Hossein Daraei, PhD

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Staff research engineer with 8+ years at Meta Reality Labs and Magic Leap building neural 3D reconstruction pipelines, physically-based sensor simulation frameworks, and synthetic data systems for XR hardware. A recurring thread across both roles: simulation engines that generate synthetic training data for vision AI running on resource-constrained wearable devices. Specializes in NeRF, Gaussian Splatting, and Neural SDF methods, grounded in classical multi-view geometry, structure-from-motion, and bundle adjustment from a PhD on tightly-coupled LiDAR–camera fusion.

WORK EXPERIENCE

Staff Research Engineer, 3D Reconstruction & Spatial AI Jan 2023 – Present
Magic Leap Inc. — in partnership with Google *Remote*

- Led a 5-person research team building room-scale indoor 3D reconstruction pipelines for an XR platform; coordinated weekly research syncs and mentored junior engineers; achieved <4 cm Chamfer distance against LiDAR ground truth in 60-second reconstruction of 7×7 m scenes
- Extended Neural SDF methods (Neuralangelo, NeuS, MonoSDF, VolSDF) on RGB-D data within Nerfstudio and Sdfstudio; implemented a block-wise reconstruction approach with overlapping margins for seamless multi-room mesh generation at scale
- Integrated depth, normal, and HDR-aware priors into NeRF and Gaussian Splatting variants (SuGaR, 2DGS, Gaussian Opacity Fields), leveraging per-frame camera metadata (exposure time, gain) to recover saturated regions and improve geometric accuracy under challenging illumination
- Applied feed-forward foundation models (DUSt3R, MASt3R, Spann3R) to headset camera streams for dense point cloud reconstruction without per-scene optimization; fused with depth sensors to fill regions where depth hardware fails (dark, absorptive, or reflective surfaces)
- Integrated open-vocabulary 3D semantics by baking CLIP and DINOv2 features into mesh vertices; demonstrated interactive natural-language spatial queries on a live XR headset

Research Scientist, Eye Tracking & Computational Perception Sep 2018 – Sep 2022
Meta Inc., Reality Labs Research *Redmond, WA*

- Reconstructed photorealistic, identity-specific 3D eye surface geometry from multi-camera, multi-LED near-infrared light-dome captures using NeRF, including explicit modeling of the transparent, specular, refractive corneal surface invisible to standard photogrammetry; the resulting pipeline served as the algorithmic substrate for all downstream sensor simulation work
- Designed a physically-based sensor simulation framework for virtual placement of cameras, photodiodes, fringe projectors, and OCT systems around reconstructed eye models, predicting sensor response from first principles (ray-traced scene radiance, spectral sensitivity, shot noise, dark current) and enabling XR eye-tracker hardware design-space exploration entirely in simulation before manufacture
- Calibrated simulation-to-real gaps via bundle adjustment over benchtop measurements with anthropomorphic phantoms, jointly optimizing sensor, optical, and geometric parameters using Ceres Solver
- Proposed and co-authored an event-camera-based kilohertz-rate eye tracking method using coded differential illumination; published at WACV 2022

Research Engineer Intern (4 summers) Summers 2014–2017
Volkswagen Group of America, Electronics Research Lab. *Belmont, CA*

- Implemented real-time CUDA pipelines for LiDAR–camera early (measurement-level) fusion and semantic segmentation on NVIDIA Jetson TK1, achieving frame-rate ADAS perception on resource-constrained edge hardware
- Built SfM, SLAM, and bundle adjustment systems for 3D scene reconstruction and vehicle localization from LiDAR + camera sensor stacks
- Designed and calibrated a stereoscopic vision system on Jetson TK1 — multi-view extrinsic/intrinsic calibration via bundle adjustment, stereo rectification, and real-time disparity estimation
- Designed a Siamese deep network to score LiDAR–camera extrinsic calibration quality, enabling automated assessment in cross-modal sensor fusion
- Co-invented a multi-sensor lane detection system for early identification of exit-only and shared lanes; issued as US Patent 10,025,996

