Robots Waiting for the Elevator:

Integrating Social Norms in a Low-Data Regime Goal Selection Problem

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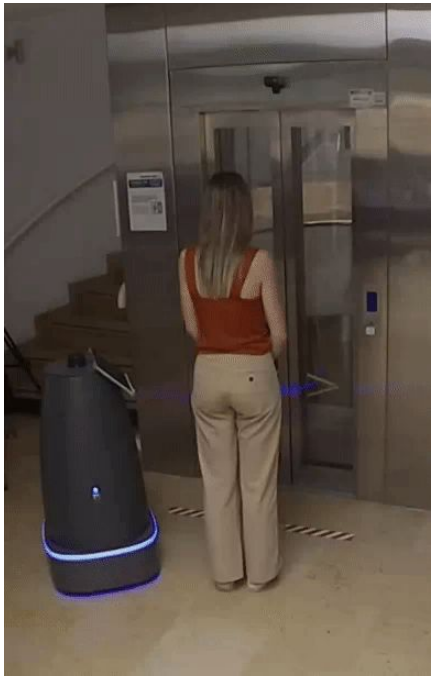
NAVER LABS

2025 IEEE RO-MAN

Robots Sharing Elevators with Us



Taking the lift is a **non-event** with **minimal interaction where** use **positioning** to convey **intentions**, leveraging unspoken **social norms**

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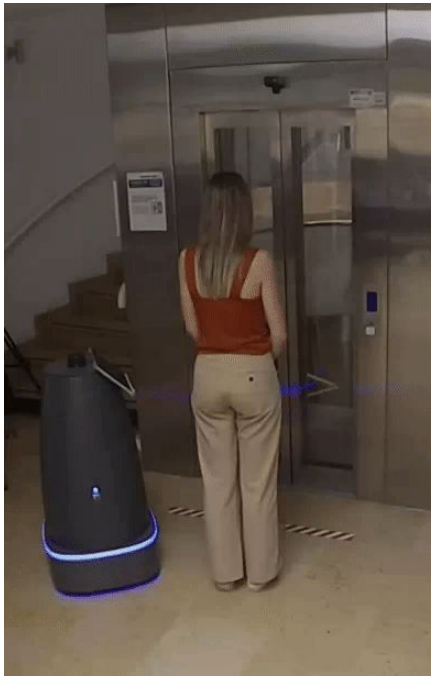

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As we aim for **repeated encounters,** we wanted our robots to be **intentionally non-interactive**

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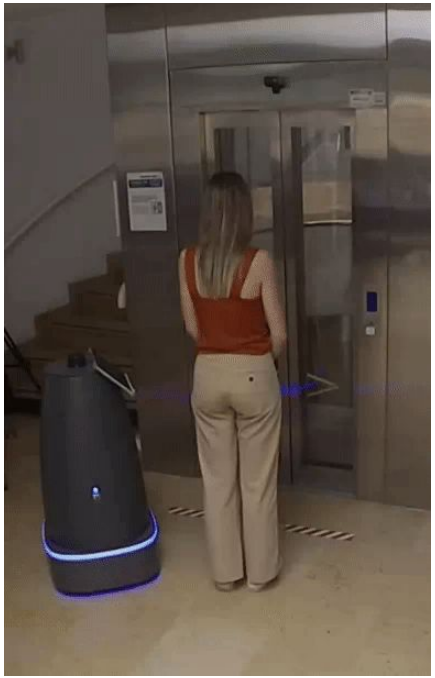

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Can we **select meaningful waiting poses** for robots?

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Behaving while Waiting for the Elevator

- Respect proxemics
- Do not stand behind
- Do not stand in front of the elevator doors
- Do not block access to elevator commands
- Respect the transactional space
- Wait as far as the furthest person
- Board as fast as possible
- Wait where you can see the inside the elevator
- Don't collide with walls

Leverage the ethnographic knowledge about the task at hand, *i.e.* the **social norms**

