Knowledge-based Reasoning for Navigation in Public Spaces

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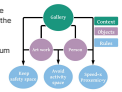
Introduction

- Social cognition can help a robot act more appropriately in public spaces around people.
- importance of understanding the art museum environment before integrating social robotics.
- While previous navigation models focus on objects, context, or human presence in the scene, we incorporate all three to recognize the context and follow social rules more accurately.
- Convert the interview data into predetermined social rules for our system

Aims

- Interview corpus of socially appropriate and inappropriate behaviors and movements in particular museum spaces.
- Delivering a data-driven knowledge base representation (ontology) serves as a socially aware navigation approach capable of making inferences about the behavior necessary in the museum and exhibitions to observe the social rules specific to space.
- A socially aware planner leverages the above ontology to select appropriate behaviors in museum spaces for appropriate navigation.



Discussion

✅ Empty hallway → Stay on the right

✅ Person in hallway → Stay on the right + Respect people's personal space

Preliminary Findings - Knowledge Base Representation

Context Classification

A context classifier, a trained CNN that distinguishes between environment contexts such as gallery rooms, hallways, and other areas.

Object/Person Detection

Used the 'You Only Look Once' v3 (YOLOv3) which is among the most broadly used deep learning-based object detection approaches.

Knowledge graph

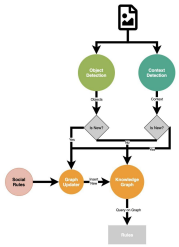
We make our KG using Ontology. "An ontology is a formal description of knowledge as a set of concepts in a domain and the relationships that hold between them."

Reasoning

The relationships between the objects and the context are used to get the associated social rules. We use the SPARQL language to retrieve and manipulate data stored in Resource Description Framework (RDF) format.

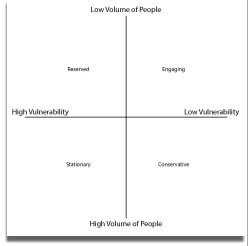
Social Rules

The analysis of interview corpus shows different social rules that are expected in museums.



Preliminary Findings - Museum Regions

- **Engaging:** The robot could operate without restrictions depending on their assigned role. These behaviors may include ' 'ask a stagnant visitor if they have any questions" or ' 'move at the speed of traffic."
- **Conservative:** Conservative behaviors may follow social rules such as "move slowly to avoid collisions" but it could be considered socially appropriate for a robot to offer information to interested visitors.
- **Reserved:** Reserved behaviors designed for SAN may reflect social rules such as "move at a consistent speed to destination" rather than to creep slowly and cause concern to the visitor.
- **Stationary:** These rules may be reflective of a museum security guard that stays stationary in the gallery but is available to answer questions, offer directions and more.



Ongoing Research Efforts

Larger knowledge graph, autonomously built from text sources using NLP methods

An accurate object detection method

A broader context classifier and knowledge base using MIT Indoor Scenes dataset

Develop the system and validate our proposed method on a real-world robot

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Summary and Acknowledgement

In this research project, we focus on the process of robot decision-making while navigating in public spaces in the presence of humans. For different spaces, the agent has to consider particular social norms. Our model consists of a few modules. Context Classification, Object/Person Detection, Knowledge graph (ontology), and Reasoner.

Our ongoing efforts include gathering interviews with museum experts and analyzing text data, building a broader knowledge base using a more extensive dataset such as MIT Indoor Scenes dataset, and finally integrating our knowledge base with an optimization-based social navigation planner and validating our proposed method on a real-world robot.

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