



Application for the Doctoral Contract 2025

Indoor Localization System for Patient Behavior Analysis in the Context of Connected Healthcare

Ph.D. Candidate:

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Outline

Personal Background

- Academic Background
- Research Experience
- Internship Experience
- Technical Skills

Research Context and Proposed Approach

- Project Context
- Research Objectives
- Methods & Contributions
- Challenges & Roadmap

Profile Summary and Motivation

- Key Strengths
- Research Fit
- PhD Timeline
- Future Goals

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Academic Background



- **Engineering Diploma in Wireless Communication & IoT Systems** 2022-2025

ISEP – École d'ingénieurs du numérique, Paris, France

- Embedded Systems & Sensors, IoT Networks & Protocols, Neural Networks, 4G/5G/6G

- **Bachelor's Degree in Computer Science** 2018-2022

- *With Honors (Mention Très Bien)*

Université Clermont Auvergne, Clermont-Ferrand, France

- Machine Learning, Path Recognition, Sensor Integration, Signal Processing, Programming

Research Experience-Published Article

Performance Evaluation of the Networks with Wi-Fi based TDMA Coexisting with CSMA/CA

Wireless Personal Communications, Springer, 2020

➤ **Objective:**

- Introduce TDMA into Wi-Fi to improve real-time performance and reliability when coexisting with CSMA/CA.

➤ **Method:**

1. **Canceling Carrier Sensing:** TDMA devices transmit directly in allocated slots without checking channel availability.
2. **Priority Mechanism:** TDMA devices gain priority over CSMA/CA devices on the shared channel.
3. **Collision Handling:** TDMA devices immediately retransmit data until an ACK is received, ensuring reliability.

➤ **Result:**

- The TDMA mechanism significantly reduced delay for real-time applications and improved reliability through retransmissions.
- As frame length and duty cycle increased, CSMA/CA throughput slightly decreased but the impact remained manageable.

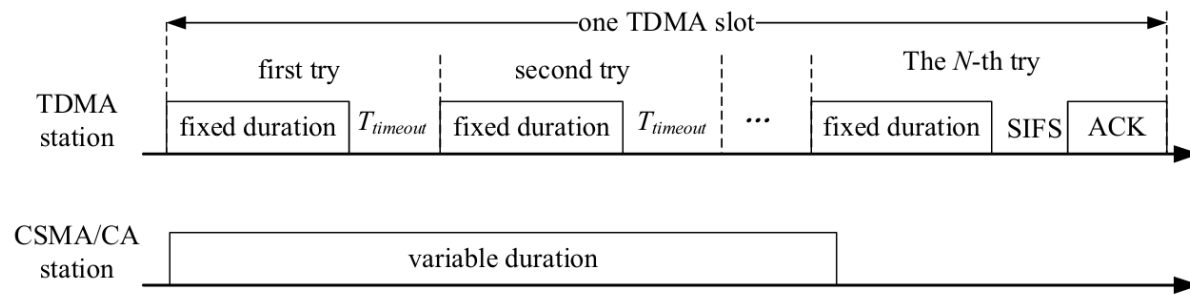


Fig. 2 Preemptive TDMA scheme

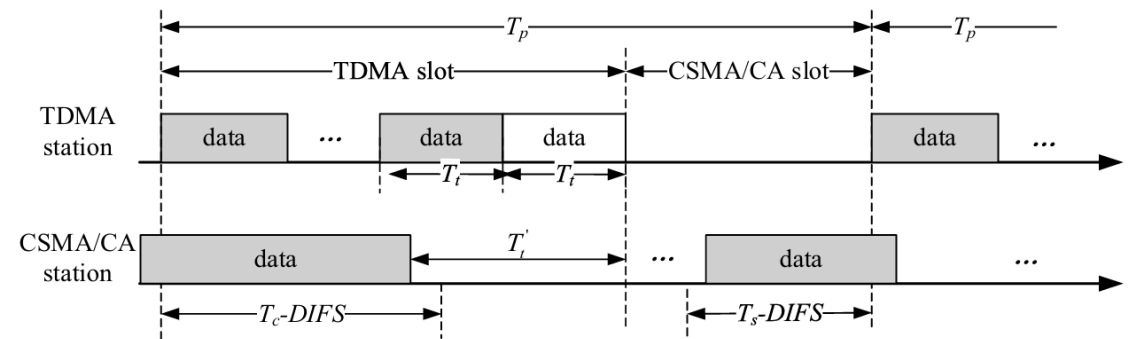


Fig. 4 The interference a CSMA/CA frame suffered from the Wi-Fi TDMA station

Research Experience-Article Under Preparation

Indoor Localization in IoT Networks Based on Graph Neural Networks

2025

➤ Objective:

- Compare the performance of DNN and GNN in Wi-Fi RSSI fingerprint-based localization. Including predictions for longitude, latitude, floor and predicted time.

