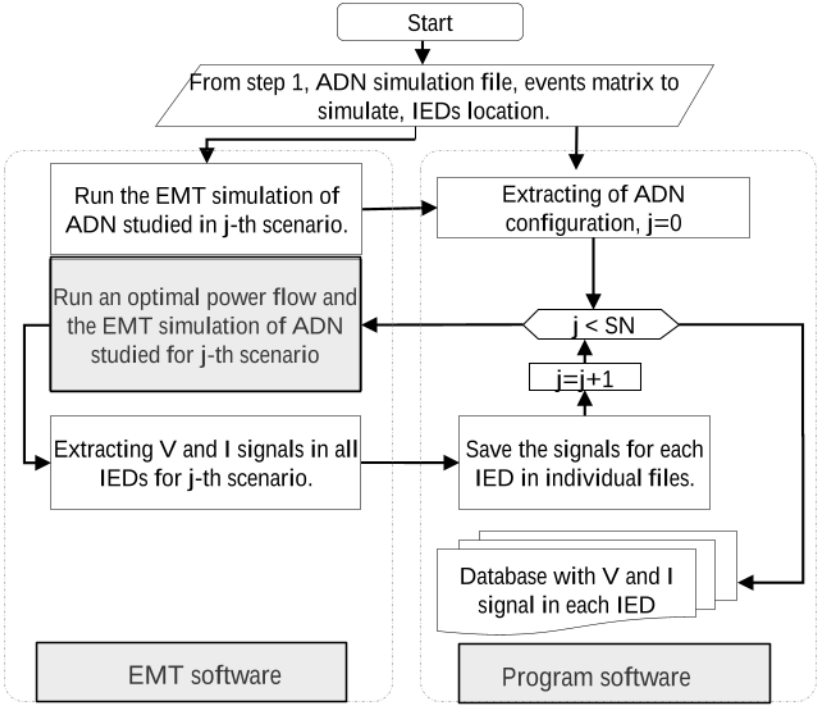
  (lines for reconfigurations, intermittence of DER)
- Short-circuit conditions

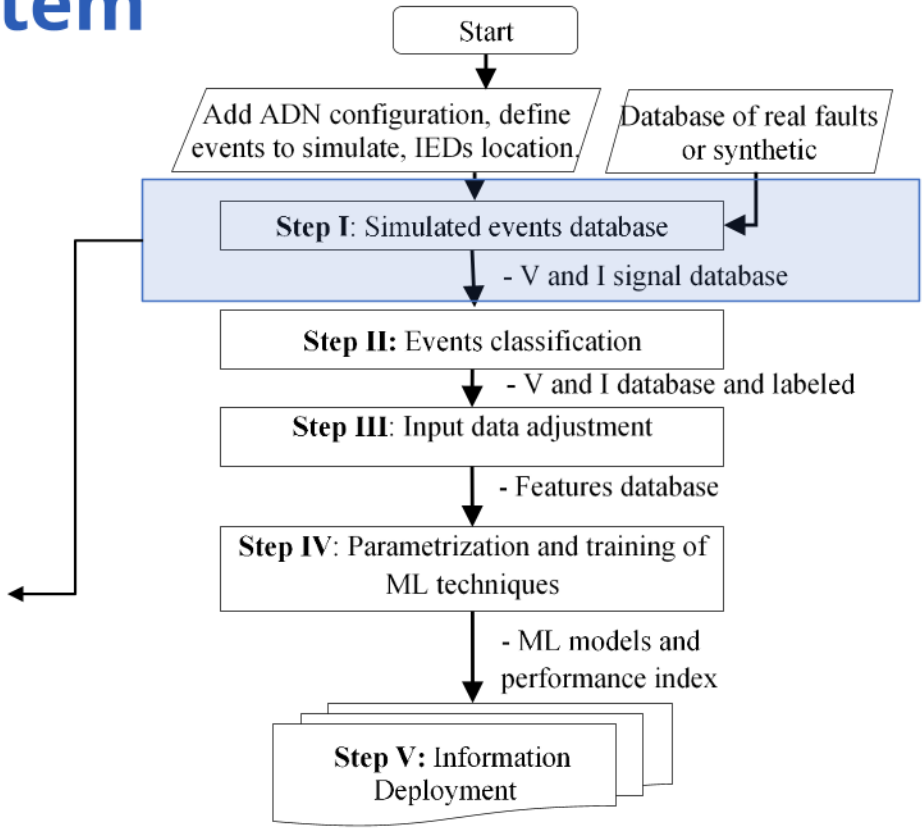
  (fault types, fault location, fault resistances)



