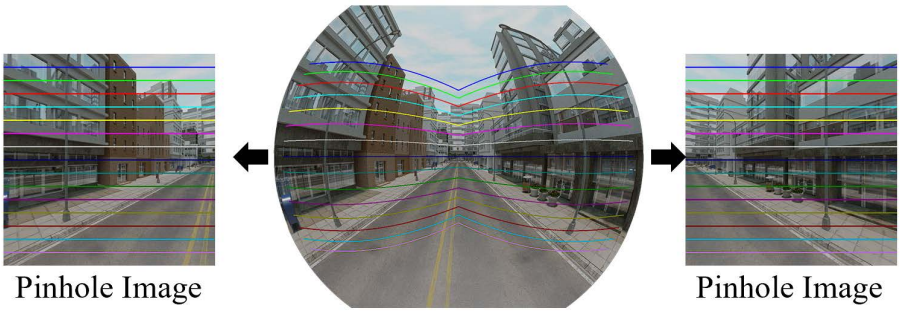
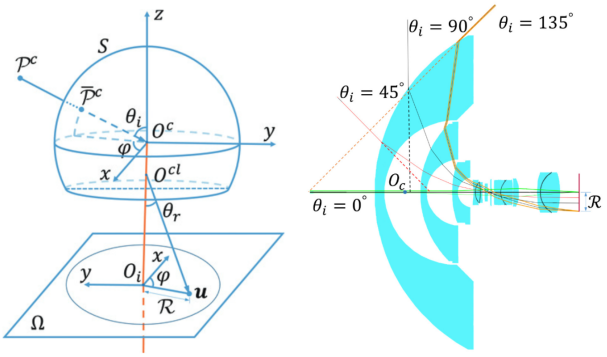
Research on Real-Time Fisheye Image Correction on Embedded FPGA for Robotic Vision

Description

This project is at the exciting intersection of robotics, computer vision, and high-performance computing. We aim to solve a critical challenge for autonomous systems: correcting severe fisheye camera distortion in real-time. Using Verilog and FPGA technology, you will develop a hardware-accelerated system that "flattens" distorted video streams instantly, a vital function for enabling robots and drones to accurately perceive and navigate their world.





(a) (b)

Background

Fisheye lenses are essential for modern robotics, drones (UAVs), and autonomous vehicles. Their ultra-wide Field-of-View (FoV), often 180° or more, allows a system to "see" its entire surroundings with a single camera.

The Challenge: This wide view comes at a cost: severe image distortion (the "fisheye" effect). While humans can interpret these images, robotic algorithms for navigation, object detection, and SLAM (Simultaneous Localization and Mapping) cannot. They require a clear, "undistorted" (rectilinear) view of the world.

The Solution: We must correct this distortion in real-time. Software-based solutions on a CPU or even a GPU are often too slow, too power-hungry, or introduce unacceptable latency for a robot that needs to react instantly. Field-Programmable Gate Arrays (FPGAs) are the perfect solution, offering massive parallelism for pixel-level operations at extremely high speeds and low power.

Implementation & Testing: Synthesize, place, and route the design for a target FPGA board (e.g., Xilinx or Intel) and perform real-world testing with a camera.

Technische Universität München

TUM School of Computation, Information and Technology

Lehrstuhl für Robotik, Künstliche Intelligenz und Echtzeitsysteme

Supervisor:
Prof. Dr.-Ing. Alois Knoll

Advisor:
Qian Huang M.Sc.

Type:
MA,SA,BA

Research area:
Computer Vision, Hardware Acceleration, Embedded System Design, SLAM

Programming language:
Verilog , C++ or Python

Requirements:
High self-motivation and passion for robots; At least six-month working time; (Optional) With experience on embedded system design.

Language:
English

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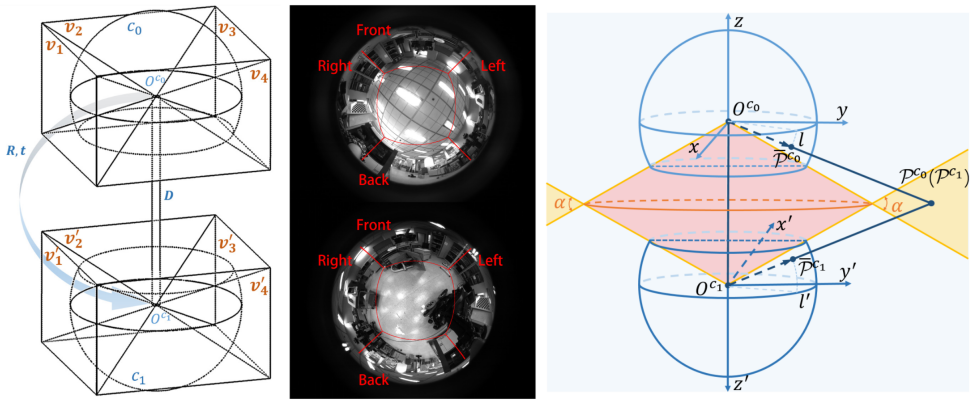

(a) (b) (c)

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Tasks

As a key member of this project, you will:

·Research: Conduct a literature review of fisheye distortion models (e.g., polynomial models, field-of-view models) and correction algorithms (e.g., lookup-table based, mesh-based).

·Algorithm Modeling: Model a chosen algorithm in a high-level environment (like Python/ OpenCV or MATLAB) to understand its behavior.

·Hardware Architecture: Design a novel, high-throughput digital architecture optimized for FPGA implementation. This involves managing memory bandwidth, creating efficient computational pipelines, and handling video stream protocols (like AXI-Stream).

·Verilog Implementation: Write synthesizable Verilog code for the entire processing pipeline.

·Verification: Create a comprehensive simulation testbench (e.g., using ModelSim or Vivado Simulator) to verify your design's functional correctness.

·Implementation & Testing: Synthesize, place, and route the design for a target FPGA board (e.g., Xilinx or Intel) and perform real-world testing with a camera.

What You Will Gain

Robotics: Directly contribute to a core component of autonomous systems.

Computer Vision: Gain deep, practical knowledge of real-time image processing pipelines.

Advanced Digital Design: Master the complete FPGA workflow, from algorithm to hardware, using Verilog—a skill highly sought after by companies like NVIDIA, Intel, Apple, and Xilinx (AMD).

This project is perfect for a strong bachelor's thesis, a master's project, or as a launchpad for a career in embedded systems, robotics, or ASIC/FPGA design.

Mentorship & Support

This topic, merging advanced algorithms with deep hardware design, may sound challenging. However, you will not be starting from scratch.

Your mentor (Ph.D. Student) has extensive research experience in this specific domain and has already established a solid foundation for this project. We are fully prepared to provide comprehensive, step-by-step guidance to ensure you get up to speed quickly. You will receive dedicated, hands-on support throughout the entire research and implementation process.

This is a unique opportunity to tackle a high-impact problem with expert, full-time mentorship.

For further discussion on specific tasks, welcome to direct contact me via email.