SIMULATING THE HEART USING MAXELER DATFLOW SUPER-COMPUTING AND FPGA

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INTRODUCTION

Within the scope of the Cyber-Physical Systems Group of the TU Wien my diploma thesis introduces a new approach for cardiac cell simulation. Cardiac cell simulation can be used to test medical monitoring systems, like pacemakers. Hereby it is possible to provide early diagnosis of cardiac arrhythmia.

Despite the great effort to implement efficient GPU-based and CPU-based simulators for different mathematical models, the analysis and the prediction of the cardiac dynamics remains still a very computational task. The aim of our work is to investigate how to use data-flow hardware-based solutions, using Maxeler Dataflow Techology, to improve further the simulation of different cardiac models.

PROBLEM DESCRIPTION

The aim of this work is to gather information about the advantages and disadvantages of using Maxeler Technology to simulate cardiac cells. Therefore given implementations of cardiac cell models, are re-implemented using Maxeler Dataflow.

This will allow a detailed analysis of the resource efficiency and probable optimization. Furthermore, to get statistically relevant results, the obtained simulations will be compared to the ones obtained using other hardware solutions such as using GPU, FPGA and CPU. Furthermore, we aim to evaluate the advantages and disadvantages of using Maxeler Dataflow Technology. Despite the possible benefits, it has to be determined if the complexity of cardiac cell simulation exceeds the scope of what is possible with this technology. To do so, the implementation of cardiac cells is split into three steps. The first step is to implement a single cell of the given model. Building on that, the second step is the implementation of a cell cable according to the cable theory of cells, see [3]. The last step is the simulation of cardiac tissue, represented as multidimensional model.

Based on the implementation in Maxeler Technology several tests with respect to performance, power and memory consumption will be performed. The results of these tests will be set against the values of known state-of-the art technologies. Another part of the evaluation is the comparison of the different models. These will be analyzed regarding their mathematical complexity and realizability in Maxeler Dataflow. Furthermore, the performance, power and memory consumption of the different models in Maxeler Dataflow will be compared.

Additionally this thesis will provide the relevant background information regarding Maxeler Technology, cardiac electro-physiology and other technologies used for simulation.

CURRENT STATE AND EXPECTED RESULTS

The results of the work include a full implementation of a single cell, a cell cable and cardiac tissue in Maxeler Dataflow Technology. Furthermore, as several mathematical models will be implemented, they will be analyzed and compared regarding complexity and performance. The results will be provided as tabular overview, with respect to known benchmarks. As the structure from dataflow application generally differ from control flow applications, the whole structure of the given implementations has to be modified for a working and possible ideal result. In the thesis, the differences of data flow and control flow will be presented, focusing, among others, on the advantages and disadvantages of these architectures.

CONCLUSION

The highly parallel computations generated by Maxeler Dataflow Tchnology allows an acceleration of complex calculations. Such calculations include the simulation of mathematical models of excitable cells. These simulations are important in medical research to provide deeper insight into the causes of certain diseases. Based on this, new preventive measures can be developed. In the work presented, the focus is on cardiac cell simulation and cardiac arrhythmia. Nevertheless technology can easily be adapted and used for other cell types, like neurons. Furthermore the technology can be used to accelerate machine learning algorithms and neural network based AI algorithms, which presents a broad area of application. Further examples of the possible usage of Maxeler Dataflow Technology are provided in the Maxeler App Galary [4].

REFERENCES

[1] https://www.maxeler.com/technology/dataflow-computing/

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[4] http://appgallery.maxeler.com/#/