II. Events automatic system structure in microgrids

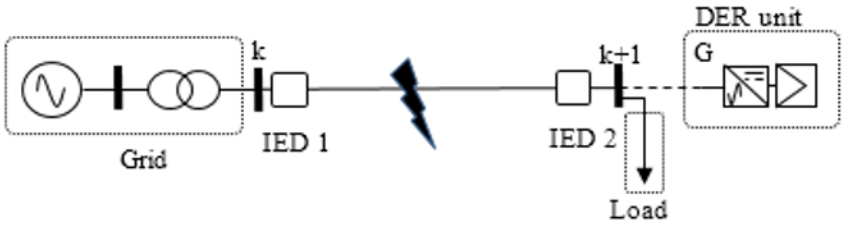
Step I: Events simulation



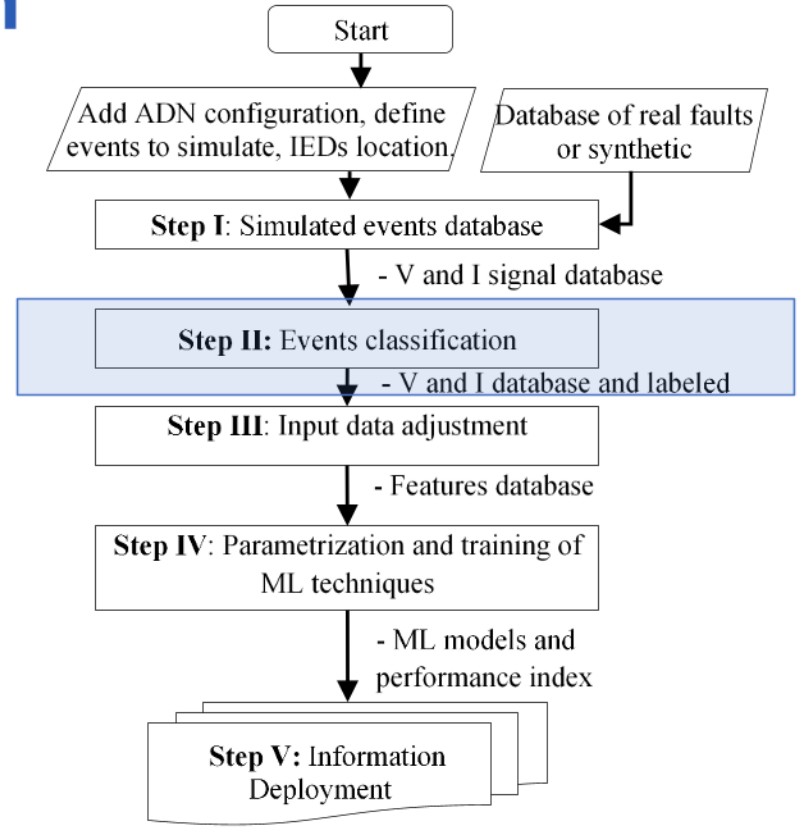


II. Events automatic system structure in microgrids

Step II: Events classification

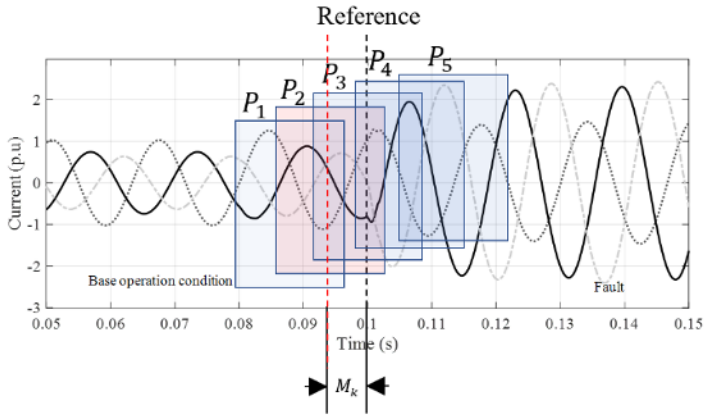


Event	Operation condition	IED	State
1	Fault in the middle of the line and DG connected	IED 1	Faulted
		IED 2	Faulted
2	Fault in the middle of the line and DG disconnected	IED 1	Faulted
		IED 2	No faulted

