RESEARCH PROFILE

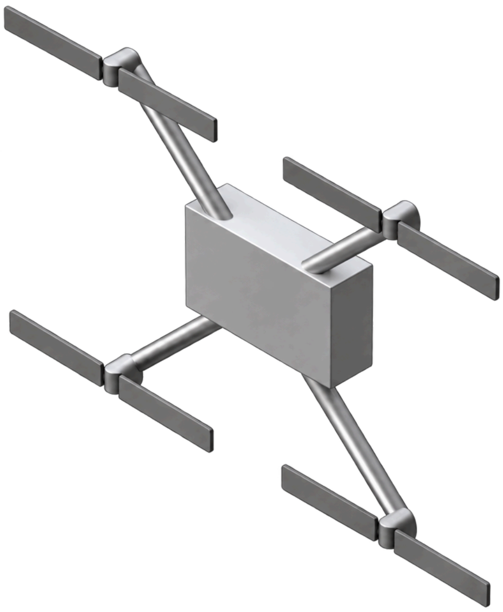
本科科研项目概览

Undergraduate Research Project Overview

格物穷理致数博学

RESEARCH IDENTITY

本科阶段围绕计算电磁、旋翼微多普勒与无人系统仿真开展研究，形成从物理建模、数值实现到受控实验和证据审计的方法链。重视坐标与相位约定、变量控制、负结果和结论边界，并关注模型与工程实现的可复现性。



Quadrotor target model
for simulation and electromagnetic analysis

RESEARCH THEME EVOLUTION

EM-Trace
Computational Electromagnetics

LowAlt-MD
Rotor Micro-Doppler Modeling

EMvision
Controlled Experiment & Domain Mismatch

箭头表示研究主题与方法关注点的演进，不表示项目间的数据、代码或严格技术依赖。

独立分支

QuadControl-Lab
Autonomous Systems Simulation

FOUR PROJECTS AT A GLANCE

EM-Trace
可审计的计算电磁工程链
Computational Electromagnetics

LowAlt-MD
合成模型下的旋翼微多普勒机制研究
Physics Modeling

EMvision
受控合成实验与域失配统计归因
Experimental Design

QuadControl-Lab
可审计四旋翼闭环仿真与观测机制研究
Auditable Quadrotor Simulation

Representative Research Projects

EMvision

Controlled Synthetic Domain-Mismatch Experiment

在 fixed synthetic test domain 上，以 C/G/P 2×2×2 full-factorial design、20 paired seeds、paired bootstrap、interaction analysis 和 negative controls 审查训练域失配。固定分类器作为 measurement instrument，用于比较 v000 完全失配与 v111 完全匹配条件。

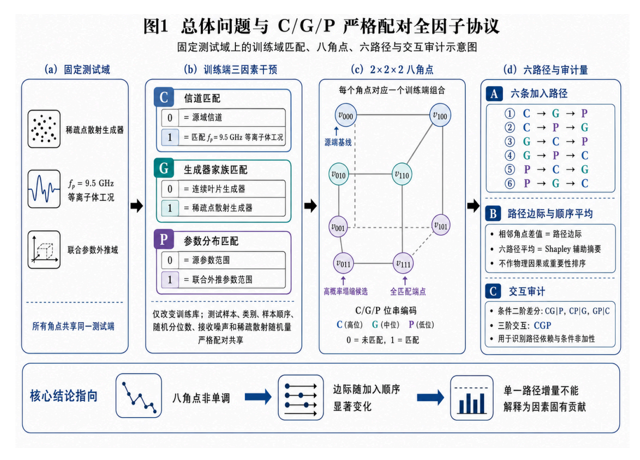
REPRESENTATIVE EXPERIMENTAL EVIDENCE

0.1864 → 0.9897

Macro-F1 · Δ = 0.8033 · 95% CI [0.7729, 0.8299]

通过固定测试域、严格配对和负对照，将域失配问题转化为可审计的受控实验。

Shapley 仅作 frozen protocol 下的 path-order summary，不是 physical causality；结果来自 synthetic experiment。