➤ Method:

1. **DNN Encoder-Decoder:** Built an encoder-decoder baseline model with multi-task regression to jointly predict.
2. **GNN with k-NN Graphs:** Constructed graphs using k-NN and applied GCN layers with message passing to capture spatial topology.
3. **Evaluation Metrics:** valuated models by comparing hidden layer configurations, localization error, and runtime performance.

➤ Result:

- GNN achieved lower localization error and shorter runtime with fewer hidden layers, improving accuracy and robustness.

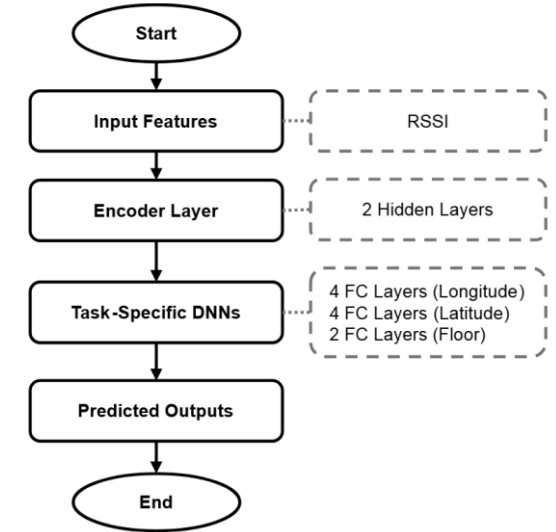


Fig. 1. Overall data preprocessing and prediction workflow of the DNN-based localization model. (FC: Fully Connected).

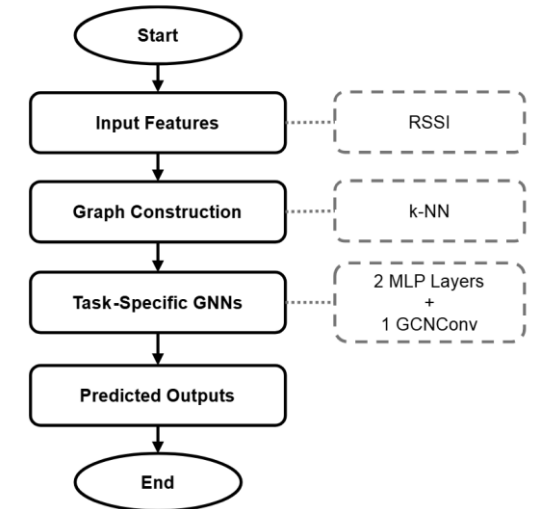
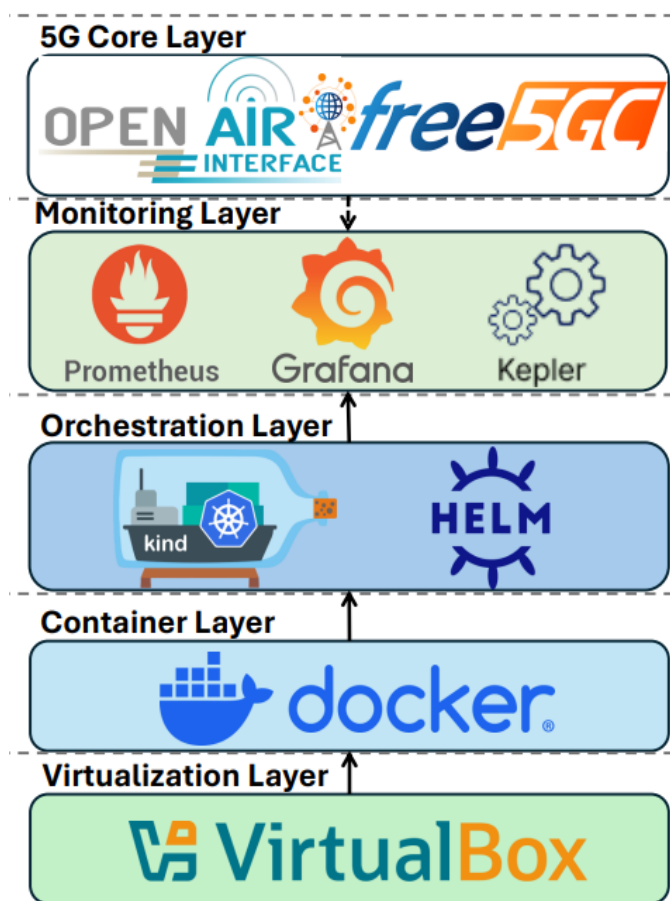