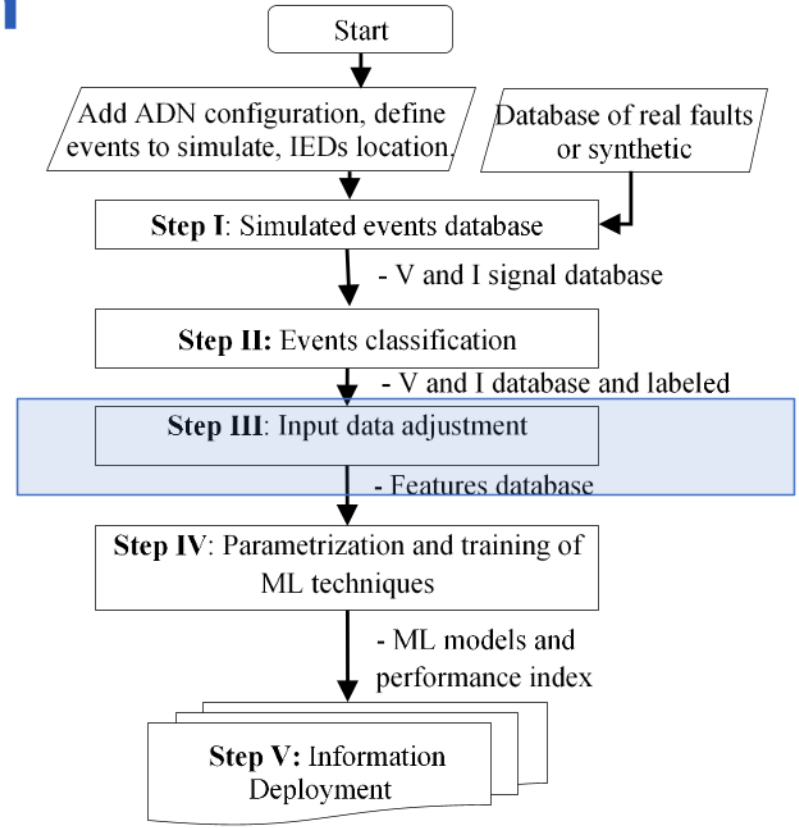


II. Events automatic system structure in microgrids

Step III: Input data adjustment



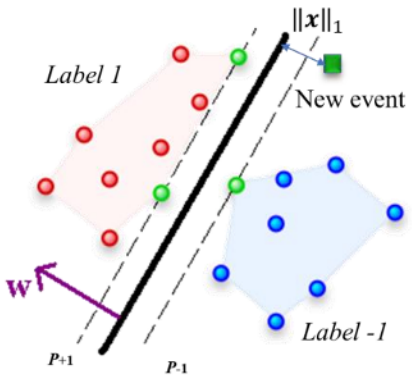
Item	Features	Description
1-3	Magnitude of voltage in each phase	$\|V\|_k$
4-6	Angle of voltage in each phase	θV_k
7-9	Magnitude of current in each phase	$\|I\|_k$
10-12	Angles of current in each phase	θI_k



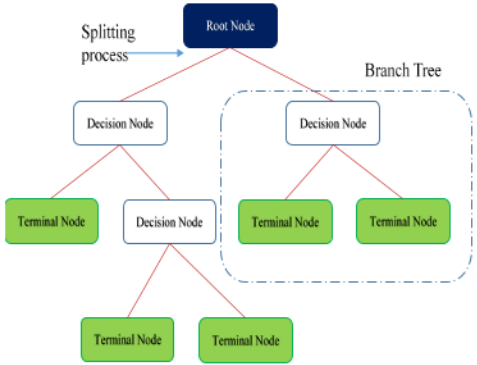
II. Events automatic system structure in microgrids

