Mustafa Shaikh

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Machine learning engineer focusing on computer vision and object tracking, with research experience in robotics, specifically optimal control. I have 5 years of industry experience in data science working closely with business stakeholders. I have lead projects end to end, from identifying a problem and designing a solution, to implementation and delivery.

EDUCATION

M.S. Electrical and Computer Engineering   San Diego, CA | 2022 - 2024
UNIVERSITY OF CALIFORNIA, SAN DIEGO
 Specialization: Robotics and Intelligent Systems

B.A.Sc. Engineering Science   Toronto, ON | 2013 - 2017
UNIVERSITY OF TORONTO

WORK EXPERIENCE

RESEARCH ENGINEER | MANORLAB; CELL BIOLOGY AND NEUROSCIENCE, UC SAN DIEGO San Diego, CA | 2024 -

Key Skills: Multi-object tracking, deep learning, transformers, ResNet, rotary positional embeddings, cell segmentation, Kalman filters, optical flow, Hungarian matching, pose estimation

Goal: Implement a reliable transformer based multiple object tracking system for microscopy and animal video data

Applications: Studying motion of organelles and animals to understand effects of neurodegenerative diseases

- Implemented **rotary** positional and temporal **embeddings** to encode relative position between organelles; improved key metric **ID switches** by average **5%** vs. fixed embeddings but lags learned embeddings
- Obtained baselines from state of the art cell tracking methods to identify areas for improvement for our method
- **Proposed** and **implemented** new 'global tracking accuracy' metric to address gaps in multi-object tracking metrics
- Created **value proposition** for our method, selected **tracking** and **biological metrics** to compare to existing methods
- Proposed automatic **error detection** system to **assist users** with finding **inference-time tracking errors**

GRADUATE RESEARCH ASSISTANT | EXISTENTIAL ROBOTICS LAB, UC SAN DIEGO San Diego, CA | 2023 - 2024

Key Skills: Model predictive control, control barrier functions, casADi, CVX, JAX, automatic differentiation, QP, Extended Kalman Filter, motion planning (RRT*), collision avoidance, ROS, Jackal robot, LiDAR, depth camera, HectorSLAM

Goal: Determine the optimal trajectory for an autonomous robot with limited field-of-view to keep a target within view while avoiding collisions with obstacles

Applications: Search-and-rescue, field crew support in dangerous environments, various security applications

Paper: *"Control Strategies for Pursuit-Evasion Under Occlusion Using Visibility and Safety Barrier Functions"* submitted to ICRA 2025. Preprint available soon on ArXiv.

- **Formulated and implemented** a **model predictive controller** using a **Quadratic Program** (QP) with CBF constraints to compute the optimal trajectory of the 'seeking' robot in order to keep the target within the field of view
- Implemented features to improve the **stability, reliability, and performance** of the controller, including: **trajectory smoothing** to reduce sudden changes in direction; **adaptive tuning** of CBF hyperparameter to improve collision avoidance; **slack variables** to improve feasibility of solution
- Demonstrated **>95% tracking** in **real world experiments** with Jackal wheeled robot in a cluttered environment
- Operated lightweight controller at 50Hz onboard the robot; fused sensor data from 3D LiDAR and RGB camera for SLAM and target detection
- Implemented **Extended Kalman Filter** to estimate target's position and velocity using camera detections

DATA SCIENTIST, SR. DATA SCIENTIST | WALMART CANADA   Toronto, ON | 2019 - 2022

Key Skills: Natural Language Processing - Spacy, Named Entity Recognition, BERT, human-in-the-loop systems, AutoML, PySpark, SQL, MLOps, Python, Pandas, Numpy, Keras, Google Cloud Platform, Airflow

Project lead - Automated Attribute Assignment (Jul 2021 to Jun 2022). **Goal:** Extract product features from item descriptions to populate missing data for products on walmart.ca to improve search quality for customers

- Developed **named entity recognition pipeline** (Spacy, BERT) to learn **context-aware** features from product descriptions; led to **>$1MM CAD revenue increase** annually by populating features for over 500,000 items
- Recognized need for **high quality custom annotated data**; pitched and integrated a **human-in-the-loop** annotation tool (Prodigy); setup **active labelling** loop with **least confident predictions** annotated
- **Coordinated Jr. Data Scientist**, and guided the implementation of an **asynchronous orchestration layer**
- Worked closely with business stakeholders to guide problem framing, roadmap, execution and production support

Other Projects (Apr. 2019 to Jun. 2021)

- Developed and deployed **hierarchical model factory** (xgboost) to categorize 3rd party vendor items on walmart.ca; increased **categorization rate from 90% to 97%** which increased product views for previously 'unfindable' items
- Lead developer for data-driven, rules based online **grocery substitutions recommendation** engine; **300bps improvement in customer satisfaction**
- Created and maintained **fulfillment centre forecast** (ARIMA, Prophet, AutoML) to optimize labour; >90% accuracy up from 75% previously, **>$1MM annual labour savings** by achieving high accuracy during holiday period

PROJECTS

ROBOTICS, DEEP LEARNING AND SOFTWARE ⤴   UC San Diego, 2023-2024

Key Skills: Extended Kalman Filter (EKF), Particle Filter, IMU, LiDAR, encoder, stereo camera features, instrinsics, sensor fusion, odometry, disparity, occupancy grid, texture map, SIFT, point cloud registration, PyTorch, C++, RAII, smart pointers, design patterns, templates, variants, STL

- **Visual-Inertial SLAM** for a car moving in an urban environment with an Extended Kalman Filter using **IMU data** and **stereo camera features** to map landmarks and plot the trajectory of a car in an urban environment
- **Particle Filter SLAM** for a differential drive robot moving through a building, in order to create an **occupancy grid map** and color **texture map** using **structure from motion**
- **Weighted A*** and **goal-biased RRT** for 3D motion planning in environments with obstacles; achieved faster convergence with RRT but less optimal path in obstacle-dense environments
- **PointNet-based neural network** in PyTorch to solve the **point cloud registration** problem, and achieved performance close to **Iterative Closest Point** (ICP) method on basic trajectories in Eden dataset
- **String library** with underlying buffer manager from scratch. **Achieved 33% lower memory usage than C++ std::string** for common string operations: append, replace, insert, erase, search
- Graph-based **in-memory JSON datastore** with query capability
- **Compressing archive tool** with add, extract, retrieve capability

SKILLS

C++, Python, SQL, Numpy, Pandas, PyTorch, Keras, CVX, JAX, OpenCV, GCP, PySpark, Hadoop, Airflow, ROS, ROS2