# {HUMAN-CENTRIC ROBOT NAVIGATION}: LEVERAGING PEDESTRIAN OCCLUSION PATTERNS FOR TRAVERSABILITY ANALYSIS IN CROWDED INDOOR ENVIRONMENTS

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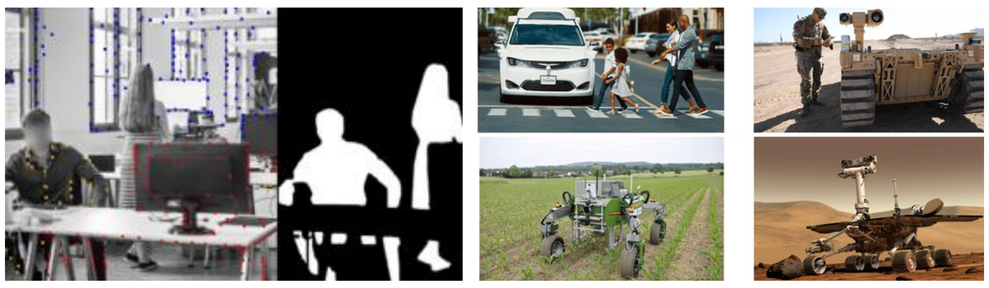
## <Traversability Prediction Problem>



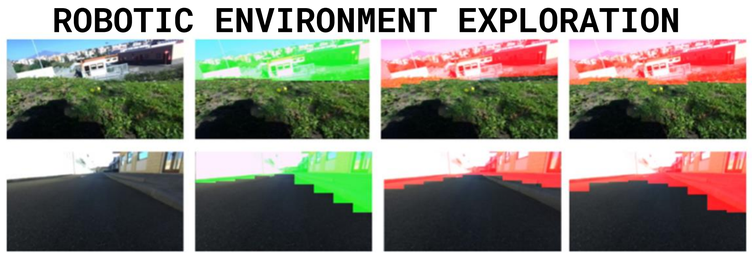
Applications:
- Autonomous mobile robots
- Self-driving
- Planetary exploration robots [SevastopoulusSurvey2022]

- "Can the floor area be traversed safely?"
- Obstacle avoidance, avoidance of falling or getting stuck

- Traversability Prediction in Complex Indoor Environments
  - Challenges in predicting safe and efficient robot navigation paths
  - Critical for ensuring reliable autonomous movement in crowded spaces

## <Mainstream Approach>

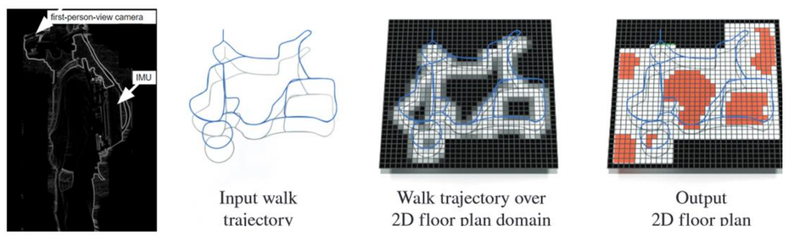
### ROBOTIC ENVIRONMENT EXPLORATION



- Pros: Highly accurate direct object observation
- Cons: Labor-intensive direct object observation
- Floor Observation, Obstacle Reconstruction
- [Domain Adaptation for Outdoor Robot Traversability Estimation from RGB Data with Safety-Preserving Loss, IROS 2020]

## <Emerging Approach>

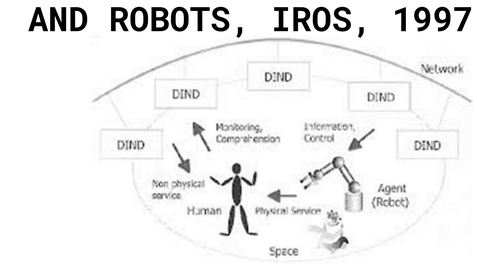
### FIRST-PERSON VIEW PEDESTRIAN OBSERVATION