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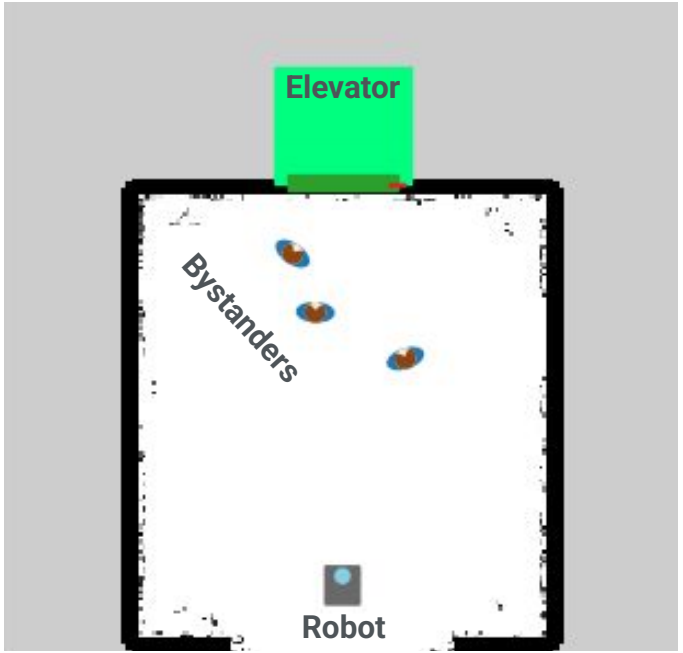

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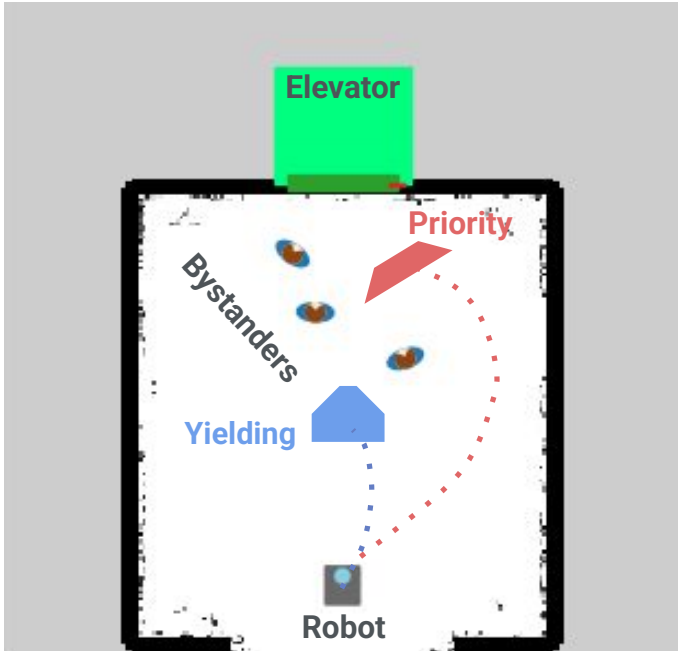

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Solve a **goal selection problem** - Given a **scene** and a **mission**, we select an **appropriate waiting pose**

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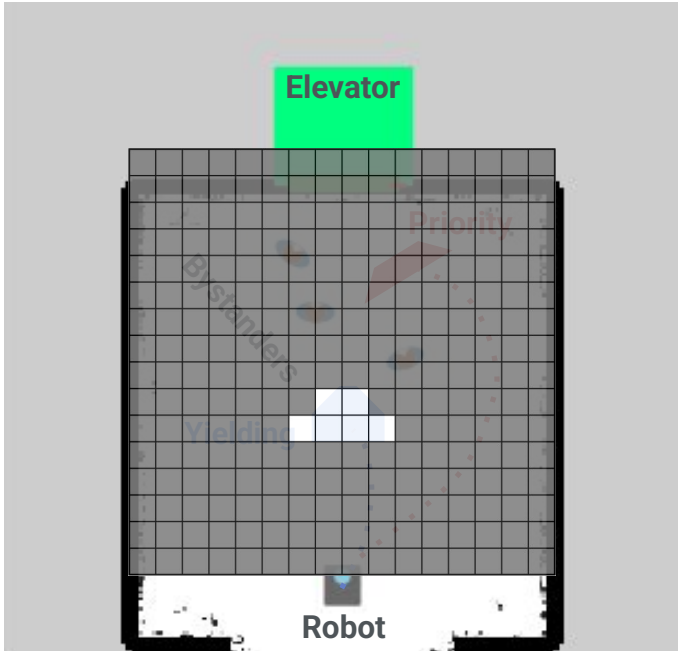

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Solve a **goal selection problem** - Given a **scene** and a **mission**, we select an **appropriate waiting pose**

