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OPTIMIZATION OF PHYSICAL LAYOUT OF PROCESSORS USING DEEP LEARNING

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У роботі вивчається потенціал глибокого навчання для розв'язання проблеми оптимізації дизайну процесорів, покладаючись на доведені можливості глибокого навчання у розв'язанні складних задач. Нещодавні інновації в open source інструментах для дизайну процесорів знизили ціновий бар'єр та дозволили зробити дослідження у сфері оптимізації процесорів доступними для невеликих дослідницьких груп та для індивідуальних дослідників. Однак незрілість цих інструментів у поєднанні і загальною складністю сфери розробки мікропроцесорів залишає процес оптимізації дуже складним. Не дивлячись на все це, потенційні переваги глибокого навчання у значному покращенні архітектур мікропроцесорів дуже значні, що робить цей підхід багатообіцяючим для майбутніх досліджень.

The microprocessor is the fundamental building block of modern computing technology, and its performance directly impacts the speed and efficiency of all digital devices, from smartphones to data centers. Modern processors contain so many transistors that are so small that it makes it extremely difficult to follow Moore's law. Because of that industry leaders such as AMD, Intel and TSMC start devoting more attention towards the optimization of the architecture and specialization of the processors for some specific set of computations. The latter is extremely important for the application of new artificial intelligence models. Microprocessors tailored specifically for the inference of large AI models or specifically for the inference of a single model could drastically decrease time and energy cost of the model execution and make such models available in laptops and smartphones. Another trend that has been started by Apple is moving towards SoC (system on the chip). Apple has shown that such systems have great computational capabilities along with high efficiency. However, such systems are even more difficult to build and optimize than CPUs or GPUs because of extremely large number of components that have to be placed on the die and interconnected together. These two facts mean that the optimization of processor architectures will be very important for the foreseeable future but considering the maturity of this field it is obvious that the problem is very difficult to tackle. This is where another rapidly advancing field might become helpful, namely deep learning.

It has been shown that the neural networks are highly capable when it comes to solving the most complicated problems that humans know of, such as

protein folding [1]. Deep learning can also be used to optimize physical systems using various methods, for example algorithm developed in this work [2]. Optimization of processor architectures is very difficult task and it makes sense to try applying deep learning techniques to solve it. Some attempts have already been made [3, 4] but in general this direction of research is very novel and unexplored.

One of the biggest obstacles in the field of designing microprocessors have been extremely high cost of software and hardware tools required to create simulations and prototypes. Luckily it is no longer the issue as there are open-source tools that allow creation of microprocessor designs and their simulation without paying high entry fees. What makes it even better that the core tools such as OpenRoad are supported not only by community but also by the institutions such as DARPA [5]. Even though cost barrier has been mitigated, other problems remain, namely, open-source tools are relatively new, have complex APIs and, in general, lack the documentation. This makes the task of optimization of processor architectures quite difficult from the software development point of view as well.

Summing up, the task of optimization of microprocessor's architectures is very important now and will remain important for the foreseeable future. The field is extremely mature and the optimization task is extremely difficult. It makes sense to try applying deep learning to this problem, however, it has been difficult because of high cost of entry to the industry. Even though, cost barrier has been eliminated the task remains difficult due to the lack of proper documentation of existing open-source tools and general complexity from the point of software engineering. In spite of the difficulties and problems, the approach is worth trying because deep learning shows extreme capability when it comes to solving highly complicated problems and it might significantly improve microprocessor's architectures.

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