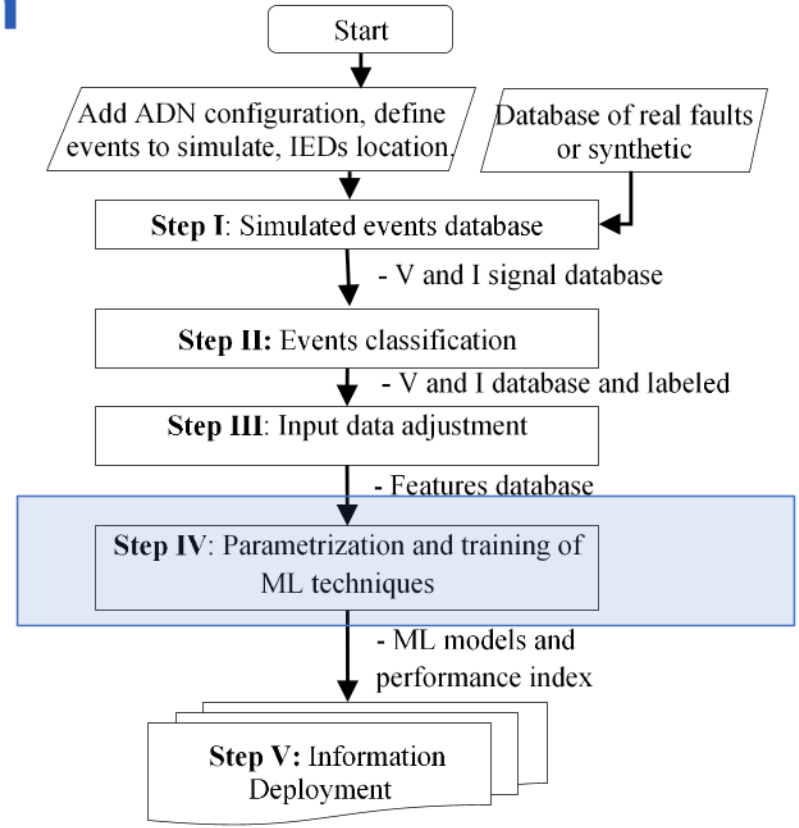
Step IV: Parametrization and training of ML techniques

Support Vector Machines (SVM)



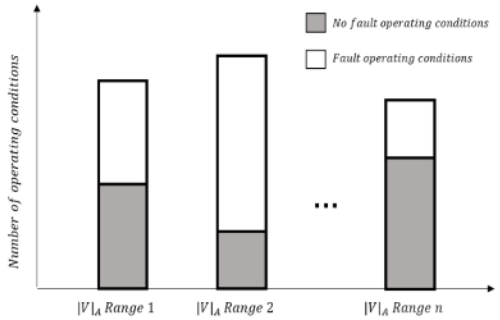
Decision Tree (DT)