Formalized as a **segmentation problem** over a grid in front of the robot

Operationalizing Social Norms

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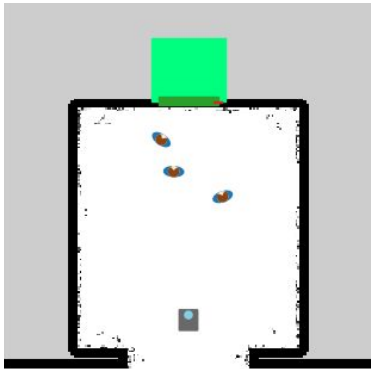
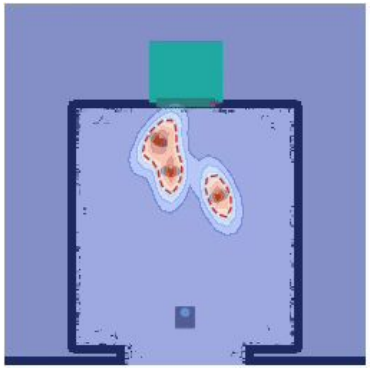


Respect proxemics



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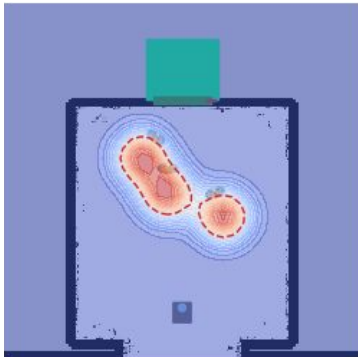

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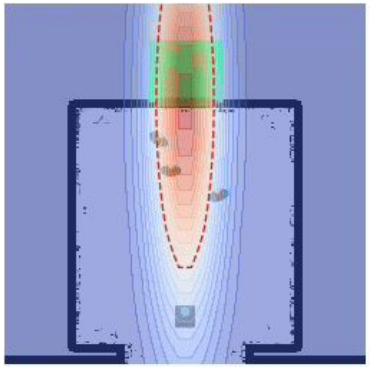
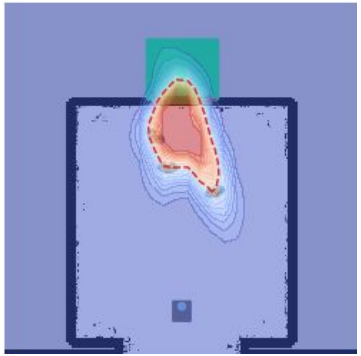


Respect the transactional space



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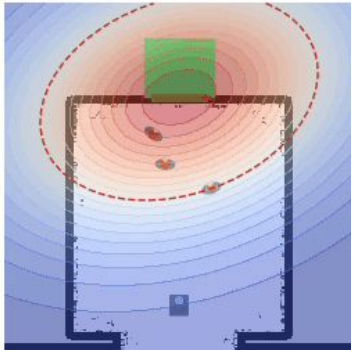

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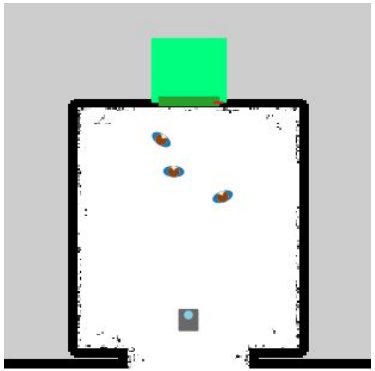

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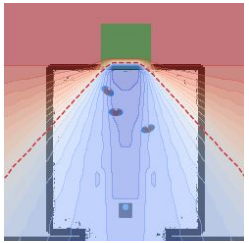

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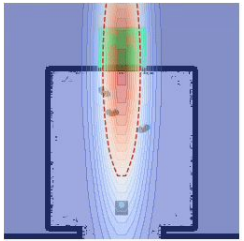

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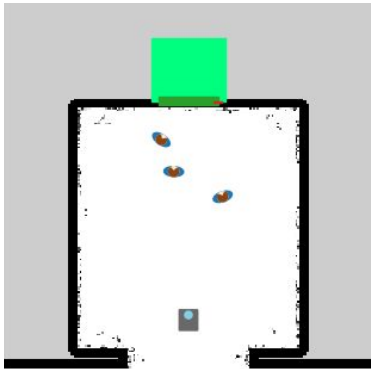

