Semiconductor Synthetic Biology (SemiSynBio) Annual Review

Poster Session

Wednesday, July 21, 2021

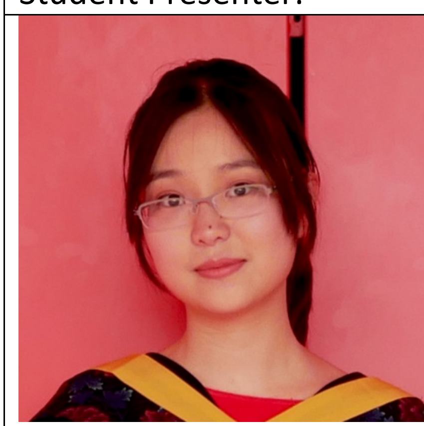
Student Presenters

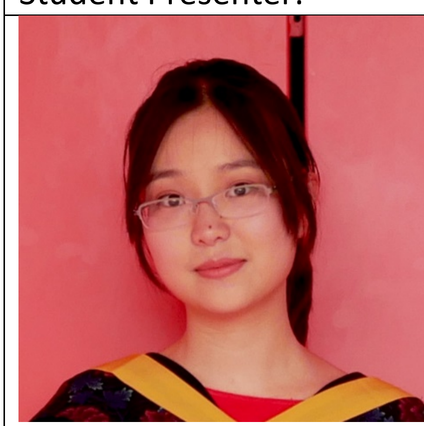
Mohammad Khairul Bashar (U. Virginia)
Hashem Mohammad (U. Washington)
Arpan De (Jadavpur Univ.)
Jiaying Ji (Notre Dame)

Poster #1	Display Room: Gather Town
Poster Title:	**Solving Graph Coloring Using Coupled Cardiac Cell Oscillators**
Task 2840.001	Cardiac Muscle-Cell-Based Coupled Oscillator Networks for Collective Computing
Abstract:	Coloring a graph is a computationally hard problem to solve on a digital computer that entails an exponential increase in the computational resources (time, memory) with increasing problem size. Dynamical systems such as synchronized oscillators offer unique advantages wherein discrete (digital) sequential computing is replaced by continuous-time evolution. Our work will consider the cardiac-cell-based oscillators evaluated in the project. Using the developed cardiac cell model, we will evaluate the computational properties of the coupled cardiac oscillators to evaluate their application in solving graph coloring problems for various graphs including larger benchmarking instances from the DIMACS database. We will also present a study of the effect of cell parameter variations on the coupling dynamics and quality of graph coloring solutions obtained using such dynamics. Furthermore, we will develop and demonstrate a heuristic (polynomial time) post-processing scheme that can help further improve the solution (computed by the oscillators) without a significant time penalty. Finally, we will also present graph coloring solutions using coupled CMOS oscillators.
Student Presenter:	Mohammad Khairul Bashar (University of Virginia)
	Dept: Electrical Engineering Faculty Advisor: Dr. Nikhil Shukla Graduation Date: May 2023 Email: mb9mz@virginia.edu Other Authors on the Poster: Antik Mallick & Nikhil Shukla

Poster #2	Display Room: Gather Town
Poster Title:	**Designing DNA Based Electronic Memory Element**
Task 2836.003	DNA X-Wire – Developing a DNA-based, Electrically Readable Memory for Next Generation Electronics
Abstract:	DNA sequences can be self-assembled into designer nanostructure with high precision and interesting electrical properties. Understanding the electronic properties can also lead to new electronic memory elements and devices. In this poster, we present our results about designing DNA memory elements which are obtained via theory and computational modeling. We present three studies that include: 1) DNA doping with an intercalator, 2) a comparison between strands that comprise energy wells and barriers, and 3) G-quadruplex DNA structures. Once we understand the fundamental properties of charge transport in these nucleic acid nanostructures and find the molecules having highest conductance ratios, this will pave the way of designing electrically readable DNA based memory devices.
Student Presenter:	Hashem Mohammad (University of Washington)
	Dept: Electrical Engineering Faculty Advisor: Dr. Manjeri Anantram Graduation Date: 7/15/21 PhD Graduation Date: 6/15/17 MS Email: hashemm@uw.edu Other Authors on the Poster: Busra Demir, Caglanaz Akin, Binquan Luan, Ersin Emre Oren & M. Anantram