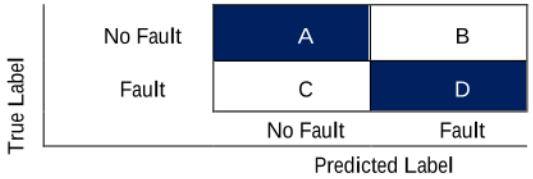




II. Events automatic system structure in microgrids

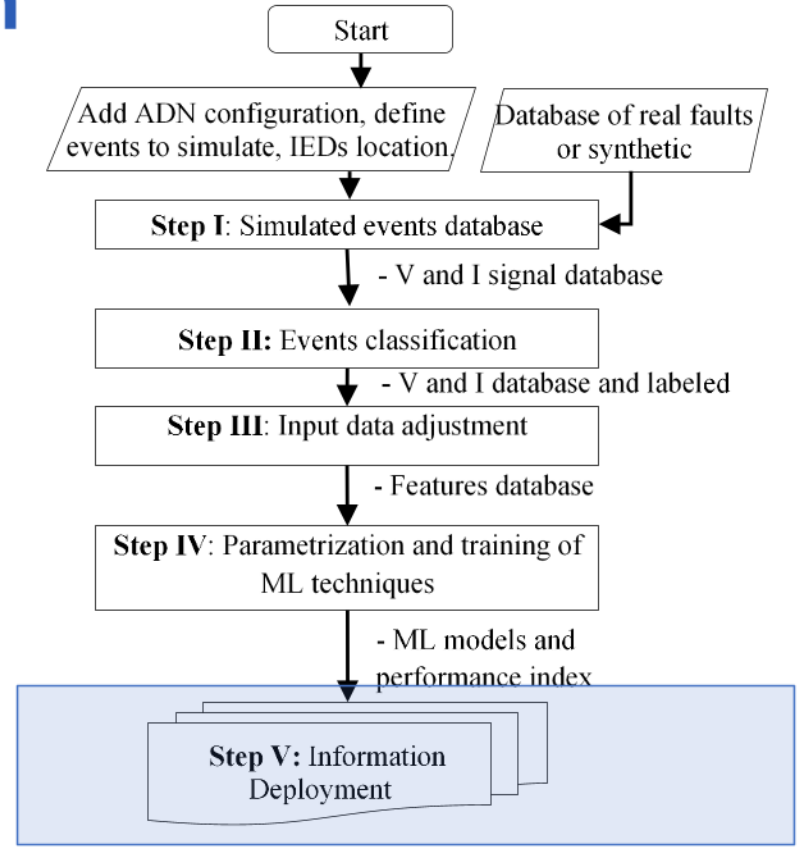
Step V: Information Deployment





$$A_{cc} = \left[\frac{Scenarios\ \ well\ classified}{\#\ total\ Scenarios}\right] * 100\%$$

$$D_{ep} = \left[\frac{Fault\ Scenarios\ well\ classified}{\#\ Total\ Fault\ Scenarios}\right] * 100\%$$



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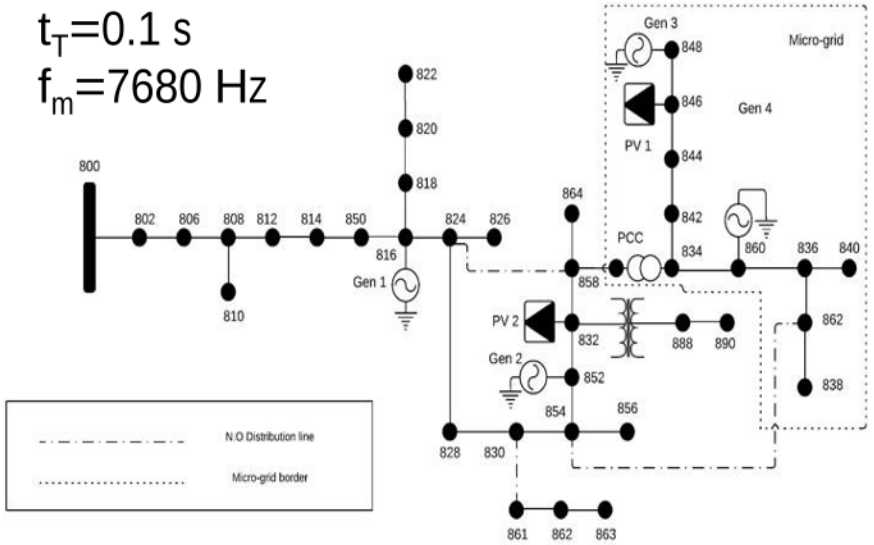
III. Application of system for development of protection strategies