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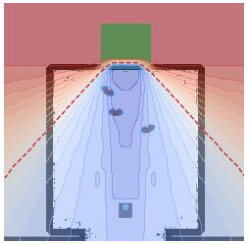

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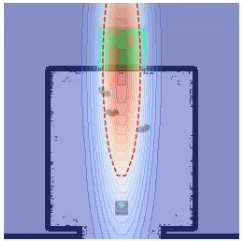
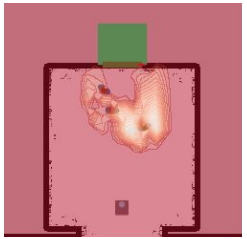
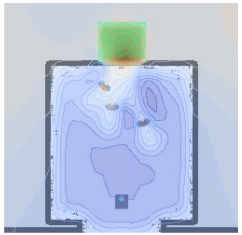


Issue #2

Respect all norms



Respect average of norms



Operationalizing Social Norms

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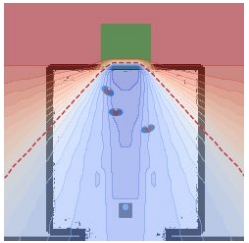

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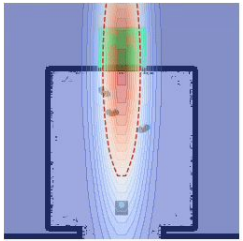

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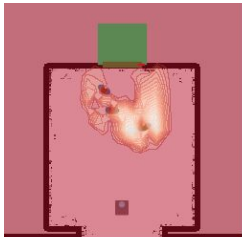

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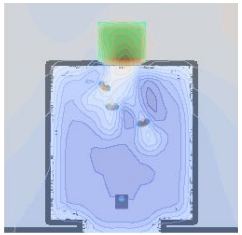

Learning to Select Waiting Poses

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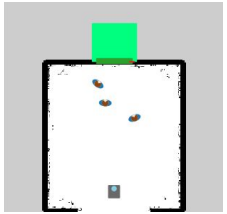
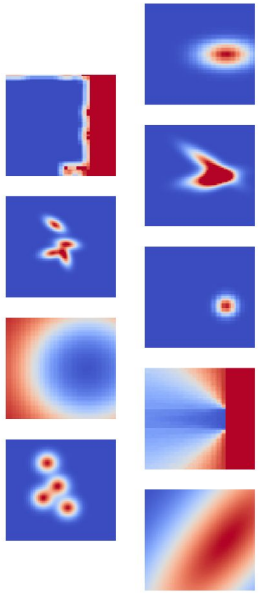
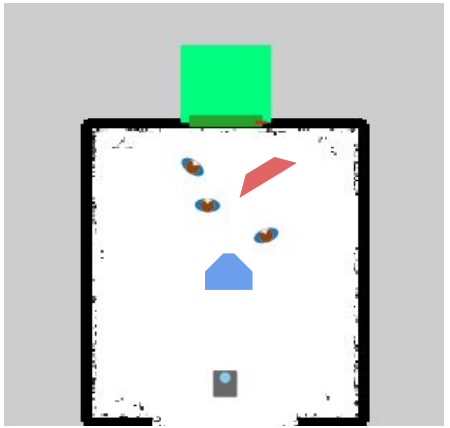


