Abhiraj Singh

Linkedin: https://www.linkedin.com/in/abhirajsingh77/ Homepage: https://www.singhabhi.com/

I'm currently a Graduate student at ExoLab, KAIST, with a strong foundation in reinforcement learning, environment recognition systems, and MPC based control for powered exoskeletons and I aim to contribute to cutting-edge research in robotic mobility and autonomy.

EDUCATION

KAIST

- PhD in Mechanical Engineering (Ongoing); GPA: 3.92/4.3 (96.2%) Research Focus: Model Based Control, Learning Based Control, Depth Vision Based Environment Recognition
 - $\circ\,$ Currently on a two-year leave (April 2025 Feb 2027) to pursue entrepreneurial ventures and startup activities.:

KAIST

Masters in Mechanical Engineering; GPA: 3.92/4.3 (96.2%) Courses: Learning Based Control, Reinforcement Learning, Intro to Visual Intelligence, Mathematical Methods, Artificial Neural Network, Human Assistive Robotics.

IIT Roorkee

Bachelor in Mechanical Engineering; Score: 79.2% Courses: Automatic Control, Robotics and Control, Kinematics of Machines, Dynamics of Machines, Modelling and Simulation, Operating System, Data Structures and Algorithms.

SKILLS SUMMARY

- Programming Languages: C++, Python, Unix Scripting, Javascript, Dart
- AI/ML & LLM Frameworks: LangChain, LangGraph, Gemini API, OpenAI API
- Robotics & Control: ROS, Gazebo, Mujoco, Crocoddyl, Pinocchio, Pybullet, MPC
- ML & Vision: OpenCV, Open3D, Pyrealsense2, TensorFlow, PyTorch
- Web & App Development: Angular, React, Flutter, Next.js, TailwindCSS
- Backend & DevOps: FastAPI, Supabase, Firebase, PostgreSQL

EXPERIENCE

- EXOLAB, KAIST
- Masters Research
 - **Depth Vision based Environment Recognition for Powered Exoskeleton**: Developed a real-time stair localization and its parameter estimation system for powered exoskeletons in Python using an RGBD camera, also introduced adaptive parameterization to improve the accuracy and stability of the model enhancing mobility for individuals with physical challenges in various environments.
 - **Sim-to-Real Trajectory Generation using MPC**: Utilizing Model Predictive Control (MPC) and Python libraries Crocoddyl and Pinocchio to develop Sim-to-Real trajectory generation for a 12-DoF powered exoskeleton. This approach enables the creation of precise walking and stair-climbing trajectories, significantly improving the real-world functionality and adaptability of the exoskeleton.
 - **Cybathlon 2024**: Secured first place in the Exoskeleton Race at Cybathlon 2024 as a core motion control team member. Developed MPC algorithms for precise walking and adaptive gait control, ensuring stability and responsiveness on varied terrain.

GE Digital

- Software Development Engineer
- Designed and optimized component based architecture by utilizing Angular framework.
- Built reusable libraries and web apps with Typescript and Angular.
- Built next-generation Grid UI/UX for global utility customers through UI innovations and User Experience prioritization

SiCureMi Healthcare Technologies Pvt. Ltd.

Data Science Intern

- Worked on statistical planning and analysis of patient data from IoT devices and from past medical records.
- Built APIs for retrieving data from the MySQL database and catering it to the Front End (Python).
- Used machine learning tools on patients' medical records to help build personalized predictive models for lifestyle & chronic diseases which include diabetes, hypertension and cardiovascular diseases.

Daejeon, South Korea Feb 2025 - Present

Daejeon, South Korea Feb 2023 - Feb 2025

Roorkee, India

Daejeon, South Korea Feb 2023 - Feb 2025

Hyderabad, India August 2020 - January 2023

November 2018 - January 2019

New Delhi, India

Startup & Product Development

Tivra - AI-Powered Study Assistant for Students (tivra.io) Feb 2025 - Present Co-Founder & Product Architect

- Built an AI-based education platform to help students learn more effectively through Socratic questioning, concept review, and practice-based learning.
- Implemented document ingestion and an AI tutor that answers based on uploaded content using Langchain.
- $\circ\,$ Led technical development using Next. js, Supabase, LangChain, and Gemini for building a responsive, intelligent tutoring system for K-12 and exam-focused learners.