Poster #3	Display Room: Gather Town
Poster Title:	**DNA Based Crossbar Architecture for High Density Memory Storage Application**
Task 2836.003	DNA X-Wire – Developing a DNA-based, Electrically Readable Memory for Next Generation Electronics
Abstract:	According to IRDS 2020 Projection, by 2040, worldwide data will amount to 10^{24} bits which may increase up to 10^{29} bits. The existing technologies like DRAM and HDD have reached their scaling limit. DNA storage systems appear to be a promising alternative. It can offer high data storage, high scalability at a low power consumption. In this work, simulated results of DNA based crossbar array are presented for high density memory storage with fast read-out mechanism. The theoretical computation methodology has been discussed. Next, system overview is discussed. The circuit model of the architecture is presented with description of the modelling parameters. Choice of interconnect is an important study for any crossbar technology. For the proposed DNA based crossbar technology, array performance is analyzed over a wide range of interconnect resistances. Following this, some design guidelines have been stated. Fermi Energy Variation is a major source of variability. Thus, its impact on array performance is studied in details. Finally, the scalability of the DNA nano-crossbar has been studied based on power consumption and bit error rate metrics.
Student Presenter:	Arpan De (Jadavpur University)
	Dept: Electronics and Telecommunication Faculty Advisor: Dr. Manjeri Anantram Graduation Date: June 2022 Email: arpantukan@gmail.com Other Authors on the Poster: Yiren Wang, Hashem Mohammad, Arindam Kumar Das, M. Anantram

Poster #4	Display Room: Gather Town
Poster Title:	**Cardiac Muscle-Cell-Based Coupled Oscillator Network for Vertex Coloring Problems**
Task 2840.001	Cardiac Muscle-Cell-Based Coupled Oscillator Networks for Collective Computing
Abstract:	Inspired by the natural biological system's efficiency and complexity, biocomputing that utilizes or mimics natural information processing inherent in living organisms provides a new computational approach that performs computing in a massively parallel way with energy efficiency. Here, we present a new biocomputing platform, cardiac muscle-cell-based (CM-based) bio-oscillator network, for solving computationally hard problems such as vertex coloring problems, which entail computing the minimum number of colors required to assign colors to all vertexes in a graph such that every two adjacent vertexes have different colors. We aim to harness the unique phase ordering produced by the coupled CM-based bio-oscillators to approximate the solution to the minimum vertex coloring problem. We first studied the synchronization behavior of the two coupled CM clusters which exhibited stable phase delays caused by the time lag in transporting electrical signals through the cardiac fibroblast (CF) bridge. Such delays can be exploited to build up the phase ordering in multi-node oscillators. Then, we aimed to use the bio-oscillator network to solve multi-node coloring problems (9 nodes) by mapping the vertexes and edges onto the CM clusters and CF bridges.
Student Presenter:	Jiaying Ji (Notre Dame University)
	Dept: Aerospace Engineering Faculty Advisor: Dr. Pinar Zorlutuna Graduation Date: 6/30, 2024 PhD (Aerospace Engineering) Graduation Date: 6/30/18 BS Email: jj2@nd.edu Other Authors on the Poster: Xiang Ren, Jorge Gomez, Mohammad Khairul Bashar, Hsueh-Chia Chang, Nikhil Shukla, Suman Datta, Pinar Zorlutuna

Poster #5	Display Room: Gather Town
Poster Title:	**Cardiac Muscle-cell-based Re-programmable Bio-Oscillator Network (CARBON) in a Multi-layer Microfluidic Device**
Task 2840.001	Cardiac Muscle-Cell-Based Coupled Oscillator Networks for Collective Computing
Abstract:	The computing capability of the cardiac muscle-cell-based (CM-based) bio-oscillator for solving coloring problems is limited by the pre-designed cell-patterning, which defines the unique connection path between clusters and, therefore, provides a unique solution for that pattern. In order to improve the flexibility and computing capacity of the bio-oscillator network, we designed a reprogrammable bio-oscillator network in a multi-layer microfluidic device to achieve various cell-patterning by logically controlling the on-and-off of a flow input. The bottom layer of the microfluidic device consists of a four-node CM-based bio-oscillator network interconnected by five cardiac fibroblasts (CFs) bridges. The middle layer is used for directing trypsin flow responsible for purging individual bridges. The top layer works in a fundamentally different way, pneumatically controlling the on-and-off of the vertical valves for a specific bridge in middle layer. Re-programming is achieved by specifically purging the CFs in the targeted bridge and, consequently, break the connection between the two adjacent nodes. By this logic microfluidic device, we can achieve an exponentially large number of cell-patterning and solve related coloring problems with a small number of controlled inputs.
Student Presenter:	Jiaying Ji (Notre Dame University)
	Dept: Aerospace Engineering Faculty Advisor: Dr. Pinar Zorlutuna Graduation Date: 6/30, 2024 PhD (Aerospace Engineering) Graduation Date: 6/30/18 BS Email: jj2@nd.edu Other Authors on the Poster: Xiang Ren, Jorge Gomez, Mohammad Khairul Bashar, Hsueh-Chia Chang, Nikhil Shukla, Suman Datta, Pinar Zorlutuna