Adaptive Robot to Person Encounter

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Introduction

How does a robot tell if a person is interested in interacting with the robot? How should the robot move when approaching a person showing interest in interaction? This poster concerns this spatial relationship between a robot and a person as shown in Fig 1.

A novel approach for adaptive movement control of the robot is developed based on the human to human proxemics described by Hall [1]. (see Fig. 2). The control strategy is inspired by [2] and utilizes a cost function centered in the person.

The proposed method for determining if a person is interested in interaction, is based on a cognitive approach using Case Based Reasoning (CBR) [3].

The methods have been tested both in simulation and in a real world laboratory experiment, and have showed promising results.

Methods

Interaction interest: A person’s willingness to engage in interaction is analyzed based on the person’s spatial motion and based on knowledge from previous human-robot encounters. Motion primitives like a person’s velocity, distance, direction, to the robot is stored in a case database, and these cases are used to determine the interaction interest of the current person (see Fig. 3).

Control strategy:

An adaptive Gaussian person centered cost function is used to represent the desired spatial behavior of the robot, allowing the knowledge about social interaction described by hall zones [1], to be taken into account. The cost functions are adaptive and adjusted by the person’s interest in interaction, allowing the robot to move into the person’s personal zone at a 45 degree angle in case interaction interest is expressed. The cost function is a weighted summation of four Gaussian cost functions shown in Fig. 4, and examples are shown in Fig. 5.

\[ f(x) = \sum_{i=1}^{4} \frac{1}{\sqrt{2\pi} \sigma_i} \exp \left( -\frac{(x-x_i)^2}{2\sigma_i^2} \right) \]

where \( x \) is the weight assigned to each Gaussian cost function, and the width and orientation of the cost functions are determined by:

\[ \sum_{i=1}^{4} \sigma_i^2 = 2\sigma^2 \]

Distributions:

Attraction: In a circular region distribution used to attract the robot towards the person.

Rear: Prevents the robot from passing behind the person.

Parallel and perpendicular: right direction.

\( \theta \)

Experiment and Results

Experiments have been done both in simulation and in real world. The simulation tests the capability of the Case Base Reasoning module, and the real world experiment tests the movement pattern of the robot. The simulation has been done using the robotic software framework, Player/Stage, and the real world experiment has been done using a FESTO Robotino® robot platform equipped with a laser range finder and a camera for detecting persons. In the simulation an extra simulated robot was used to represent a person. Experiments were made with persons both interested and not interested in interaction.

Simulation: Results from the simulation is shown in Fig. 6. The left column shows the behaviour with an untrained database for both an interested and a not interested person. After this, the CBR database was trained with 20 series including 10 interested and 10 not interested persons. The results with trained database is shown in the right column. For the interested case, it is seen that the robot is much slower to start interaction, and even reverses a little (Fig. 6a). For the not interested person, the trained database makes the robot much faster to change the situation and start to move away from the person again.

Real world experiment: Results from the physical experiments are shown in Fig. 7. In this experiment the robot CBR database is not trained, but is given prior information about the person’s interest. In a) and b) the pose of the person is indicated by moving forward towards the person, and c) and d) the pose is not indicated, which makes the robot think it comes from behind the person. In the left column the person is not interested in interaction, and it is seen that the robot is repelled. In the right column the person is interested, and it is seen that the robot is attracted towards the person. Comparing the top row to the lower row, it is seen that the robot moves around the person to get in front of the person.

Discussion

The real world test results demonstrates how an adaptive Gaussian cost function may be used as the basis for a spatial robot behaviour scheme. Furthermore simulations show a proof of concept that a Case Based Reasoning (CBR) database can be utilized to incorporate learning capabilities of the robot. The CBR module needs further testing and development. It could be enhanced with information about robot velocity or e.g. speech or gesture recognition. Furthermore a limitation of the current system is that it relies on the pose of the persons, but if the person is standing still, it is not possible to know which side to approach from. The real world experiments are quite limited to a few scenarios without use of the CBR module. This needs further and more extensive testing also.

Although these limitations, the simulation and experiments has shown a proof of concept that a summation of adaptive Gaussian cost functions can be used to control the motion of a robot in human interaction. Additionally it has been demonstrated that CBR can be used to implement cognitive abilities on a robot for human interaction.

Experiment

and

Results

References