A. Case study

Step 0: Initial settings

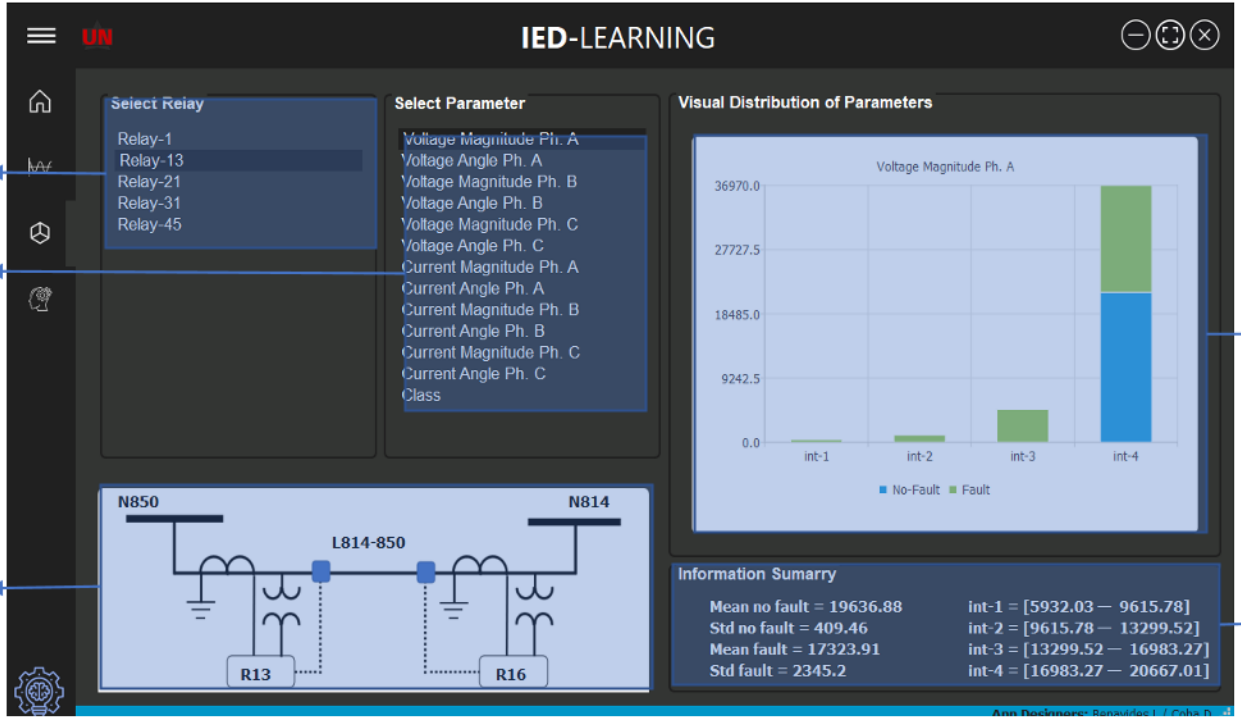
t_T=0.1 s
f_m=7680 Hz



Analyzed scenarios	Factors	Levels
Fault scenarios	Fault Resistance	0 - 20 Ω and 40Ω
	Fault type	A-g, AB and ABC
	Load variation	[40–55] [85–100] [100–120] %
	Topology changes	Scenario 1 to 6
	Generation cut-off	All the generators are working DG_1 out DG_2 out DG_3 out
	Fault location	25 three-phase distribution line
No-fault scenarios	Load variation	[40–55] [56–70] [71–85] [85–100] [100–120] %
	Generation cut-off	All the generators are working DG_1 out DG_2 out DG_3 out
	Topology changes	Scenario 1 to 6
IEDs	Location	ADN: IED-1, IED-13, IED-21 MG: IED-31, IED-45
	ML techniques	SVM, DT
	Number of windows	4
No-Fault		28320
Fault		72576

III. Adaptive coordination algorithm

B. Step I, II and III: Events simulation, classification and data adjustment



Relays with database

Estimated features for processed database.

