

# Towards a Social Robot that Incrementally Justifies Personal-Space Intrusion

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**Abstract.** Robots should appropriately give reasons for their actions when these actions affect a human’s action or goal space. Communicating reasons may help the human understand the robot’s intents and may initiate joint action, i. e., accepting the robot’s goals and cooperating on the robot’s actions. However, to be efficient, the communication of reasons should be limited to the necessary rather than to completeness, conforming to the Gricean Maxim of Quantity. Furthermore, what is necessary only becomes apparent as the situation evolves and hence, for seamless interaction, ongoing utterances must be adapted as they happen. We present a system that flexibly gives reasons in a reduced setting in which the robot needs to intrude a human’s personal space in order to reach its goal.

## 1 Introduction

When robots and humans act in common spaces they inevitably encounter each other regularly. Imagine a hospital service robot that has just adopted the goal to rescue a patient on the other corridor. On its way to the patient the robot encounters a human being standing in the hallway. The robot’s planned path leads right across the human’s personal space. Knowing that personal-space intrusion should be avoided on the one hand and knowing about the urgency of the task on the other hand, the robot decides to continue on its planned path while verbally explaining to the human that it needs to pass urgently to rescue a patient.

The robot thus invites the human to commit to its goal: Because the human understands the robot’s goal, she may either decide to step aside or even to assist the robot, thereby establishing a joint commitment. Joint commitments like this are often established by verbal communication [2].

Hence, we propose the following hypothesis: A robot that utters its reasons for action towards humans may create a commitment between itself and the human to jointly see to it that the robot’s action can be successfully performed.

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**Fig. 1.** (a) As soon as the local path plan (pink) overlaps the personal space (yellow) the robot starts to say “Excuse me, I need to pass urgently to rescue a patient in the other corridor – thank you.” (b) However, as the person steps aside the robot leaves personal space before the whole explanation was uttered resulting in “Excuse me, I need to pass urgently – thank you.”

Reasons and the corresponding explanations can easily become very long. In situated interaction, the human may signal her joint commitment long before all reasons have been given and hence, a robot that fully explains itself would disobey the Gricean Maxim of quantity [3].

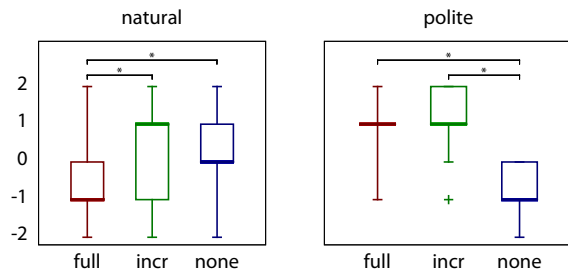
In our work [1] we focus on the technical challenges of integrating knowledge about social (spatial) norms and the capability to incrementally produce speech that enables the robot to seamlessly adapt its speech to the evolving situation.

## 2 A Software Architecture Integrating Social Spaces, Reasons, and Incremental Speech Production

To enable a social robot to planfully intrude personal space while passing a human, we present a software architecture that integrates the capability to reason about personal space and the capability to incrementally produce spoken language.

Within the *social spaces* component we represent a personal space as an entity that is produced by a (single) human and the human provides reasons for action to robots. In the example domain depicted in Figures 1(a) and 1(b) the human provides a reason against the robot driving along the planned path. This reason-driven view is inspired by contemporary work in practical philosophy (e.g., [4]) and motivated by the fact that reasons can be used both for deliberate decision making and for generating justifications or apologies social agents owe to others.

Additionally, we assume that there is a patient in the other corridor which needs to be rescued by the robot. Consequently, the patient provides the robot with a reason in favor of driving along the planned route. Hence, given the navigation action *driving along the global path* represented by the global path plan, the knowledge base can be queried for reasons that speak in favor of or against actually executing that particular plan and an utterance can be built in which reasons that speak in favor of an action play the role of justifications whereas reasons that speak against an action can be used to formulate regret.



**Fig. 2.** Subjective ratings of naturalness and politeness for the three system configurations. Significantly different ratings between configurations are marked with a star.

For instance, in the example depicted in Figures 1(a) and 1(b) the social-space component informs the verbal planner that there are two reasons  $\rho_1, \rho_2$ . Reason  $\rho_1$  is the fact that the personal space should not be intruded and reason  $\rho_2$  is the fact that some patient has to be rescued in the other corridor. Therefore,  $\rho_1$  speaks in favor of executing the given path plan and  $\rho_2$  speaks against doing so. Consequently, the *verbal planner* maps  $\rho_2$  to an apology and  $\rho_1$  to a justification. As a result the component outputs  $S :=$  “Excuse me, I need to pass urgently to rescue a patient in the other corridor. Thank you.”

We anticipate that  $S$  tends to become quite long the more reasons are at stake and hence we propose to order reasons by importance and to insert additional chunking information that the incremental speech production may use to skip parts of the resulting utterance for brevity.

The *controller* component interfaces the verbal planner and the incremental speech synthesis. It is implemented as a finite state machine that sends commands to the incremental speech synthesis component depending on whether the robot enters personal space, is within personal space, or leaves personal space.

Given the utterance plan  $S$  of the verbal planner, the *incremental speech production* component prepares a flexible utterance tree that provide for the alternatives of the original plan (in our case: skipping parts of the explanation).

### 3 Study and Results

In [1], we tested our hypothesis that giving reasons for passing through a personal space is superior in terms of perceived naturalness and politeness of the robot to alternative strategies in a highly controlled observer rating experiment.

We generated simulation videos where the robot needs to enter a human’s personal space in order to reach its goal (cmp. Figure 1(a)). Depending on the condition, the robot utters the full reason and apology for disturbing the human, is able to incrementally shorten the utterance if the human steps aside (cmp. Figure 1(b)), or does not speak at all. Subjects rated the robot behaviour wrt. naturalness and politeness. Results are given in Figure 2.

As can be seen in the figure, when giving the reason for personal space intrusion the robot is rated as significantly more polite compared to not explaining why it needs to disturb the human. However, the robot is rated as significantly less natural if it does not obey the Gricean Maxim of quantity and utters the full reason even though the human has already reacted and stepped aside. Thus, to be both polite and natural, the robot needs the ability to explain itself to the extent that is necessary in the situation.

## 4 Conclusions

We have presented an architecture that integrates reason-based action (exemplified by the robot knowing about the pros and cons of personal-space intrusion) and the capability of incremental speech production. Our architecture enables a robot to verbally justify its action towards a human. Consequently, the human understands why the robot acts as it does. As a result, the human can decide to help the robot—either by stepping aside or even by offering assistance to the robot and thus establishing a joint goal.

Clearly, our one-way mode of communication only scratches the surface of a fully interactive, personal space-aware social robot. Such a robot should be able to engage in a full dialogue with the human (or humans) it encounters, either if more elaborate negotiations are necessary for the robot to pass, by initiative of the human, or to explain its goals and ask for help if this is situationally appropriate (e. g. while jointly waiting for the elevator).

## References

1. Baumann, T., Lindner, F.: Incremental speech production for polite and natural personal-space intrusion. In: *ICSR 2015: Procs. of the 7th IEEE Int. Conf. on Social Robotics (2015)*
2. Gilbert, M.: *Joint Commitment: How We Make the Social World*. Oxford University Press (2013)
3. Grice, P.: Logic and conversation. In: Cole, P., Morgan, J. (eds.) *Syntax and semantics*, vol. 3: *Speech Acts*, pp. 41–58. Academic Press, New York (1975)
4. Raz, J.: *From Normativity to Responsibility*. Oxford University Press (2011)