Machine learning for timing estimation

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1. CONTEXT

The execution time is calculated in specific cases depending on the needed application domain, (e.g, worst case execution for realtime applications, average case for compiler optimization).

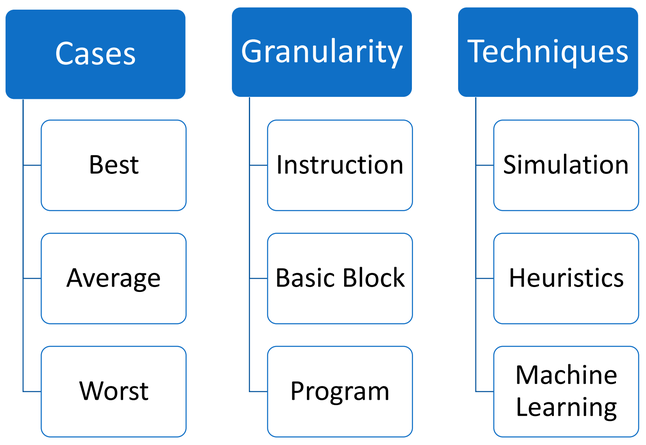


Figure 1 Execution time estimation classification

Challenges of using Machine Learning for timing estimation :

- Context-awareness (Cache and Pipline).
- Representativity of training data.
- Reliability of the estimations.

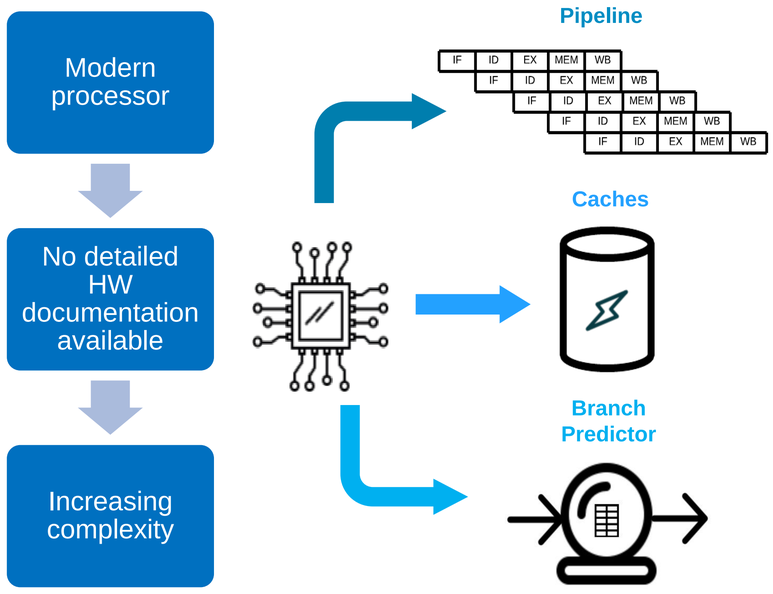
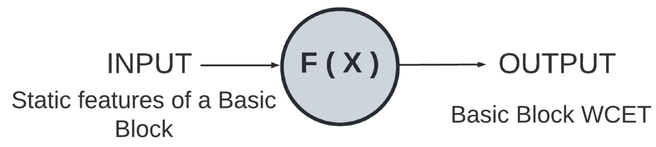


Figure 2 Challenges to estimate the execution time of modern processor

2. TIMING WORST CASE



WE-HML [1] (WCET Estimation using an Hybrid Machine-Learning based technique) estimates the WCET for processors that have caches.

- **Learning phase :** Training on Basic Block and WCET.
- **Estimation phase :** ILP for longest path combined with ML model.

