In-Network Acceleration for Light Propagation Modeling

Rigden Atsatsang❑, Nadia Netolicky❍, Shivam Patel❑, Kenneth Tichauer❍, Nik Sultana❑

❑Dept of Computer Science, ❍Dept of Biomedical Engineering

ILLINOIS TECH

1) Problem & Background

- Surgery is often the first line of treatment for patients diagnosed with solid cancer, where complete removal of the tumor(s) is not always achieved owing to challenges in detecting remaining cancer cells.
- It is estimated that up to 50% of patients with head and neck cancer receive incomplete surgeries because of particularly complex anatomy.
- To tackle this problem, our collaborators at the University Medical Center Groningen in the Netherlands have initiated the first clinical trial using cancer-targeted fluorescence agents injected into patients prior to surgery to help better identify remaining cancer in their patients so that it can be removed.
- To assist with these efforts, we have been developing advanced imaging strategies to help detect even the smallest amounts of cancer.
- Optimization of these strategies requires accurate understanding of how fluorescent light propagates through biological tissue at the margins of cancer resections. However, accurate simulations are restrictively time-consuming using current methods.

2) Motivation

The goal of this collaborative project is to explore using cutting-edge computational methods to significantly amplify the efficiency of light propagation modeling.

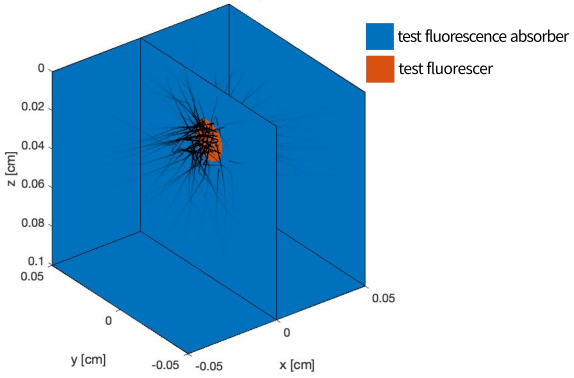


Fig (1) Fluorescence Photon Paths

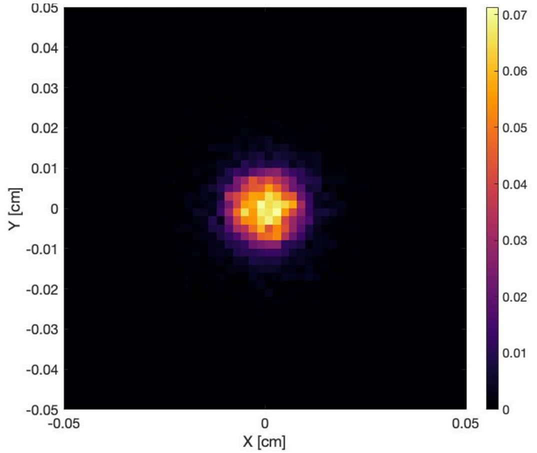
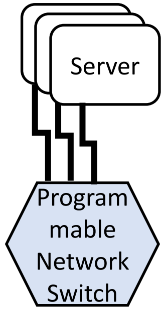


Fig (2) Normalized Fluorescence Fluence Rate in the Image Plane at 1x Magnification [W/cm^2/W.incident]

3) Approach and Methods



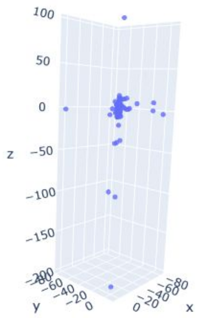


Fig (3) 3D Plot of Values Generated by P4 Program

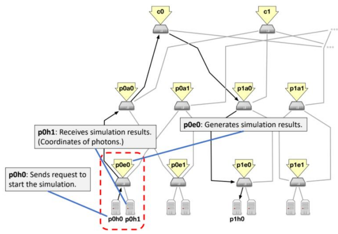


Fig (4) Network Diagram

- This project will use advanced methods in Computer Networking to accelerate a computational task.
- This research will model a computer cluster that contains modern networking hardware that can execute simple programs on traffic as it crosses the network.
- We'll use this capability to model the propagation of light through a tissue – this implementation will be the first outcome of this research.
- Next we'll look for ways of optimizing the implementation – to have it model more detailed or complex experiments, and at higher performance.

  We'll use a benchmark consisting of realistic datasets or examples and will later be used to evaluate the in-network program.

Prototype Implementation: Our current P4 prototype runs on a single switch (p0e0 in Fig 4) and uses a neighbourhood of photon coordinates encoded in a table as a seed. The table is consulted at runtime at random offsets to obtain coordinates that are then randomised further by the P4 program to produce final photon coordinates that are sent to p0h1 for collection. In later prototypes we plan to improve the P4 program to rely less on seed values, and to use additional switches.

Acknowledgement

We thank the RES-MATCH organisers at Illinois Tech for making this work possible.