Fig. 2. Overall data preprocessing and prediction workflow of the GNN-based localization model. (MLP: Multi-Layer Perceptron, GCNConv: Graph Convolution layer).

Graduation Internship (24 Mar – 22 Sep 2025)

Energy Optimization in 5G Core Networks – Orange Innovation



➤ Objective:

- Analyze the energy consumption of open-source 5G Core (free5GC and OAI) and explore methods to reduce it.

➤ Method:

- Deployed** an energy monitoring framework (Kepler + Prometheus + Grafana on Kubernetes).
- Installed and compared** free5GC and OAI; experiments revealed OAI consumed significantly more energy.
- Proposed three hypotheses:** database implementation differences, residual container processes, and frequent inter-Pod signaling.
- Identified frequent AMF heartbeat** signaling as the main cause, **modified** the source code, and extended the cycle from 10s to 100s.

➤ Result:

- Extending the heartbeat cycle significantly reduced OAI's energy consumption while maintaining system stability.
- The achievements were integrated into an AI assistant at Orange to support rapid future deployment.

Technical Skills



Programming Languages

Python, Java, R,
C/C++, JavaScript



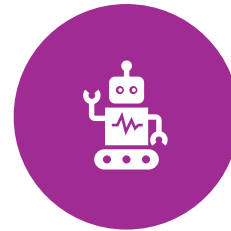
Scientific Computing & Simulation

MATLAB, PyTorch



Monitoring & Observability

Prometheus, Grafana,
Kepler, Wireshark



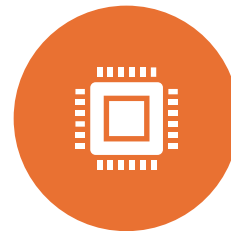
DevOps & Automation

Docker, Kubernetes
(Kind), Helm, Airflow



Databases

SQL/MySQL,
MongoDB, PL/SQL



Operating Systems

Linux (Ubuntu, Lubuntu, VM),
Windows

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Project Context

1. Importance

Smart hospitals need indoor localization to :

- Reduce risks.
- Improve efficiency.
- Support real-time patient monitoring.

2. Requirements

- High accuracy.
- Low latency.
- Energy efficiency.
- Scalability.

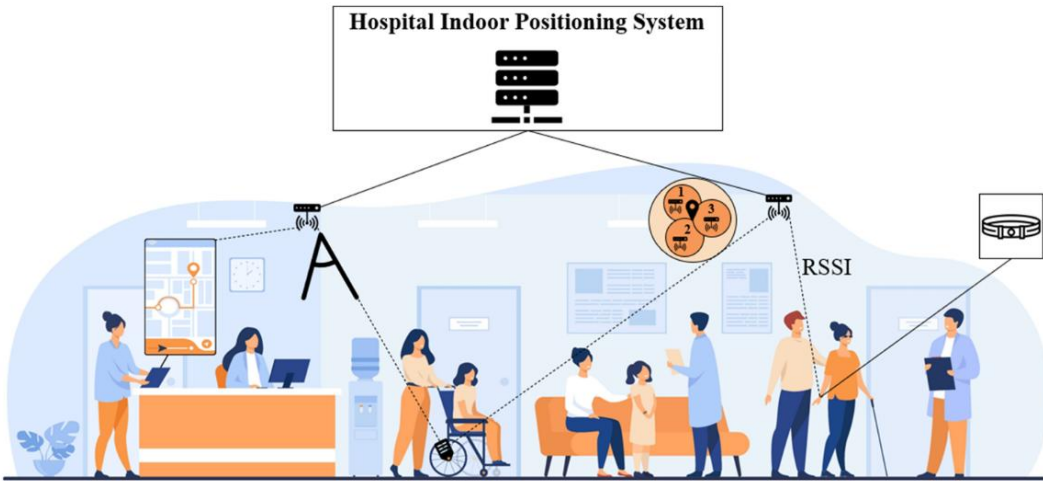
3. Challenges:

- Multi-technology coexistence (Wi-Fi, BLE, IR, ultrasound).
- Interference from medical devices (e.g., X-ray).
- Highly dynamic hospital environments.