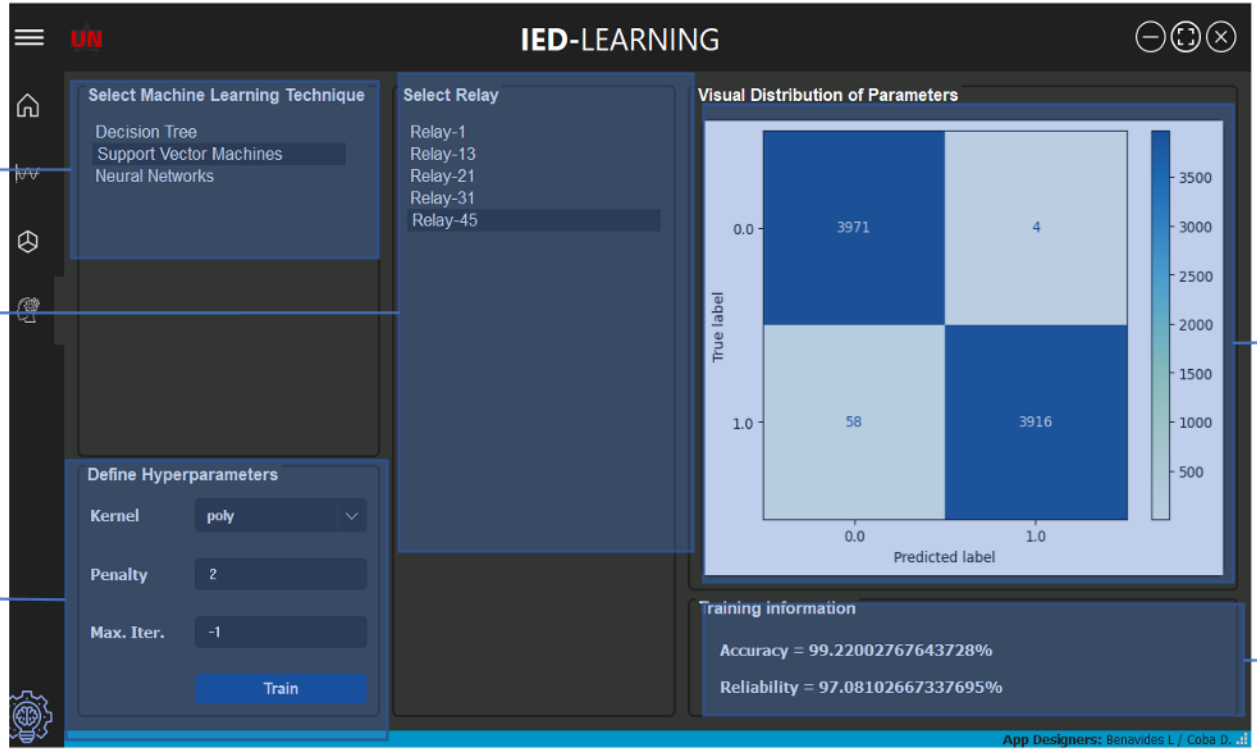
line section where the relay is located.

Visualization of data distribution by feature.

Intervals for distribution of data by feature.

III. Adaptive coordination algorithm

B. Step I, II and III: Events simulation, classification and data adjustment



ML techniques integrated.

Trained and validated relays.

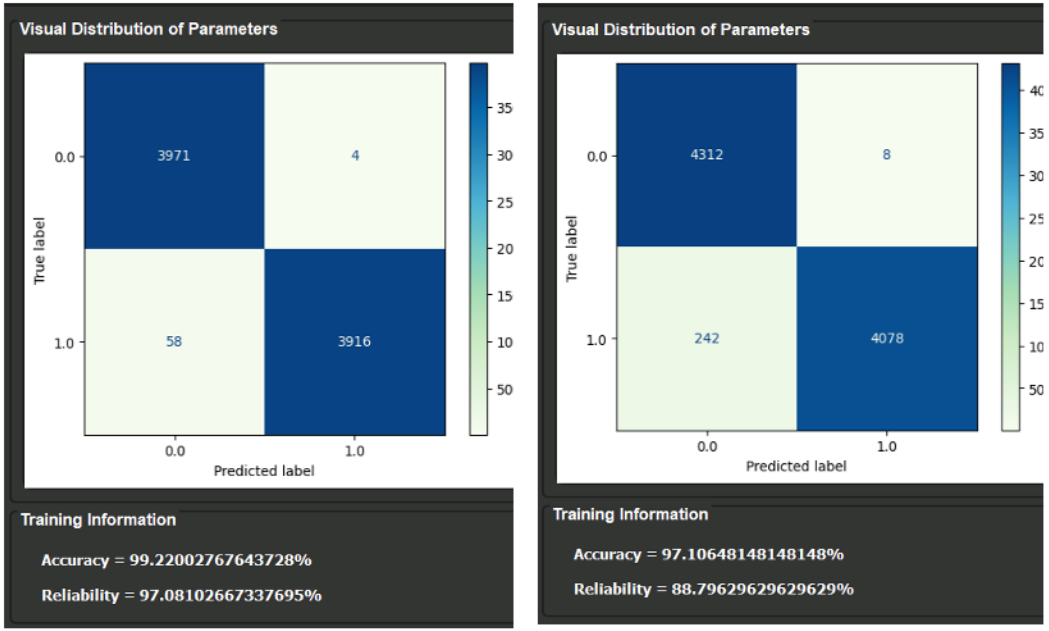
Hyperparameter settings

Results visualization: confusion matrix.