TECHNICAL SKILLS

Neural Rendering	NeRF (Instant-NGP, Mip-NeRF 360, Zip-NeRF, Nerfacto), Gaussian Splatting (SuGaR, 2DGS, Gaussian Opacity Fields, 4D GS, LangSplat), Neural SDF (Neuralangelo, NeuS, MonoSDF, VolSDF), feed-forward 3D (DUSt3R, MASt3R, Spann3R, MonST3R), foveated rendering, Nerfstudio, Sdfstudio
3D Vision & SLAM	Multi-view geometry, structure from motion (COLMAP), bundle adjustment (Ceres Solver, GTSAM, factor-graph optimization), feature extraction and matching (SIFT, ORB, SuperPoint), SLAM, visual-inertial odometry, visual localization, stereo vision, LiDAR + camera sensor fusion
Simulation	Physically-based sensor simulation, light transport (Mitsuba, OptiX), physics-grounded 3DGS (PhysGaussian, Material Point Method), agentic synthetic data pipelines (Blender scripting), sim-to-real calibration, room acoustics (*pyroomacoustics*, SOFA models)
Novel Sensors	Event cameras (Prophesee, Inivation), LiDAR (Velodyne, Luminar, Valeo), IMU, ToF depth sensors, photodiodes, fringe projectors, OCT
Agentic AI	LangGraph, MCP, CrewAI, Gemini API; Vision-Language Models (VLMs), diffusion-based generative models; multi-agent orchestration with Critic/Refiner sub-agents for 3D simulation and spatial AI systems
Wearable / Edge AI	On-device and always-on inference under wearable power budgets, model compression and quantization (TensorRT, ONNX, CoreML), embedded deployment (NVIDIA Jetson)
Signal Processing	Robust Bayesian data fusion, Kalman / Extended Kalman / Particle Filters, factor graphs and nonlinear least squares, optical flow, scene flow, image denoising and deblurring, HDR and radiometric calibration
Languages	Python, C/C++, CUDA/GPGPU, MATLAB
Libraries & Tools	PyTorch, TensorFlow, JAX, Hugging Face, OpenCV, PCL, Ceres, GTSAM, Eigen, OptiX, Mitsuba, Blender, ROS, Linux

SELECTED PUBLICATIONS AND PATENTS

T. Stoffregen, **M. H. Daraei**, C. Robinson, A. Fix, "Event-Based Kilohertz Eye Tracking using Coded Differential Lighting," *IEEE/CVF Winter Conference on Applications of Computer Vision (WACV)*, January 2022.

M. H. Daraei, A. Vu, R. Manduchi, "Region Segmentation Using LiDAR and Camera," *IEEE Intelligent Transportation Systems Conference (ITSC)*, October 2017.

M. H. Daraei, A. Vu, R. Manduchi, "Velocity and Shape from Tightly-Coupled LiDAR and Camera," *IEEE Intelligent Vehicles (IV) Symposium*, June 2017.

M. H. Daraei, "Optical Flow Computation in the Presence of Spatially-Varying Motion Blur," *10th International Symposium on Visual Computing (ISVC 2014)*, Las Vegas, NV, December 2014.

Raghu, **Daraei**, Natarajan, Lopez, "Early Detection of Exit Only and Shared Lanes Using Perception Technology," US Patent 10,025,996, June 2018.

Fix, MacDonald, Model, **Daraeihajitooei** et al., "Apparatuses, Systems, and Methods for Mapping a Surface of an Eye via an Event Camera," US Patent 11,176,367, November 2021.

Fix, MacDonald, Model, **Daraeihajitooei** et al., "Systems and Methods for Using a Display as an Illumination Source for Eye Tracking," US Patent 11,112,865, September 2021.

Fix, Robinson, **Daraeihajitooei**, Stoffregen, "Differential Illumination for Corneal Glint Detection," US Patent 11,853,473, December 2023.

Full publication and patent list on Google Scholar.

EDUCATION

University of California, Santa Cruz — *Sep 2014 – Jun 2018*
Ph.D. in Electrical Engineering — *Santa Cruz, CA*
Advisor: Roberto Manduchi · Thesis: Tightly-Coupled LiDAR and Camera for Autonomous Driving
Research focus: multi-view geometry, structure-from-motion, bundle adjustment, SLAM, and visual localization.
In collaboration with and sponsored by Volkswagen Group of America, Electronics Research Lab.

University of California, Santa Cruz *Sep 2012 – Sep 2014*
M.Sc. in Electrical Engineering *Santa Cruz, CA*
Advisor: Peyman Milanfar · Thesis: Optical Flow Computation Under Spatially-Varying Motion Blur

Sharif University of Technology *Sep 2008 – Jun 2012*
B.Sc. in Electrical Engineering *Tehran, Iran*

Allameh Helli National Talent School *Sep 2004 – Jun 2008*
National Organization for Development of Exceptional Talents *Tehran, Iran*

HONORS AND AWARDS

- Full PhD Research Scholarship, Volkswagen Group of America, Electronics Research Lab *2014–2018*
- Regents Fellowship, School of Engineering, UC Santa Cruz *February 2012*
- Ranked 84th out of 400,000+ applicants in Iran's national university entrance examination *July 2008*