Research Objectives

1. Develop an accurate and energy-efficient indoor localization framework for healthcare environments.
2. Leverage AI models (e.g., DNN & GNN) to improve positioning accuracy and robustness in complex hospital settings.
3. Enable patient behavior analysis to support safety monitoring (e.g., fall detection, abnormal mobility).
4. Provide an accuracy–complexity trade-off analysis to guide IoT and healthcare deployments.



Source: Wichmann J. Indoor positioning systems in hospitals:
A scoping review. *DIGITAL HEALTH*. 2022;8.

Methods & Contributions

Multi-floor

Multi-floor · Fixed Localization

Possible Approaches

- Multimodal input: combine Wi-Fi, BLE, UWB.
- Add a floor classification module in DNN.

Possible Challenges

- Complex data synchronization.
- Strong floor-to-floor signal variation.

Multi-floor · Mobile Localization

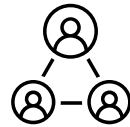
Possible Approaches

- Fuse Wi-Fi, BLE, UWB, and sensor data.
- Use GNN combined with temporal models for cross-floor trajectory modeling.

Possible Challenges

- Cross-floor attenuation & dynamic interference.
- High computational and scalability requirements.

Fixed



Mobile

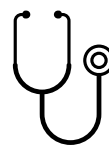
Single-floor · Fixed Localization

Possible Approaches

- Use Wi-Fi or BLE RSSI fingerprinting.
- DNN regression model for (x, y) prediction.

Possible Challenges

- Signal interference from walls and devices.



Single-floor · Mobile Localization

Possible Approaches

- Use BLE/UWB with IMU sensors.
- GNN (k-NN graph) for trajectory modeling.

Possible Challenges

- Dynamic interference sources.
- High real-time computational cost.

Single-floor

Key Challenges & Solutions

- **Signal Instability & Interference** → Robust filtering and adaptive modelling.
 - **Scalability & Deployment** → GNN for large-scale, cross-floor scenarios.
 - **Energy Efficiency** → Lightweight models and optimized inference complexity.
- (Other issues such as calibration and privacy will be considered as complementary)*

Research Roadmap

- **Step 1 – Problem Definition & Data Exploration**
 - Define the research focus: accuracy vs efficiency in unstable signal conditions.
 - Dataset exploration and baseline design for single-floor localization.
- **Step 2 – Model Development & Evaluation**
 - Compare different models.
 - Introduce multimodal data inputs.
 - Conduct experiments in mobile and cross-floor scenarios.
- **Step 3 – System Integration & Application**
 - Integrate the localization system in healthcare/IoT environments.
 - Validate accuracy, robustness, and energy consumption.
 - Disseminate results through publications and dissertation.

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Key Strengths

Rich research background	Participated in multiple projects with publication experience.
Solid wireless & IoT expertise	Independently completed 5G Core energy & indoor localization projects.
AI & data analysis skills	Proficient in DNN, GNN, and machine learning applications.
Hardware & sensor experience	Developed “health wearable” device on TIVA board (fall detection, etc.).
International collaboration	Experienced in cross-cultural communication and teamwork.

Research Fit



Final Year Engineering Project: Highly aligned with the PhD topic, both focusing on indoor localization.



Orange Innovation internship: Gained experience in 5G Core energy optimization and deployment, extendable to energy-efficient indoor localization.



Wearable sensors experience: Applied in health monitoring, including temperature, CO₂, and fall detection, consistent with smart healthcare goals.