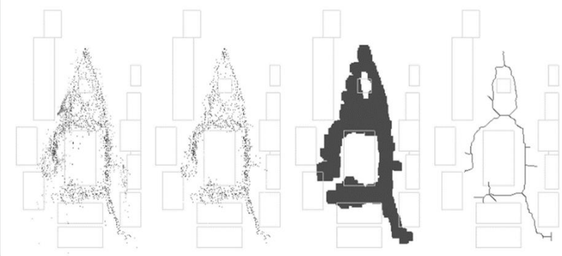



- Pros: Delegating hazardous exploration tasks to humans
- Cons: Requires an IMU-equipped specialist
- [Walk2map study on extracting floor plans from indoor walk trajectories, Computer Graphics Forum 2021]

## <Surveillance Setup>

REF:
[BUILDING TOPOLOGICAL MAPS BY LOOKING AT PEOPLE: AN EXAMPLE OF COOPERATION BETWEEN INTELLIGENT SPACES AND ROBOTS, IROS, 1997]

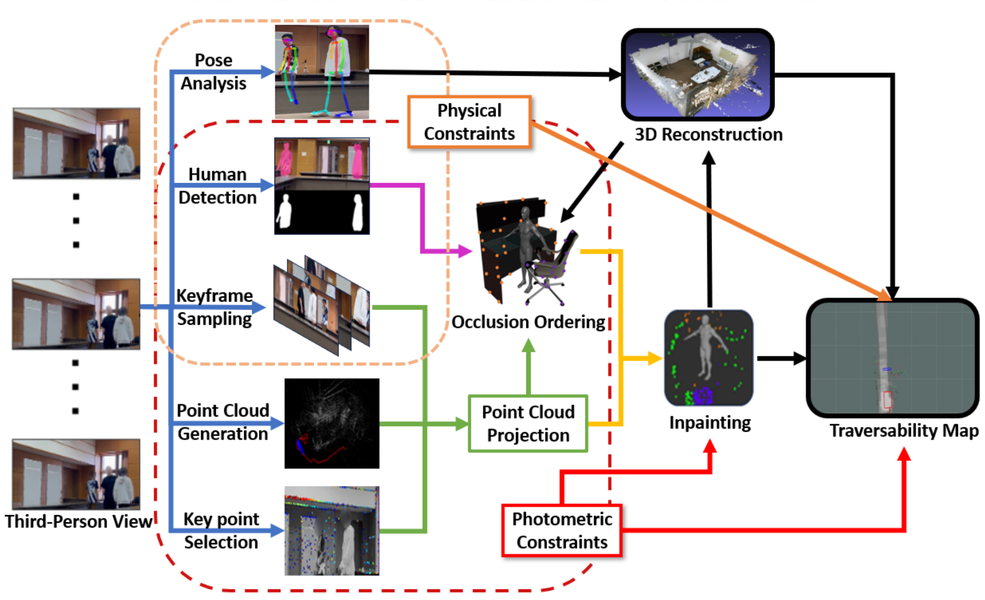


**Sensor Network Setup: Stationary Viewpoints**

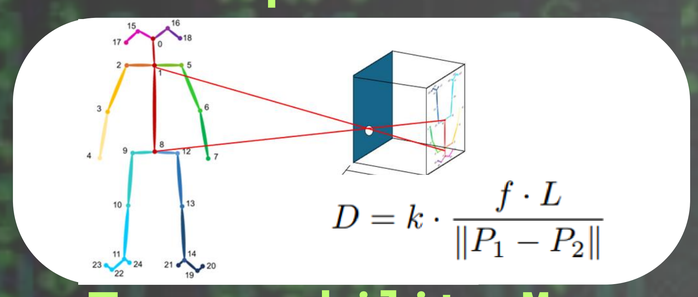
## <Our Approach>

### THIRD-PERSON VIEW PEDESTRIAN OBSERVATION



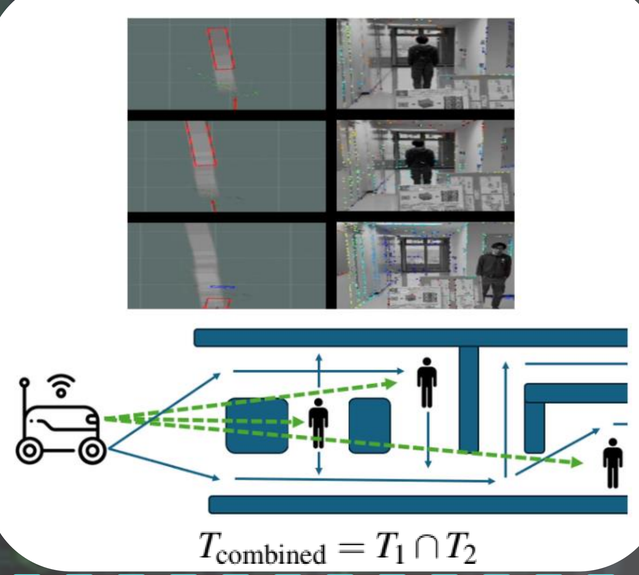

- Extend Walk2Map from first-person view IMU to third-person robots
- Pros: Non-expert pedestrians with no special sensors equipped
- Cons: Non-rigid objects (Pedestrians), Partial Observability

## <Human Depth Estimation>



$$D = k \cdot \frac{f \cdot L}{\|P_1 - P_2\|}$$

