

MASTER THESIS ET/CE/ESE

Integration of ESIM Principles into NVIDIA Isaac Sim for High-Fidelity Event-Based Data Generation

Semester: WS 2025/26

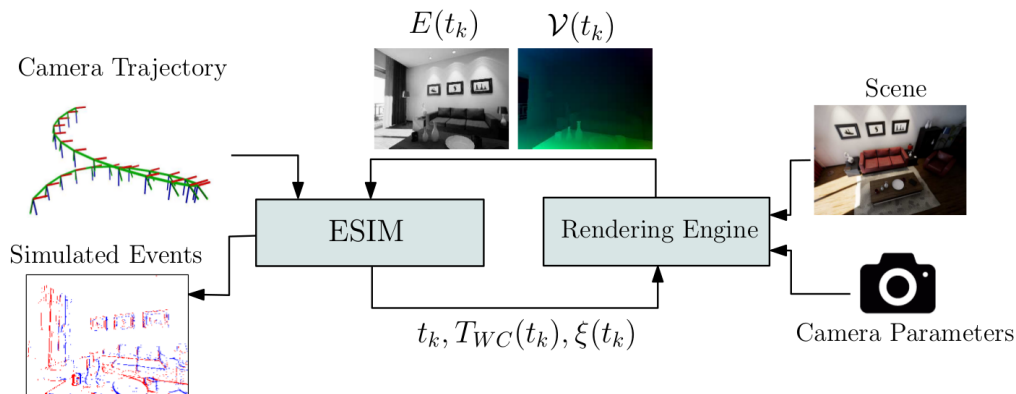


Figure 1: Conceptual workflow: Leveraging NVIDIA Isaac Sim's RTX rendering pipeline to generate ESIM-accurate event streams.

Background

Event cameras are bio-inspired sensors that respond to per-pixel intensity changes with microsecond latency. While simulators like ESIM have been instrumental in developing event-based algorithms, they often lack the photorealism and physics-engine integration required for complex robotic tasks. NVIDIA Isaac Sim, powered by Omniverse, offers state-of-the-art RTX rendering and GPU-accelerated physics, but lacks a native, high-fidelity event generation model that matches the noise patterns and dynamics of ESIM.

Project Goal

The objective of this thesis is to design and implement a High-Fidelity Event Simulator Extension within NVIDIA Isaac Sim. By applying the mathematical foundations of ESIM to Isaac's rendering pipeline, the student will create a tool capable of generating realistic event streams in photorealistic environments. The thesis concludes with a thorough validation against real-world event datasets.

Learning Outcomes

The student will gain deep expertise in **NVIDIA Omniverse/Isaac Sim**, GPU-accelerated sensor simulation, and the physics of **Neuromorphic Vision**. This project provides a unique intersection of high-end simulation and next-generation robotic perception.

Intermediate Goals

- **Isaac Sim Mastery:** Set up the Omniverse environment and interface with the Python API / OmniGraph.
- **ESIM Core Implementation:** Port ESIM's temporal contrast model into the Isaac Sim workflow, utilizing high-frequency frame interpolation.
- **Noise & Non-Idealities:** Implement realistic sensor effects such as leak currents, refractory periods, and hot pixels.
- **Validation:** Compare the generated synthetic data with the original ESIM outputs and real-world recordings (e.g., MVSEC dataset).

Requirements

- **Core Skills:** Strong Python programming; familiarity with Linux/Ubuntu; basics of computer graphics (rendering, shaders).
- **Simulation/Robotics:** Previous experience with ROS2, Isaac Sim, or Gazebo is highly preferred.
- **Nice to Have:** CUDA/C++ knowledge for performance optimization; experience with Event-based SLAM.

References

- [1] Rebecq et al., *ESIM: an Open Event Camera Simulator*, Conference on Robot Learning (CoRL) 2018.

