BOOST AND BUCK DC-DC CONVERTERS - PREDICTION OF THE OUTPUT

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INTRODUCTION

- Machine learning techniques and prediction while using machine learning techniques are almost everywhere, in each segment of our life, in each area of human research.
- We can predict the number of cars sold in one season, we can predict atmosphere temperature, the number of children born in one year, some diseases according to a symptom and so on.
- The machine learning approach, itself is a process of learning from a set of data without being distinctly programmed.
- There are many machine learning techniques.
- we used classification as supervised learning technique.

INTRODUCTION

- Classification is a process of grouping a database of input data into separate classes premised on one or more variables.
- Some implementations of machine learning classification complication are image and video recognition and classification, document classification, spam filtering, voice recognition, medical prediction...
- Some sorts of predictive classification in machine learning are binary classification, multi-class classification, multi-label classification and imbalanced classification [6].
- Decision trees are a type of binary classification. There are decisions and leaf nodes in a decision tree. Decision nodes have more branches, and they are for decision operating, and leaf nodes are the output of decisions [7].

ITRODUCTION

- DC-DC converters are widely used for traction motors control in electronic cars, carts, marine cranes, forklifts, and tractors.
- DC converters can be used as switching mode regulators for converting an unregulated DC voltage into a regulated DC output voltage.
- There exist four switching-mode converter topologies:
  - Buck converter
  - Boost converter
  - Buck-boost converter
  - Cuk, Sepic and Zeta converter [4].
- We are going to talk about Buck and Boost converters.

ITRODUCTION

- A step-up boost converter is used when we want to obtain an output voltage greater than the input voltage.
- The values for the input voltage are 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100.
- The values for the output voltage are 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55.

- A step-down buck converter is used when we want to obtain output voltage lower than the input voltage.
- The values for the input voltage are 5, 10, 15, 20, 25, 30, 35, 45, 50, 55.
- The values for the output voltage are 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100.

- We used the same values for both converters:
- $f_s = 500kHz$ – the minimum converter switching frequency,
- $\Delta I_l = 0.4$– estimated inductor ripple current
- $I_{out} = 2$– the maximum output current,
- $\Delta V_{out} = 0.02$ – desired ripple output voltage [7].

PREDICTION USING MACHINE LEARNING TECHNIQUES

- Our aim is to see for which converter we have better prediction.
- For obtaining results we used WEKA (as a popular machine learning software package)
- WEKA offers a rich set of tools for data preprocessing, classification, regression, clustering, association rules, and visualization.
- Main features of WEKA:
- - Easy-to-use interface
- - Console interface and programming API
- - Support for various data formats
- - Rich set of algorithms
- - Experimentation and evaluation capabilities

PREDICTION USING MACHINE LEARNING TECHNIQUES

- Databases in. arff format are format that WEKA works with. Both ours. arff databases file have 130 instances, 3 or 4 attributes and one class (the output value). All the attributes have numerical values.
- The three attributes in Buck database are:
  - Input Voltage
  - Duty cycle (D)
  - Inductance (L)
- The four attributes in Boost database are:
  - Input
  - Duty cycle (D)
  - Inductance (L)
  - Capacitance (C)

IN TABLE 1 AN ANALYSIS OF THE INSTANCES FOR BUCK DATABASE IS PRESENTED, IN TABLE 2 AN ANALYSIS OF THE INSTANCES FOR BOOST DATABASE IS PRESENTED