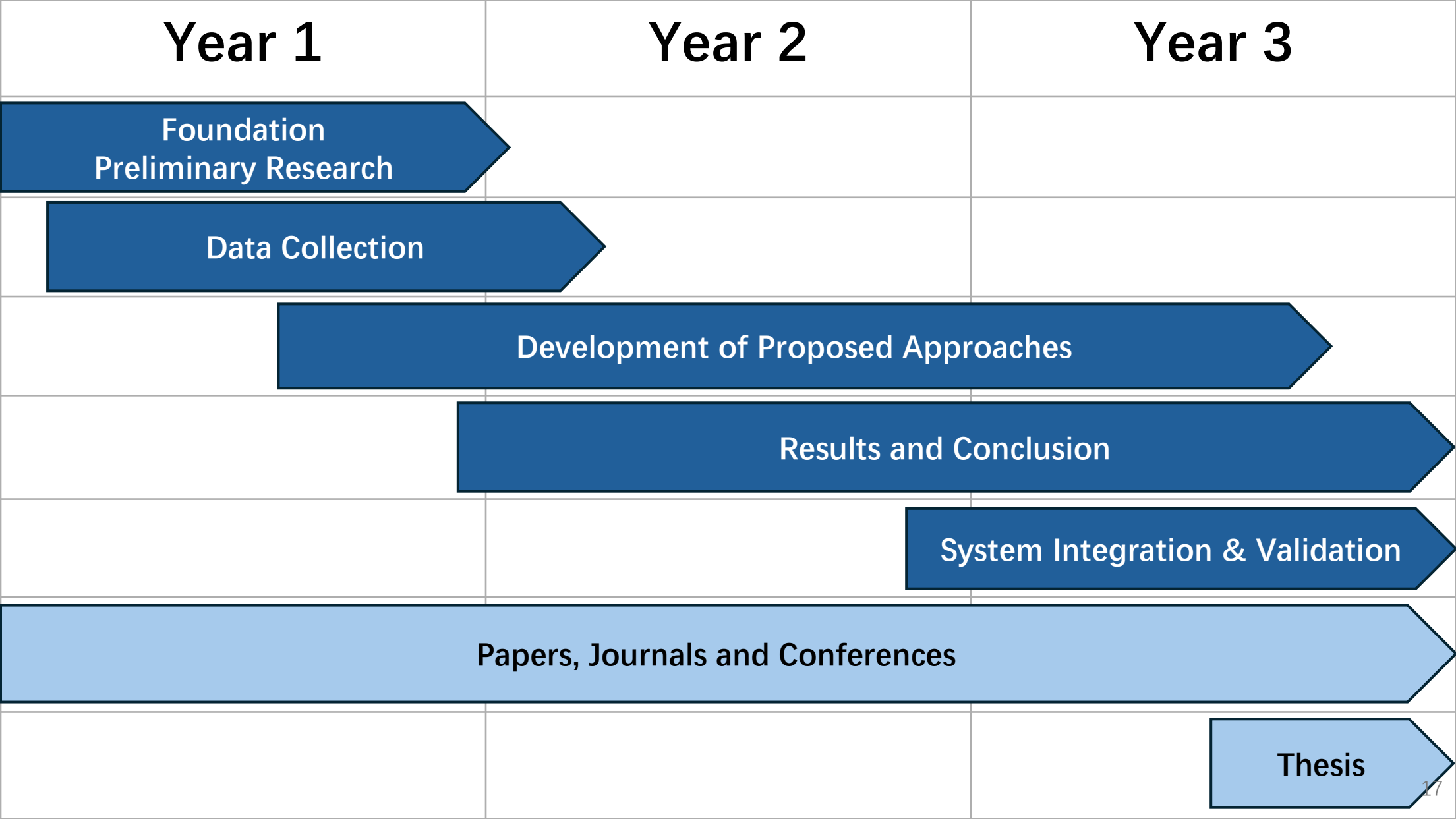


Undergraduate projects: Path & image recognition, intelligent vehicle map entry — foundation for behavior analysis.



Interdisciplinary background: AI + wireless communication + IoT, complemented by experience in signal processing, wearable healthcare sensors, system integration, and data privacy — fully matching the project needs.

PhD Timeline



Future Goals

Short-term (3 years)

Develop a multimodal AI indoor localization system with high accuracy, low energy cost, and scalability in smart hospitals.

Mid-term (5 years)

Promote the deployment and standardization of AI-based indoor localization and behavior analysis in healthcare.

Long-term (10 years)

Explore the integration of 6G networks and smart healthcare.

Thank you for your attention.

I would be happy to answer any questions.

