



Special Session Proposal

Title:

Physics-Aware SLAM: Advancing Indoor Autonomous Localization through Multi-Physical-Field Perception and Modeling

Description of the proposed special session

This session focuses on a key shift in indoor SLAM: moving from **geometry-only** to **physics-aware** systems. Instead of treating acoustic, magnetic, thermal, inertial, RF (e.g., Wi-Fi/5G), or barometric signals as noise or secondary cues, we view them as **structured, model-driven data** that encode spatial, material, and dynamic environmental information. We gather researchers at the intersection of SLAM theory, physical modeling, sensor fusion, and real-world deployment to show how integrating physical laws (e.g., wave propagation, heat diffusion, magnetostatics) enables:

- **Sub-meter level localization without infrastructure;**
- **Robustness in challenging visual conditions** (smoke, occlusion, low light);
- **Intrinsic semantic understanding** (e.g., wall thickness via magnetic attenuation, room occupancy via thermal patterns).

Novelty and motivation

Traditional SLAM (visual/inertial or LiDAR-based) dominates robotics conferences, but IPIN' s strength lies in addressing **real-world indoor challenges**: non-line-of-sight, multipath, diverse building materials, human dynamics, and limited infrastructure. Recent breakthroughs—such as magnetic anomaly mapping with Maxwell-equation-constrained optimization, acoustic time-reversal SLAM using room impulse response physics, or thermal-field-augmented graph-SLAM with heat diffusion PDEs—demonstrate that **first-principles physical models** (not just data-driven correlations) deliver unmatched robustness and generalizability. This aligns with IPIN' s core mission: translating physics into practical positioning solutions.

What sets this session apart: It centers on **physical field modeling as a core SLAM component**, not an auxiliary sensor. It rejects “black-box sensor fusion” and instead demands tight coupling between SLAM state estimation and domain-specific PDEs, material priors, and environmental dynamics. For IPIN attendees (wireless engineers, building physicists, navigation integrators), this session reveals how physics turns uncertainty into a **structured, exploitable resource**.

Scope of the session

We invite papers on (but not limited to):

- **Physics-Embedded SLAM Formulations:** Variational inference, PDE-constrained optimization, or differentiable physics layers in SLAM backends (e.g., using magnetic field gradients to constrain pose-graph optimization).

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- **Multi-Physical-Field Sensing & Calibration:** Co-calibrating heterogeneous sensors (e.g., IMU + magnetometer + barometer) via shared physical models; cross-validating fields (e.g., acoustic echoes to verify magnetic map topology).
- **Real-World Deployment & Benchmarking:** Field studies in complex environments (hospitals, underground parking, historic buildings); open datasets with synchronized physical-field ground truth (e.g., magnetic maps + CAD + thermal video); comparing physics-aware vs. geometry-only robustness.
- **Semantic-Physical Coupling:** Using physical anomalies (e.g., RF shadowing, thermal convection) to infer structural semantics (door positions, HVAC status, occupancy) within SLAM.

Keywords

- Physics-informed SLAM
- Magnetic/Acoustic/Thermal Field Mapping
- PDE-Constrained Localization
- Infrastructure-Free Indoor Navigation
- Multi-Physical Sensor Fusion

Session Chairs

- **Prof. Hong Yuan, Aerospace Information Research Institute, Chinese Academy of Sciences (China)**
- **Dr. Wenchao Zhang, Aerospace Information Research Institute, Chinese Academy of Sciences (China)**