Social Feature Maps

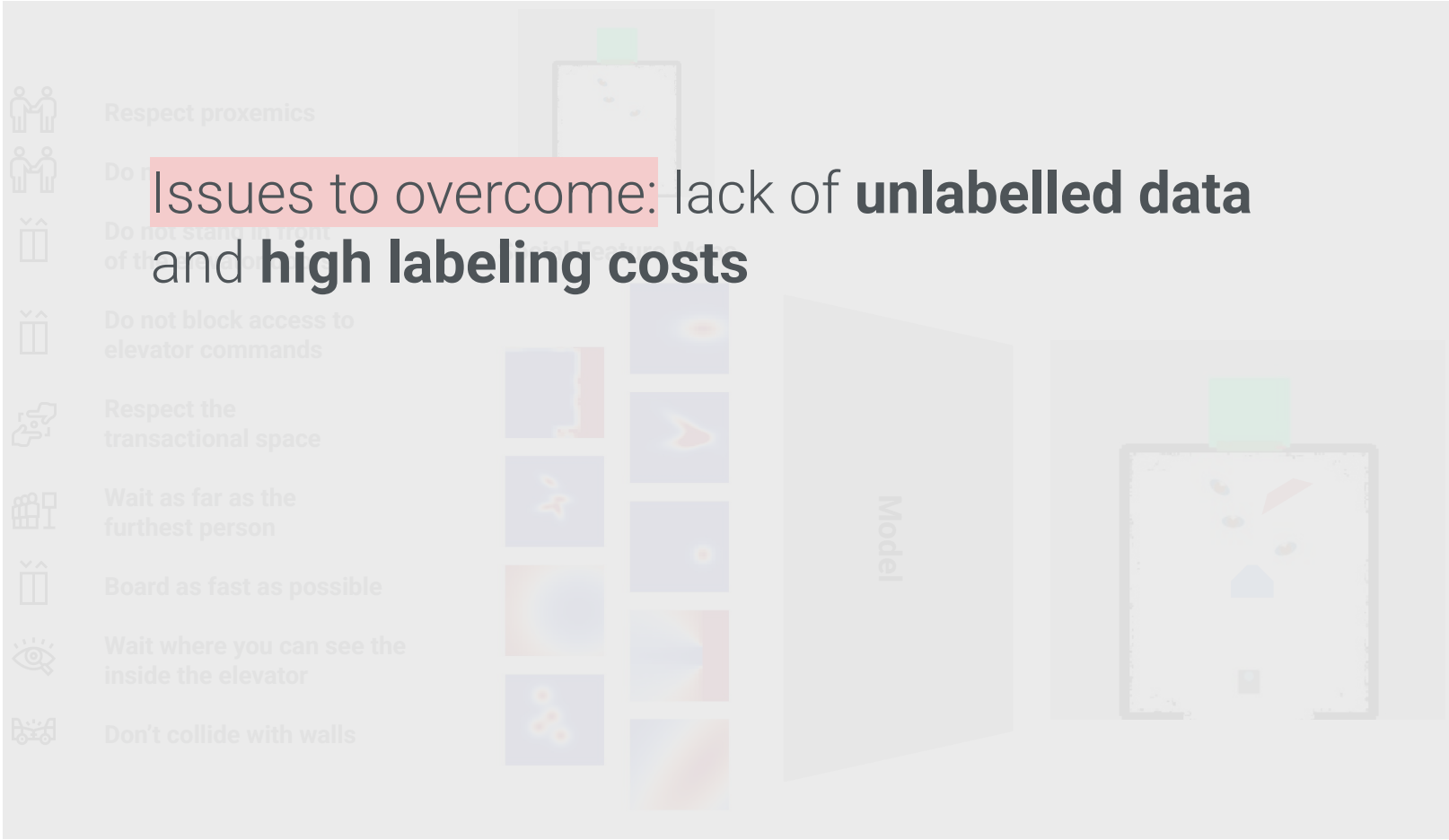


Model



Learning to Select Waiting Poses

Issues to overcome: lack of **unlabelled data** and **high labeling costs**



Learning to Select Waiting Poses

Issues to overcome: lack of **unlabelled data** and **high labeling costs**

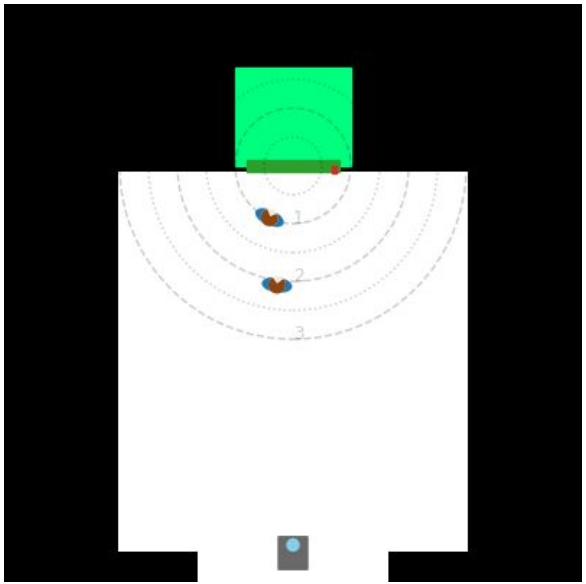
Proposed pipeline

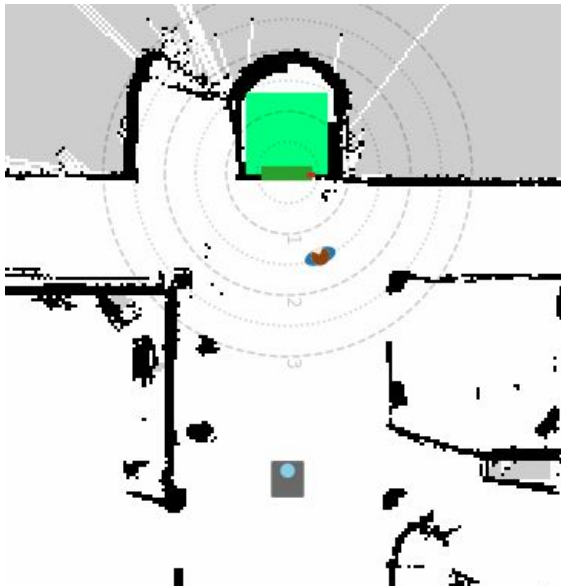
Procedurally generated unlabelled data → Label it with experts → **data-frugal models + scaffolding with feature maps**

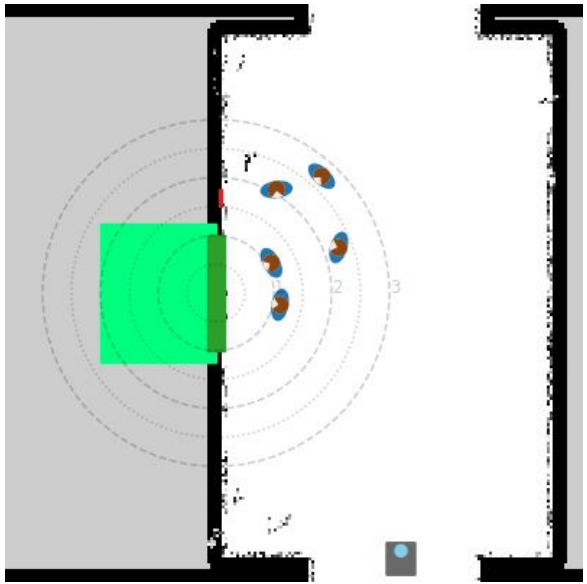
ProcGen of Elevator Lobby Scenes

Procedural Generation is the creation of content using **quasi-random** automated processes, rather than design by a human.