## <Traversability Map>

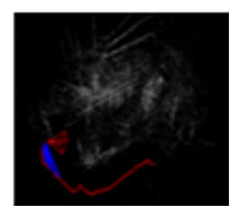


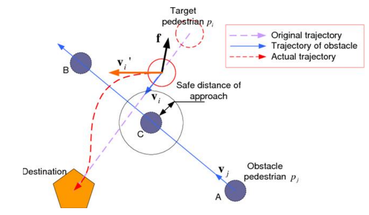
$$T_{\text{combined}} = T_1 \cap T_2$$

## <Photometric Constraint>


### HUMAN-OBJECT OCCLUSION ORDERING

## <Physical Constraint>





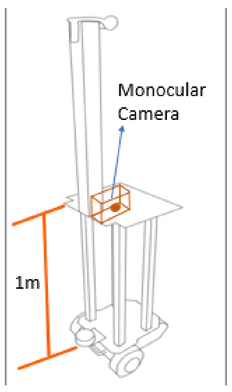

### DYNAMIC SLAM SOCIAL FORCE MODEL

- [Extended social force model-based mean shift for pedestrian tracking under obstacle avoidance, IET Computer Vision, 2017]

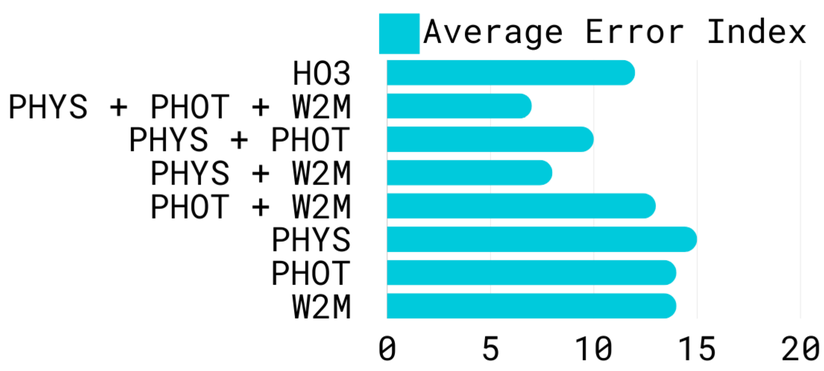
## <Experiment>

### DATASET

### PLATFORM




### MAP QUALITY EVALUATION ABLATION STUDY




### GITHUB

The source code for our framework is publicly available and free to use. Feel free to contact us if you would like to use it.

### OUR PREVIOUS HO3-SLAM PAPER

We assessed map quality using a journey-based evaluation method, achieving significant improvements over our previous HO3-SLAM method across all datasets.

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