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Master Thesis

Error Resilient Structure of Random Forest

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Memory voltage scaling or approximate memory has been used as an efficient method to develop energy-efficient embedded systems. This is done by reducing the supply voltage below the nominal level, which leads to lower power consumption and fast access. However, this improvement is achieved at the cost of timing errors that results in loss of the accuracy as a possible side effect of using approximate memory. Machine learning applications are one of the suitable candidates for using approximate memories due to their error resilience nature. In other words, they can tolerate some errors, without much accuracy loss (within an acceptable level).
Most of the studies in the literature have focused on Neural Network architectures [1, 2], and less attention has been paid to decision tree and random forest (DT/RF) models.

In this thesis[1], we seek techniques to reduce the impact of errors in RF as much as possible with an acceptable overhead. For example, by restructuring the model/data structure, the propagation of errors throughout the model can be reduced. Hence, the objective is to find highly bit error tolerant RF structure. The RF should also have high accuracy in presence of bit flip errors without any detection/correction methods.

As the first step, the student should get familiar with DT/RF models and find out how they are affected by errors and what the outcome is. For this, [3] can provide a good perspective.
The question that arises here is now how we can reduce the impact of errors e.g. on *feature indices* by only changing the structure of the model. Different ways can be explored, such as tuning hyperparameters, creating multi-valued or multi-labeled trees, feature engineering, etc.

[1] *Other suggestions and related topics are also welcome. Please do not hesitate to make an appointment.*

Then, for evaluating the proposed error resilient RF structure, a bit flip error injector is required. TREAM tool [3] is an extension of sklearn, and can be employed for error resilience analysis of the tree-based models. The student should get familiar with the general principles of the TREAM tool, and how to inject errors into different parts of DT/RF to evaluate the proposed method.

Required Skills:

- Basic knowledge of machine learning especially random forest
- Python and C++

Acquired Skills after the thesis:

- Knowledge of error resiliency and bit flip error injector
- Knowledge of Sklearn and Cython

References

[1] L. Yang and B. Murmann, "Sram voltage scaling for energy-efficient convolutional neural networks," in *2017 18th International Symposium on Quality Electronic Design (ISQED)*. IEEE, 2017, pp. 7–12.

[2] K. Pattabiraman, G. Li, and Z. Chen, "Error resilient machine learning for safety-critical systems: Position paper," in *2020 IEEE 26th International Symposium on On-Line Testing and Robust System Design (IOLTS)*. IEEE, 2020, pp. 1–4.

[3] M. Yayla, Z. Valipour Dehnoo, M. Masoudinejad, and J.-J. Chen, "Tream: A tool for evaluating error resilience of tree-based models using approximate memory," in *Embedded Computer Systems: Architectures, Modeling, and Simulation*, A. Orailoglu, M. Reichenbach, and M. Jung, Eds. Cham: Springer International Publishing, 2022, pp. 61–73.