Results visualization: accuracy and dependability

III. Adaptive coordination algorithm

B. Step I, II and III: Events simulation, classification and data adjustment



a) b)

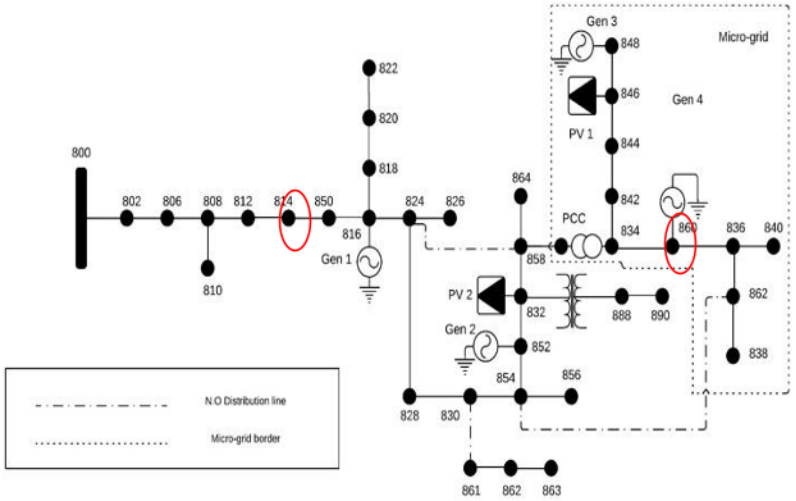


Fig. 14. ML Techniques Window – a) SVM – Relay 13, b) SVM – Relay 45

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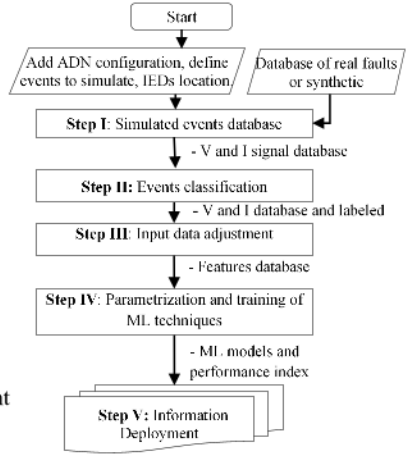
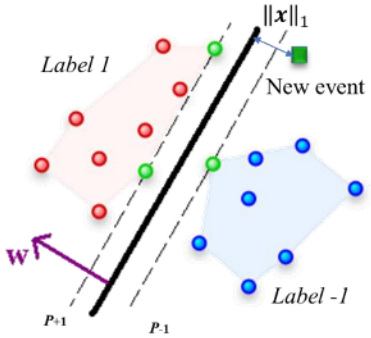
IV. Conclusions

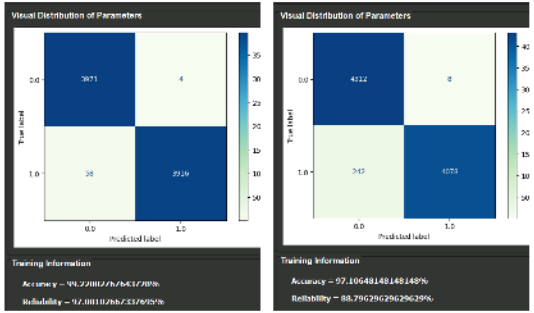


This work presented an EAS for ADN and micro-grids, which was designed to automate the entire process that involves the generation, training and validation of the IEDs present in an active distribution network or a MG.

the EAS allows training the IEDS for different machine learning techniques with the main idea to find the best model that guarantee an outstating detection of faults.



The results obtained with a SVM model presents an accuracy above of 90%.



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Thank you

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