Poisson Disk Sampling *(sort of)* an iterative sampling technique



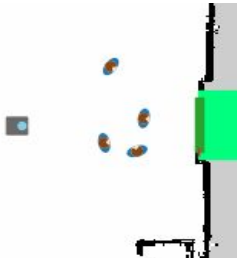




[1] Bridson, Robert. *"Fast Poisson disk sampling in arbitrary dimensions."* **SIGGRAPH sketches** 2007

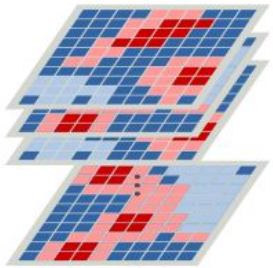
Training Pipeline

Waiting Scene

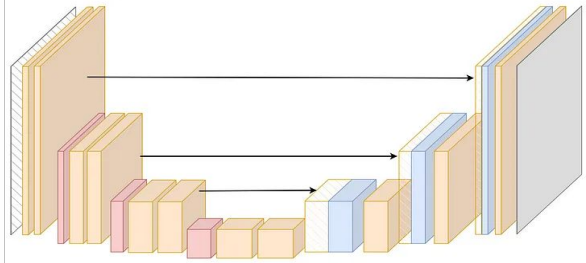


- localization
- people detection
- map and infrastructure information

Social Feature Maps
(hyperspectral image)

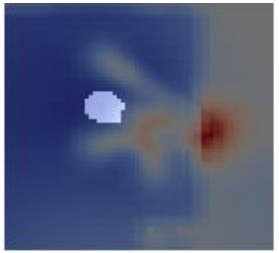


Small U-Net
(27k parameters)



(along other 6 ML models in the paper)

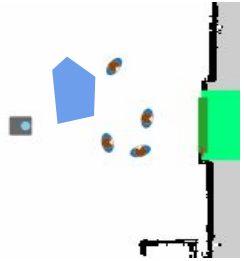
Network Output



Segmentation (i.e. socially acceptable waiting area)