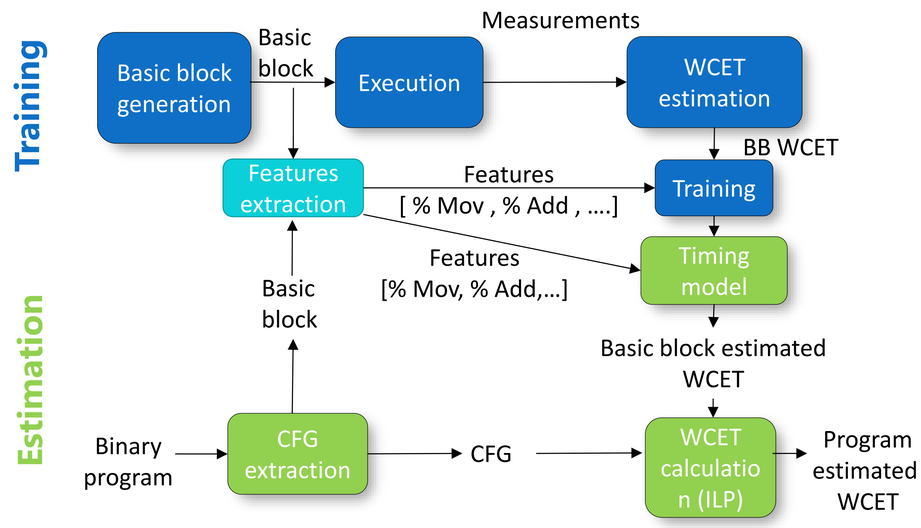
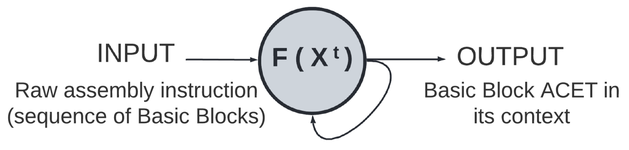


Figure 3 Training/Estimation workflow of WE-HML

3. TIMING AVERAGE CASE



- ITHEMAL [3] uses 2 stacked LSTMs layers to estimate the execution time for a BB in isolation.
- CATREEN [2] improves ITHEMAL to estimate the execution time of a BB in its context.
  - Instruction == Word.
  - Basic block == Sentence.
  - Sequence of basic blocks == Paragraph.

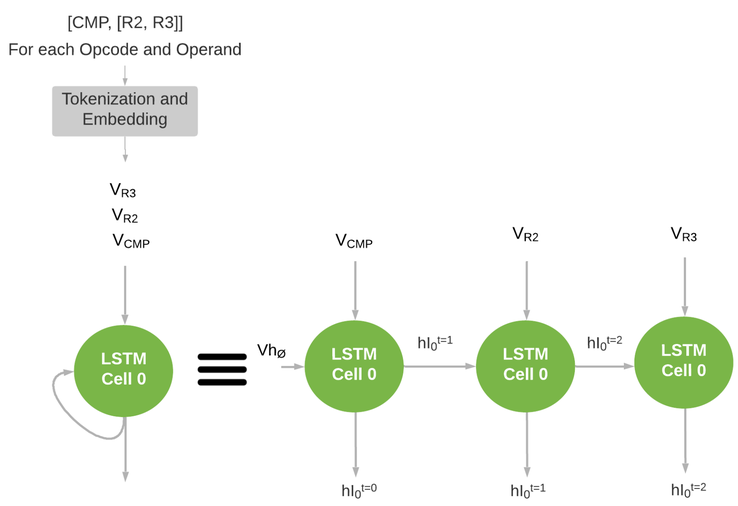


Figure 4 Unfolding of a LSTM cell of the instruction layer on a machine instruction

