Fakultät Elektrotechnik und Informationstechnik

Institut für Nachrichtentechnik, Deutsche Telekom Professur für Kommunikationsnetze

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Title: Analog Computing for Solving the Diffusion Equation in Molecular Communication
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Abstract: Diffusion is the basic transport mechanism in molecular communication (MC) systems and governs how information molecules propagate through a medium. Accurate and efficient solutions of the diffusion equation are essential for the design and analysis of MC systems, especially in complex environments where analytical solutions are unavailable and numerical methods become computationally expensive.

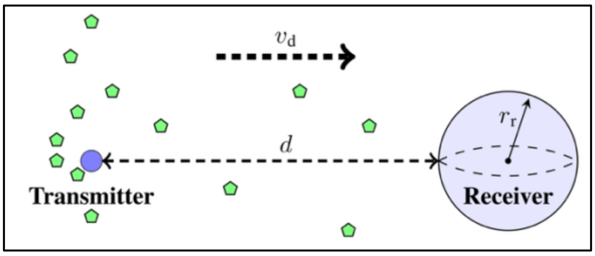

Figure 1: Simple MC system model.

This diploma thesis project investigates the use of analog computing hardware to solve diffusion equations for MC scenarios. The goal is to evaluate whether analog computing platforms can provide fast and energy-efficient alternatives to conventional numerical solvers such as the finite element method (FEM) while maintaining accuracy.

The project starts with a predefined MC scenario for which a closed-form analytical solution is available in the literature. The analog-computing-based solution will be validated and benchmarked against both the analytical reference and FEM simulations using predefined key performance indicators (KPIs). Subsequently, the work will be extended to an advanced scenario involving obstacles and complex geometries, where no closed-form solution exists and the comparison will focus on analog computing versus FEM.

Task description:

- Study the diffusion equation and its role in MC channels.
- Implement a predefined diffusion scenario on an analog computing platform using Method of Lines.
- Develop a reference simulation using FEM and reproduce the analytical solution from literature.
- Define and evaluate KPIs.
- Extend the model to a complex MC scenario with obstacles and advanced geometries that cannot be solved analytically.
- Compare the analog computing approach against FEM for the advanced scenario.

Required skillset:

- Python programming (must).
- Basic knowledge of numerical methods and scientific computing.
- Familiarity with differential equations, transport phenomena, or MC is beneficial.
- Experience with simulation tools such as FEM software (e.g., COMSOL, MATLAB PDE Toolbox, OpenFOAM) is a plus.
- Interest in analog computing, unconventional computing architectures, and performance evaluation methodologies.

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