≈

Expert Annotations

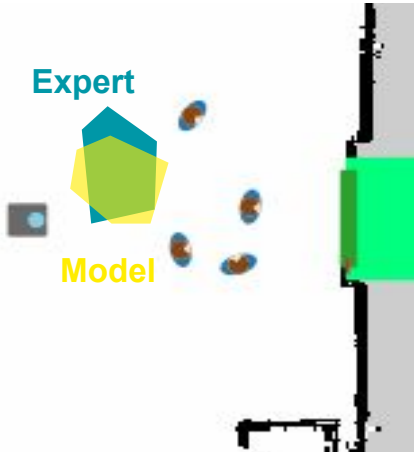


125 ProcGen Waiting scenes annotated by experts for 2 robot intentions (Yielding and Priority)

~ 2 minutes per annotation (quite expensive)

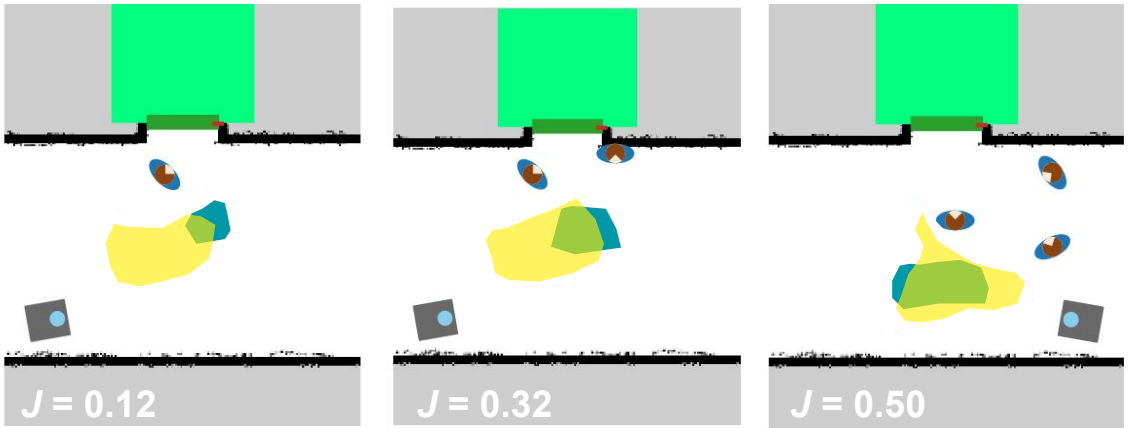
[1] Annotated Dataset available at *https://europe.naverlabs.com/research/publications/robots-waiting-for-the-elevator/*

Model Evaluation



Jaccard Index
(aka Intersection over Union)

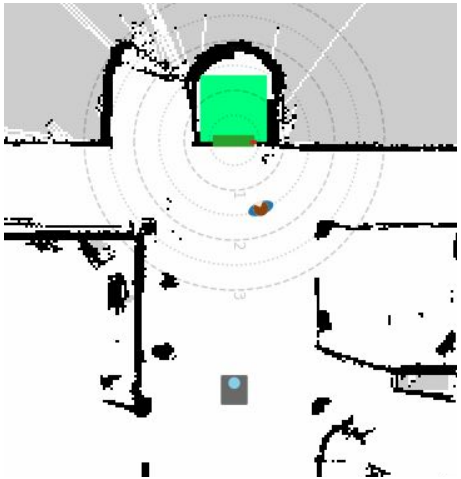
$$J(A,B) = \frac{|A \cap B|}{|A \cup B|} = \frac{|A \cap B|}{|A| + |B| - |A \cap B|}.$$

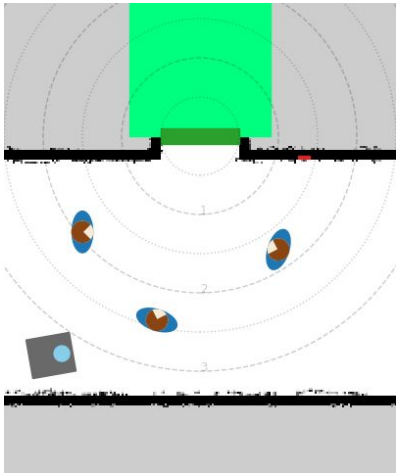


Test Datasets

3 Test Datasets

1. **In Distribution:** ProcGen with same parameters as the training dataset (same “rules”)
2. **Out-Of-Distribution:** ProcGen with out-of-distribution parameters (more people, new maps, different elevators)
3. **Real Elevator:** Manually annotated scenes from videos





Model Evaluation

Research Questions

1. Is Machine Learning necessary?
2. Do the social feature maps help with their scaffolding?
3. Do models perform on real situations (non-ProcGen)?