TABLE 1 BRIEF ANALYSIS OF THE BUCK DATABASE

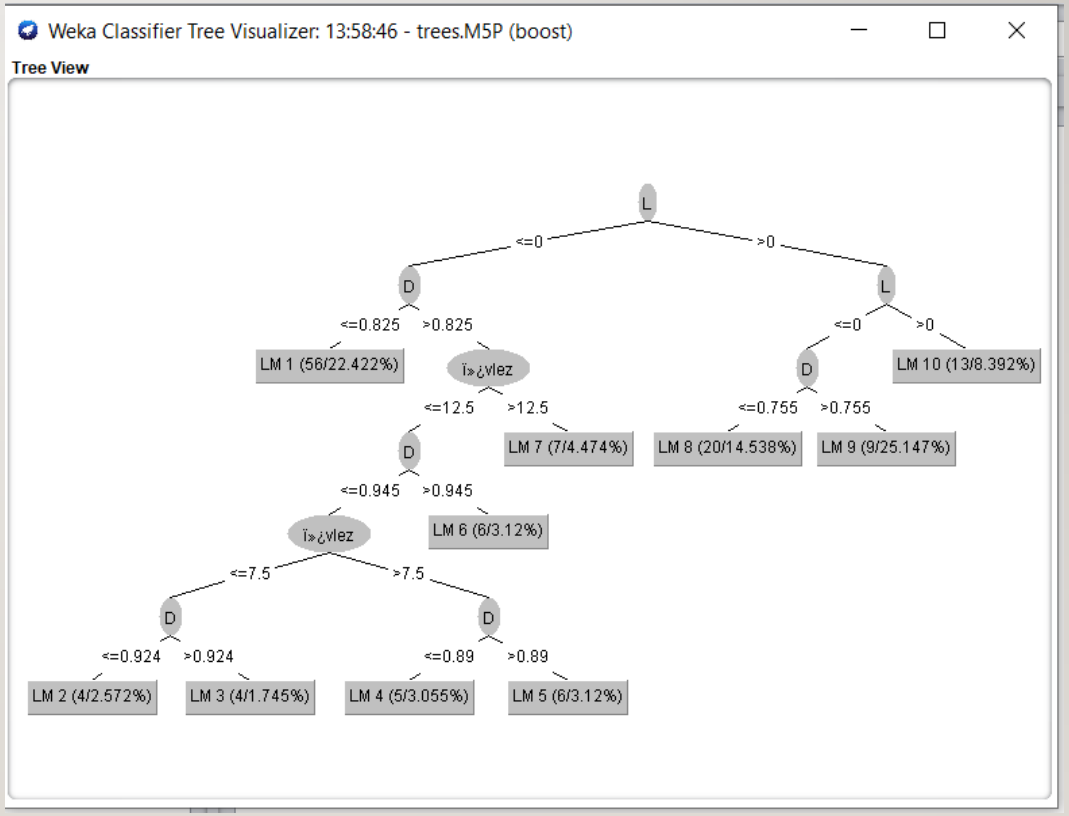
				class
attribute	input	D	L	output
distinct	18	89	19	11
unique	0	68	1	0
minimum	15	0.05	0	5
maximum	100	0.889	0	55
mean	64.231	0.379	0	22.269
StdDev	23.223	0.215	0	12.359

TABLE 2 BRIEF ANALYSIS OF THE BOOST DATABASE

					class
attribute	input	D	L	C	output
distinct	11	94	89	108	18
unique	0	74	52	88	0
minimum	5	0.28	0	0	15
maximum	55	0.96	0	0	100
mean	25.5	0.668	0	0	66.154
StdDev	15.056	0.187	0	0	23.048

DISCUSSING THE OBTAINED RESULTS

- In Fig. 4 decision tree using M5P for Boost converter is shown. The size of M5P is 10 and the time taken to build the model is 0.01.
- For buck converter, the size of the tree using M5P classifier is 1 (so there is no tree, only one node) and the time hold for model building is 0.12 seconds.



DISCUSSING THE OBTAINED RESULTS

- If we consider Table 3, we can come to several conclusions.
- First, for buck converter we have best results using **M5P classifier**. The correlation coefficient is 1 or perfect positive correlation, and all errors: mean, root, relative and squared are all zero.
- With REPTree and Random tree we have the same worst results i.e., the relative absolute error and root relative squared error are 100% (Fig. 6).
- For Random Forest also the results are not good, there is error more than 50%.

TABLE 3. DECISION TREE TECHNIQUES

	Buck				Boost			
Test options	Cross-validation, folds-10				Cross-validation, folds-10			
Parameters	Random Tree	Random Forest	M5P	REPTree	Random Tree	Random Forest	M5P	REPTree
Total Number of Instances	130	130	130	130	130	130	130	130
Correlation coefficient	-0.281	0.6322	1	-0.281	0.9717	0.9911	0.9304	0.9235
Mean absolute error	0.0001	0.0001	0	0.0001	4.8846	3.0496	6.176	7.4911
Root mean squared error	0.0001	0.0001	0	0.0001	5.4596	3.7586	8.586	8.899
Relative absolute error (%)	100 %	87.9741 %	0	100 %	24.7394 %	15.4456 %	31.2798 %	37.9405 %
Root relative squared error (%)	100 %	88.2104 %	0	100 %	23.5685 %	16.2255 %	37.0646 %	38.4157 %
Size of the Tree / number of rules (M5P)	1	/	1	1	171	/	10	45
Time taken to build model (seconds)	0	0.05	0.12	0	0	0.12	0.01	0.01

DISCUSSING THE OBTAINED RESULTS

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- for Boost converter we can see that using **Random Forest** classifier we have the best results. Here, the correlation coefficient is 0.99 or around 1. That is a good variable correlation. The mean absolute error is 3.0496 and the root mean squared error is 3.7586.
- With Random tree also the results are not so bad. These results are closer to Random Forest.
- The worst results are obtained with REPTree classifier. The results obtained with M5P are closer to REPTree results.
- The best results for both Buck and Boost converters required around 0.12 seconds for building the model.

CONCLUSION

- There exist many types of decision tree classification algorithms used for prediction, such as Decision Stump, Hoeffding Tree, J48, LMT, M5P, Random Forest, Random Tree, and REP Tree. All these types are able in WEKA machine learning software.
- For our research we used only four of them M5P, Random Forest, Random Tree, and REP Tree.
- The best results for Boost converter are obtained using Random Forest, and for Buck converter are obtained using M5P. For boost converter using M5P we have not so good results.