Measure energy consumption

**Phase 1 submission**

**963321106090- S.Sakthi priya**

# Abstract

* Energy consumption has been widely studied in the computer architecture field for decades. While the adoption of energy as a metric in machine learning is emerging, the majority of research is still primarily focused on obtaining high levels of accuracy without any computational constraint. We believe that one of the reasons for this lack of interest is due to their lack of familiarity with approaches to evaluate energy consumption.
* Approaches to estimate energy consumption
* The goal of this section is to introduce key approaches to estimate energy to the machine learning expert. First, we give a general overview of the energy estimation field, providing the reader with the basic knowledge. Second, we explain in detail how the energy estimation models are built, to give the machine learning expert or computer architecture researcher the starting point to build or use more specific machine learning energy models.
* The papers reviewed in this section are chosen from a more general survey [30] on power measurement, estimation, and management. We also include papers that we discovered from researching the field on ways to estimate the energy consumption that could be applied in machine learning scenarios. This was achieved by searching on online databases (e.g. Google Scholar) and by looking at the references from some key papers in the area.
* The surveyed papers can be clustered into four groups: (i) papers that obtain the activity factors with performance counters and use regression or correlation techniques to obtain the power or energy; (ii) papers that use simulation data to obtain the activity factors; (iii) papers providing architecture or instruction level information; (iv) papers that provide real-time power or energy estimation. Table 1 provides the connection between the general categories from the taxonomy presented in Section 3 and the specific techniques mentioned above (PMC, simulation, architecture or instruction level, and real-time estimation).
* Table 2 summarizes the advantages and disadvantages of each technique, together with examples of possible machine learning applications of such techniques. More details are given in Sections 4.1 Performance counters using regression or correlation techniques, 4.2 Simulation, 4.3 Instruction-level or architecture-level estimation, 4.4 Real-time power estimation, where we provide a synthesis of the reviewed papers grouping them in the mentioned categories.
* Table 1. Connection between the categories from the taxonomy (Section 3) and the techniques from Section 4.

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* Taxonomy Technique
* Software-level
* Application-level PMC, Simulation, Real-time power estimation
* Instruction-level Instruction-level estimation
* Hardware-level Hardware-level estimation
* Table 2. Advantages, disadvantages, and possible machine learning applications of the techniques summarized in Sections 4.1 Performance counters using regression or correlation techniques, 4.2 Simulation, 4.3 Instruction-level or architecture-level estimation, 4.4 Real-time power estimation.

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* Technique ML Application Advantages . Disadvantages
* PMC Energy consumption analysis of any ML model No overhead. Application independent No per-processor results
* Simulation. Analysis of algorithms behavior on ML specific hardware Detailed results Significant Overhead
* Instruction Energy consumption analysis of specific layers Detailed breakdown of energy consumption Not easily available
* Architecture. Improve programming hardware for ad-hoc ML applications Detailed view Usually not generalizable to dresults

# Problem

Energy and accuracy of the VFDT and the HAT in concept drift and nonconcept drift datasets with 5 million instances.

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| Alg Dataset Acc (%) Total Processor | DRAM |
| HAT RandomRBF 65.75 578.03 558.34  (0.001) | 19.69 |
| HAT RandomTree 97.75 758.80 728.32 | 30.49 |
| VFDT RandomRBF 56.45 516.92 496.43  (0.001) | 20.49 |
| VFDT RandomTree 97.40 363.30 348.60 | 14.70 |