	ID set		OOD set		Real Elevator	
	B	N	B	N	B	N
Model	Target mission: Yielding					
Baseline	.066	.159	.044	.165	.075	.147
LR	.077	.364	.067	.317	.104	.380
SVM	.078	.352	.072	.302	.106	.350
DT	.078	.325	.072	.247	.105	.328
RF	.078	.349	.072	.297	.106	.365
MLP	.078	.362	.072	.316	.106	.400
U-Net	.059	.413	.128	.309	.045	.318

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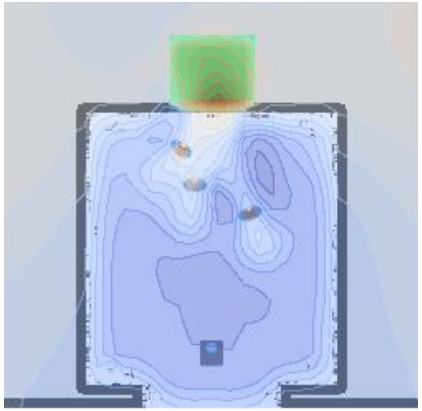

Respect average of social norms

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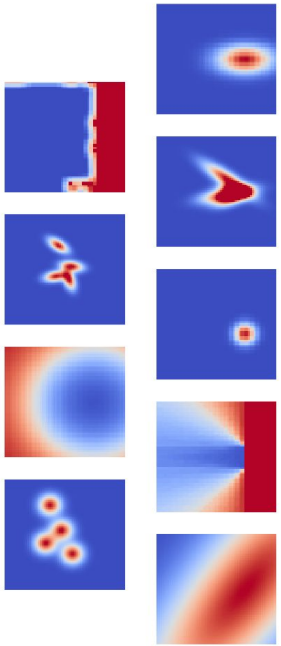
Base maps
Raw info from which all social costmaps are derived

Social Feature maps
Our designed maps

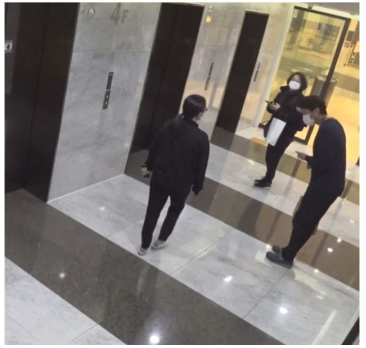


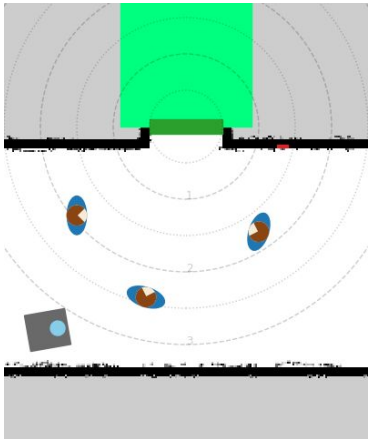
Model Evaluation

Research Questions

1. Is Machine Learning necessary?
2. Do the social feature maps help with their scaffolding?
3. **Do models perform on real situations (non-ProcGen)?**

	ID set		OOD set		Real Elevator	
	B	N	B	N	B	N
Model	Target mission: Yielding					
Baseline	.066	.159	.044	.165	.075	.147
LR	.077	.364	.067	.317	.104	.380
SVM	.078	.352	.072	.302	.106	.350
DT	.078	.325	.072	.247	.105	.328
RF	.078	.349	.072	.297	.106	.365
MLP	.078	.362	.072	.316	.106	.400
U-Net	.059	.413	.128	.309	.045	.318





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and much more in the paper!

Conclusions and Future Work

ProcGen + Scaffolding + Data-frugal models allowed us to tackle a niche yet relevant HRI problem

Deployment to assess **social acceptability**

Can we get away with just positioning for a smooth interaction?

2025 IEEE
RO-MAN

Robots Waiting for the Elevator:

Integrating Social Norms in a Low-Data Regime Goal Selection Problem

More information available at
https://europe.naverlabs.com/research/publications/robots-waiting-for-the-elevator/

NAVER LABS




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