Introduction

- Applications for mobile devices are becoming increasingly complex and power hungry, calling for improved energy-saving techniques due to limited battery capacity. Understanding power consumption in these devices requires accurate power estimation of mobile systems.

- In this project, we investigate how to utilize selected Performance Monitoring Counters (PMCs) and machine learning to predict power consumption of a mobile device during runtime.

- Performance Monitoring Counters (PMCs) are hardware counters that collect events from the processor and memory system during runtime.

Methodology

- We use the ODROID-XU3 mobile development board with ARM big.LITTLE core clusters.
- 8 cores total:
  - 4 LITTLE cores (A7 cores 0-3) maximize power efficiency
  - 4 big cores (A15 cores 4-7) maximize performance. We focus on the big cores because they consume significantly higher power than the smaller cores.
- A maximum of 6 PMCs can be collected simultaneously on the board while running a benchmark.
- Power is measured at the cluster level -- counters are measured at the per-core level.

Figure 1 (right): Figure 1 (right): We choose 6 PMCs most correlated to power.

- We refer to Walker et al. to choose 6 PMCs most correlated to power.
- Using the ODROID-XU3 mobile development board used for data collection.
- Perform each benchmark for 3x.
- Collect data every 200ms and save the CSV files.
- Preprocess the data to prepare for machine learning with scikit-learn.
- Use machine learning to make a linear regression and find coefficients for each value.
- Check the accuracy with the r² score and mean squared error.
- Get the average of every 5 rows and repeat the whole process for each separate training set.
- Use machine learning on the entire and averaged data sets.

Machine learning with scikit-learn

- A Python machine learning library.
- Ordinary Least Squares (OLS): a linear regression that minimizes the residual sum of squares between the predicted and actual values.
- Lasso linear model: minimizes coefficients, examining the tradeoff between accuracy and reducing parameters.
- Accuracy is examined with the mean absolute error and the r² value.

Discussion

Conclusions:
- Power consumption can be modeled from the use of 5 PMCs with at least 91% accuracy.
- Using the average of every 5 data points increases the accuracy to 98%.
- Lasso regression shows that certain PMCs with zero coefficients can be removed from the prediction without impacting accuracy.
- The model is accurate up to an alpha value of 0.01.

Caveats:
- Using the average data creates more extreme coefficients and increases the number of negative coefficients.
- May be due to reduced size of dataset.
- One of the lower r² score from 3 KFolds demonstrates overfitting in the model. However, the accuracy remains at more than 99%
- Applications:
  - These results demonstrate feasibility of predicting power consumption with more PMCs, and using Lasso to determine the most important features.
- Future steps:
  - Reduce overfitting with other fitting and cross validation methods.
  - Experiment with other linear modeling techniques: lasso, scikit-learn.
  - Experiment with a larger quantity of PMCs, using Lasso to determine the most important features in power prediction

References


Acknowledgements

Thanks to Onur Sahin and Prof. Coskun, as well as PEAClab group for their support and guidance throughout this project. Thanks to the Boston University RISE Internship Program for giving me the opportunity to do research in a lab setting.