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Hardware&Software Robot Engineer

Personal Statement

Breaking the Boundary Between AI and Mechanical Design: Engineering for Environment and Safety

I am an engineer dedicated to designing and validating intelligent robotic systems that simultaneously enhance environmental protection and industrial safety.
Guided by a development philosophy centered on and , I have consistently pursued the convergence of environmental sensing and autonomous control—what I call the Envirsobotics field. This mission defines not only my work but also the title and spirit of my personal website.

Motivation: Closing Field Problems with Engineering

At industrial sites, inefficiency in (SCR) catalyst cleaning leads to production downtime, safety risks, and environmental costs.
To address this, I developed and deployed an automated cleaning robot by integrating mechanical design, embedded control, and automation logic as one unified system.
I personally led the entire process—CAD design, C++/ firmware, control logic, and commissioning—and achieved a 40% improvement in cleaning efficiency, following a clear PAR framework: identifying the clogging/over-cleaning issue → designing nozzle geometry, drive systems, and control tuning → validating on-site performance.

Design Philosophy: At the Intersection of Mechanics, Fluid Dynamics, and Computer Vision

My approach layers physics-based first-principle design with data-driven AI correction:

- **Mechanical & Fluid Modeling**: I use structural and fluid simulations to predict nozzle flow rate, spray patterns, and fatigue loads, minimizing over- or under-spec design. This aligns with my core skills in structural mechanics, fluid dynamics, mechanisms, and control.
- **AI & Vision Correction**: I employ , , , and CNN/RNN models to adapt spray coverage and build closed feedback loops on , reducing costly manual tuning cycles.
- **Embedded & Control Integration**: I connect /C++ sensor nodes to nodes, ensuring stable operation even under vibration, heat, and dust.

Key Achievements

A. Automated Cleaning Robot (Field-Validated)

- Role: End-to-end lead (mechanism, embedded, control, commissioning)
- Challenges: Variable clogging, optimal spray angle, amount, and path repetition
- Solutions:
    - Parameterized nozzle geometry and spray patterns
    - Closed-loop control using Arduino sensor nodes with C++ firmware
    - Real-time correction using field-logged data
- Impact: 40% higher cleaning efficiency and 40%+ operational cost reduction through a fully automated cleaning pipeline

B. Precision Concentration Control Robot (Simulation–Control–Communication)

- Developed a precise liquid concentration control system using industrial robotic arms, load sensors, and communication
- Achieved ±0.5% accuracy via fluid dynamics modeling, adaptive control, and -based state estimation on
- Reduced response time to 8.3 seconds despite irregular flow and viscosity fluctuations

C. Industrial Safety Robotics System (Multi-Robot–Vision–Prediction)

- Built a multi-robot system for environmental and safety monitoring using vision and predictive analytics
- Achieved 93% detection accuracy, highlighting that data labeling pipelines and alarm threshold tuning often outweigh raw model accuracy in real-world impact

Interdisciplinary Foundation: Synergy of Environmental Engineering and Mechatronics

My background bridges environmental engineering—data analysis (MATLAB/Python), pollutant treatment mechanisms, and quality-monitoring prototypes—and mechatronics—pneumatics, electrical control, control theory, C programming, data structures, and hands-on manufacturing.
This enables me to design the entire sensing–decision–actuation chain as one cohesive system.

Recent Skill Updates: ROS2, Deep Learning, and Sensor Fusion

Through Doosan Robotics AI Robotics Training, I honed real-world robotics capabilities:

- LiDAR–depth camera sensor fusion
- TensorFlow/OpenCV object recognition
- Gazebo autonomous navigation simulation

These efforts culminated in a working safety-detection prototype, preparing me to scale from lab demos to pilot field deployment.

Lessons from Failures: Bridging Hardware Tolerances and Control Parameters

Early designs suffered low reproducibility due to poor tolerance control in nozzles and jigs.
I resolved this by combining process Failure mode and effects analysis (FMEA), torque/strain logging, and data-driven retuning of control gains and filters.
Since then, modeling process variability has become a standard step in all my projects.
I hold certifications in TIG welding, industrial safety, and mechanical engineering, which strengthen my ability to integrate safety and manufacturability.

How I Contribute to a Team

1. Early Requirement & Risk Mapping – Build risk registers across safety, environment, and performance dimensions
2. Hybrid Physics+Data Design – Start from physical models and continuously refine with operational data
3. Field Verification Loops – Establish continuous tuning via logging process variability and environmental factors
4. Documentation & Knowledge Sharing – Provide experiment protocols, tuning recipes, and troubleshooting playbooks
5. Ethics & Safety Compliance – Conduct design reviews with LOTO procedures and safety PLC integration, grounded in certified safety knowledge

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Long-Term Vision

As a robotics design project lead, I aim to establish benchmark references in environmental and safety robotics.
By deepening sensor-fusion-based intelligent control, I will deliver research outcomes that can be deployed directly to real-world sites—bridging the gap between lab innovation and field application.