C/G/P protocol map：固定测试域、全因子角点与审计流程

LowAlt-MD

Synthetic Rotor Micro-Doppler Mechanism Study

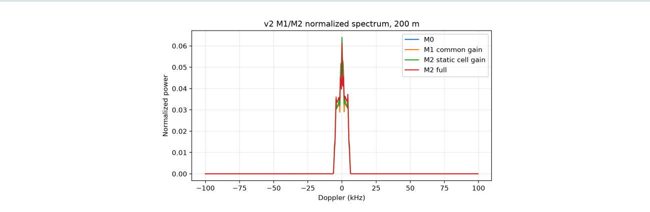
Physics Model v2、M0–M3、Fresnel Reflection、Path Phase 与 Coherent Interference 构成分层机制模型。

NORMALIZED-SPECTRUM DIFFERENCE

M1 ≈ 4.24×10^{-17} • M2 ≈ 0.0252

在当前无噪声归一化条件下，M1 公共复增益 → 谱形不变；M2 散射单元相关复权重 → 谱形改变。

结论限定于当前合成模型。



M1/M2 normalized-spectrum comparison

EM-Trace

Auditable Computational Electromagnetics Toolchain

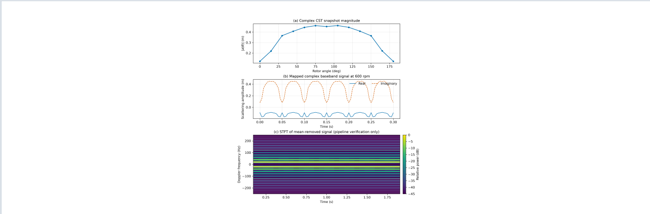
Parameterized CAD → CST → Complex Field → Python Signal Processing

以 Coordinate 约定审计、Polarization 检查及 Mesh / Calculation-Domain Audit 控制结果解释边界。

REPRESENTATIVE FINDING

坐标约定审计识别并纠正无效解释：φ = 0° 为 forward；单站后向为 θ = 90°, φ = 180°。此前错误解释已撤回。

不声称高精度 RCS 收敛或正确后向 Micro-Doppler 定量验证。



Pipeline verification only
该流程用于展示工程处理链实现和一致性检查，不代表定量雷达验证。

QuadControl-Lab

Auditable Quadrotor Closed-Loop Simulation

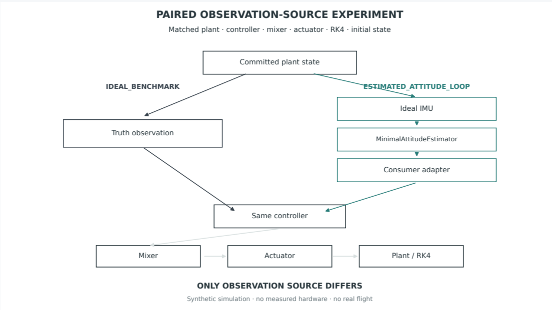
面向观测来源与估计假设影响分析的可审计四旋翼闭环仿真平台。

同一 plant / controller / mixer / actuator 和实验条件下，仅改变 controller 消费的 observation source，闭环姿态行为如何变化？

IDEAL vs ESTIMATED paired observation → Layer A controlled estimator input → Layer B full-loop replay audit

1.096029 rad	**0 → 0.3354 rad**	**10,000 rows • 0 mismatches**
True-attitude RMS paired angular distance	Layer A · A1/A2 terminal attitude error · SUPPORTED	Layer B parent replay · B-1 993/993 · SUPPORTED

Synthetic deterministic study only · No hardware / HIL / real flight



Frozen paired architecture · schematic, not measured performance

Physics Modeling	**Computational EM**	**Experimental Design**	**System Simulation**
Rotor kinematics Coherent interference	CAD–CST Complex field · Audit	Full factorial Paired evaluation	Rigid-body dynamics Observation boundary

Research Approach: Physics-informed modeling, controlled computational experiments, and evidence-oriented validation.

主要证据来自合成仿真与受控实验；不包含真实雷达验证、实机飞行或 HIL 验证。