Latexpert – Agentic LaTeX IDE with AI Assistance (latexpert.io) April 2025 – Present Co-Founder & Product Architect

- Designed an AI-based LaTeX IDE that understands the user's paper-writing context and assists with auto-completion, code suggestions, and error correction.
- Built using LangGraph, Supabase, Gemini, Weaviate and React; supports live LaTeX editing, PDF compilation, and AI agent-based document writing.
- $\circ~$ Aims to accelerate research documentation by combining AI tool-use with real-time LaTeX writing workflows for researchers and students.
- Led development and launch of MVP with early access at latexpert.io.

PUBLICATIONS

- Published Papers
 - Madhusudan Singh, Abhiraj Singh, Shiho Kim, "Blockchain Technology A Game Changer for Securing IoT", in IEEE, 2018.
- Preprints / Under Review
 - Jongwon Kim, Abhiraj Singh, Jimin Youn, Hyeongjun Kim, Jeongsu Park, Jinsu Park, Kyoungchul Kong, "Optimization of Crutch-Free Walking for a Powered Exoskeleton Considering Human Adaptation", submitted to IFAC Mechatronics, 2025.
- Manuscripts Ready for Submission
 - Abhiraj Singh, Taeyeon Kim, Kyoungchul Kong, "Real-time Depth Vision-based Stair Localization and Parameter Estimation for Powered Exoskeletons".
- Master's Thesis

Title: Multi-Stage Optimization-Based Personalized Gait Generation in Powered Exoskeletons

Abstract: The development of powered exoskeletons has revolutionized mobility assistance for individuals with lower limb disabilities. However, achieving personalized, safe, and efficient walking patterns remains a significant challenge due to the variability in human dynamics and the limitations of traditional modeling and control approaches. This research introduces a multi-stage optimization-based framework for personalized gait generation in powered exoskeletons, addressing critical challenges in stability, safety, and user-specific adaptability.

The first stage focuses on accurate Center of Mass (CoM) estimation, starting with re-estimation of the exoskeleton's link masses and dynamic parameters using real-world data to refine its standalone CoM. This is followed by combined CoM estimation for the human-exoskeleton system, incorporating real-world data to improve the human model rather than relying solely on anthropomorphic data, thereby enhancing stability and achieving a more accurate representation of individual user dynamics.

The second stage utilizes offline Model Predictive Control (MPC) to generate smooth, symmetric, and dynamically feasible walking trajectories tailored to individual biomechanics and the re-estimated CoM, ensuring natural and safe locomotion.

In the final stage, adaptive tuning of ankle push-off gains compensates for user variability and mechanical deformations, improving user comfort. This framework was validated through simulations and experimental trials with the WalkON-F1 exoskeleton, demonstrating significant improvements in stability during walking. By integrating advanced optimization techniques, personalized modeling, and adaptive control, this research contributes to the development of robust and personalized gaits for powered exoskeletons, offering enhanced mobility solutions for individuals with lower limb disabilities.

Projects

- **Trajectory Analysis and Optimization UI**: Developed a web-based UI for analyzing and modifying exoskeleton motion trajectories. Integrated forward and inverse kinematics using Pinocchio to enable fast trajectory adjustments based on user feedback. Implemented Meshcat for 3D visualization of generated trajectories, improving interpretability and debugging. Processed large-scale motion data (6.3M data points per minute) for exoskeleton gait analysis and optimization. Tech-Stack used: React, Python, Pinocchio, Meshcat. (2024) KAIST
- Intelligent Fault Diagnosis Method for Rotating Machinery using Machine Learning: Fault diagnosis using support vector machine for health monitoring of rotating machinery and its components. Vibration data collection using Spectra Quest. Trained model to predict the life of the rotating bearing component. (2019 2020) IIT Roorkee
- Web-based Problem Practice and Learning Platform: Designed and developed a problem practice website for high-school students, incorporating Angular, JavaScript, and Node.js. The platform also utilized MongoDB for database management, Express.js for server-side logic, and Bootstrap for responsive design. It featured interactive tests and practice problems, enhancing students' learning experiences through dynamic content delivery. (2022)

Honors and Awards

- Received "Deliver with Focus" award for two consecutive years while working as SDE at GE Digital 2021-22
- Secured All India Rank (AIR) 827 in JEE Advanced 2016, among over 150,000 candidates.
- An All India Rank of 327 in the Unified Cyber Olympiad.
- An All India Rank of 508 in the National level Science Talent Search Examination-2014, Organised by Unified Council
- Secured a National Rank of 111 in the National Science Olympiad