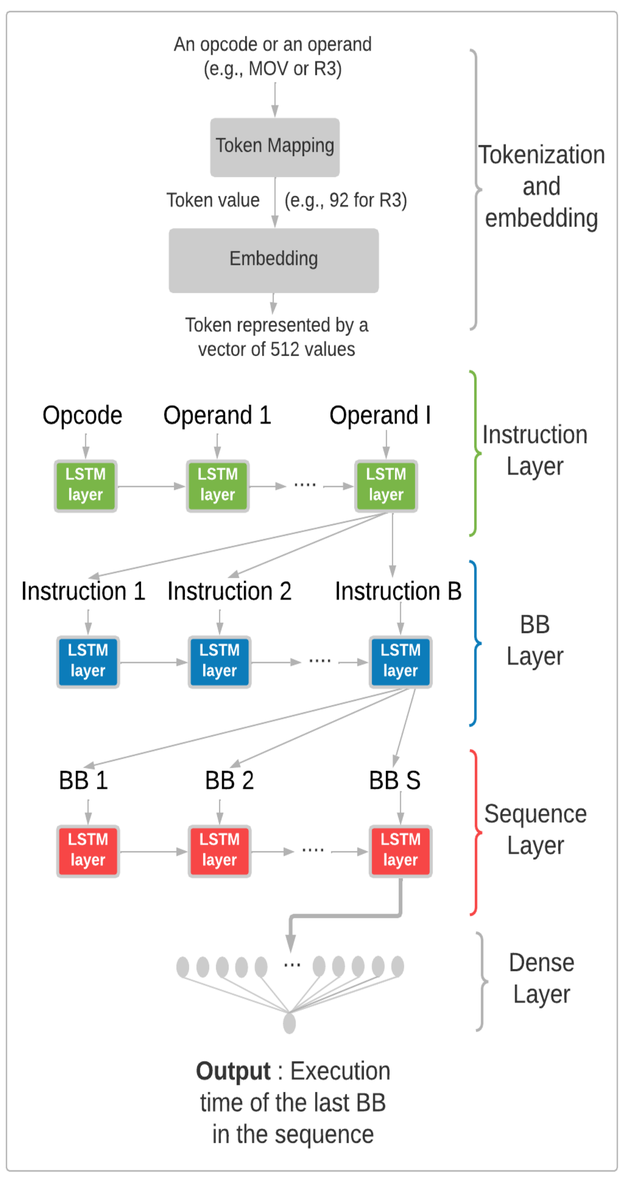


Figure 5 Architecture of CATREEN

4. RESULTS

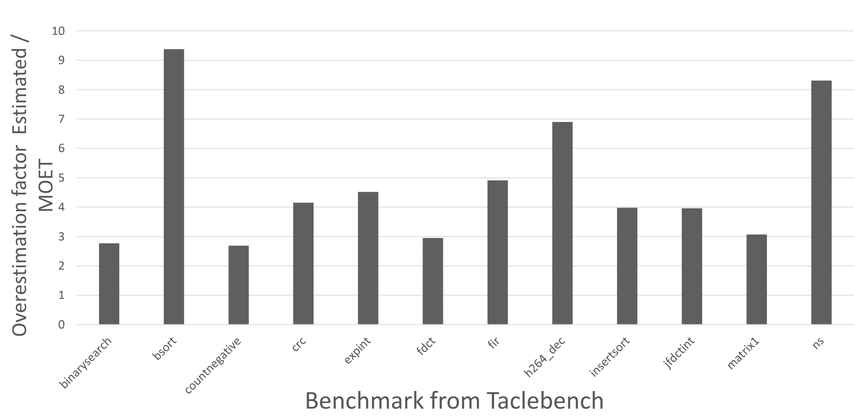


Figure 6 Estimated WCET WE-HML versus Maximum Observed Execution Time (MOET)

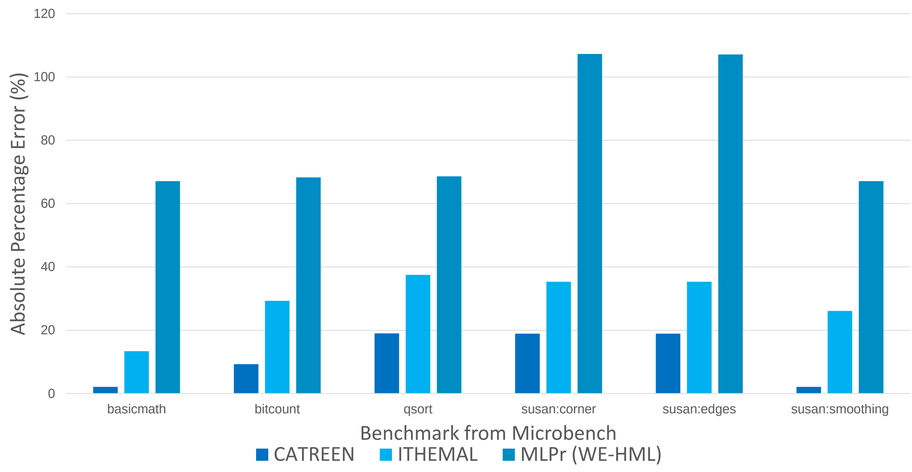


Figure 7 Absolute Percentage Error on MiBench for CATREEN, ITHEMAL and MLP regressor

5. PERSPECTIVE

- Transformers [4] are able to handle sequential data, but this is done in parallel, which drastically reduces both training and inference times.

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- [2] Authors of this poster, “CATREEN: Context-Aware Code Timing Estimation with Stacked Recurrent Networks”, 2022, submitted to ISPASS, under review.
- [3] C. Mendis, A. Renda, S. Amarasinghe, and M. Carbin, “Ithemal: Accurate, portable and fast basic block throughput estimation using deep neural networks,” in International Conference on machine learning. PMLR, 2019, pp. 4505–4515.
- [4] A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit, L. Jones, A. N. Gomez, Ł. Kaiser, and I. Polosukhin, “Attention is all you need,” in Advances in neural information processing systems, 2017, pp. 5998–6008.