Human-like robot personalities for social navigation

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***Abstract*—The aim of this work is to described an innovative way to associate a personality to a robot by taking into account only the social parameters related to the navigation task (i.e. proximity and velocity). We present a human-aware navigation system which can be replicated on any ROS-based robotic platform. We evaluated it in a dynamic scenario, in which the user needed to pass by a robot moving in the opposite direction. The Eysenck Personality Inventory and a modified version of Godspeed questionnaire were administrated to assess the user's and the perceived robot's personalities, respectively. The results show that 70% of the participants perceived a difference among the personalities exhibited by the robot. Furthermore, the results highlight a general tendency of preferring a complementary robot's personality, suggesting some guidelines for future works in this field.**

***Index Terms*—Robot's personality, Human-aware navigation**

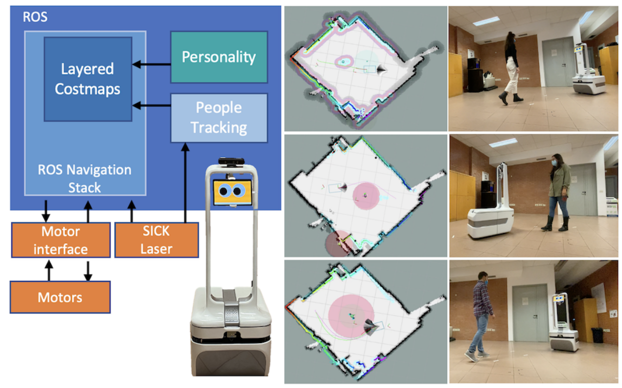
I. Introduction

Robotic systems should be incorporated with a social intelligence which allows the robot to adapt its behavior to the human user's preferences and personality. Among the human-adaptive behaviors that a robot should exhibit, social navigation must be included. As compared to traditional autonomous navigation, the social navigation poses additional requirements to the robot's trajectory in order to satisfy human sociability [1]. In the human-robot context, several works showed that individuals apply the same proxemics' conventions also in the presence of a robot [2] and that proxemics is strongly related to the personality of the individuals [3]. Namely, extroverted people, who like social interactions, may prefer a closer distance to the robot than introverted people. Starting from previous findings on proxemics, we associated three different personalities to the robot's navigation behavior: no social (NS), extrovert (EXT) and introvert (INT). An experimental setting was organized to explore user-robot personality matching (RQ1) and to investigate if the personality of the robot can be expressed in terms of proxemics in a dynamic scenario (RQ2).

II. Material and Methods

A. System Overview

The robot used in this study was CloudIA, a ROS-based robot capable of autonomously navigating in the environment by following the approach described in [4]. The human-aware navigation was implemented by integrating the *social_navigation_layers* package [5], a layered approach which adds the obstacle, inflation, and proximity layers to the 2D occupancy grid map. In this study, the *people_tracker* package [6] was used to detect a person from the laser scan data. It represented an additional input to the proximity layer. The personalities of the robot were obtained by configuring the navigation parameters. In the NS behavior, the robot detected a person as a moving obstacle and behaved with no social intelligence, since the proximity layer was deactivated. The EXT and INT personalities were obtained by activating the proximity layer (along with obstacle and inflation layers), and tuning the amplitude (A) and the covariance (K) of the Gaussian distribution covering the detected person. The EXT case was characterized by a strict and tall Gaussian shape (A=130, K=0.15), in order to allow the robot to pass closer to the person. On the contrary, the INT case was characterized by a wide and short Gaussian (A=60, K=0.6) so as to increase the avoiding distance from the person. Both avoiding distances allowed the robot to traverse the social zone [7]. The maximum velocities were kept below 0.25 m/s due to safety issues.



(a) (b)

Fig. 1: System architecture of CloudIA robot (a) and the robot exhibiting the different personalities (b): no social (top), extrovert (center), and introvert (bottom).

B. Experimental setting

A total of 20 young healthy subjects (8 women and 12 men, avg age=28.4 years old, std age=3.15 years old) were recruited. The extraversion of each participant was estimated by counting up the responses to corresponding 24 items of the Eysenck Personality Inventory (EPI) questionnaire [8]. As result, the study involved 11 participants characterized by "high" level of extraversion and 9 participants characterized by "low" level

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of extraversion. The experimental procedure was composed of 2 phases. The first phase (Ph1) consisted of bringing the participants into the experimental space and asking them to sign the consent form and to fill out a demographic form and the EPI. The second phase (Ph2), called the dynamic scenario, was composed of 3 tasks. During each task, the participants were asked to slowly walk towards a target point at 4.5m distant, while the robot was commanded to navigate in the opposite direction exhibiting a specific personality. At the end of each task, the participants filled a modified version of the Godspeed questionnaire (GQ), as described in [9], in order to rate the following factors: anthropomorphism(ANT), animacy(ANI), likeability(LIK), perceived intelligence(PEI), perceived safety(PES), emotion(EMO), social intelligence(SOI) and extraversion(EXT). To obtain a general overview of the perceived personalities, a brief interview was conducted at the end of the experiment. The interview was composed of the following questions: (a) "Did you notice any difference among the robot's behaviors?"; (b) "Did you prefer any of them?".

C. Data Analysis

The reliability of the navigation system was evaluated in terms of success rate in each task of Ph2. It was computed as percentage of the ratio between the number of accomplished services and the total number of services. The final score of each GQ was computed as the sum of the eight domains. The Spearman correlation index (ρ) was computed between the EPI extroversion scale and the GQ domains considering all the recruited cohort to investigate whether there were differences in perceiving the three navigation behaviors according to the personality of the user. Additionally, Mann Whitney U Test was applied to verify differences in the GQ domains evaluation in the two cohorts of participants (i.e. extrovert and non-extrovert) over the three selected behaviors. Finally, the data collected from the final interviews were analyzed to investigate which behavior was the preferred one.

III. Results and Discussion

The robot successfully exhibited the three distinct personalities during the Ph2. The success rate was equal 100% both in NS and EXT behaviors. Indeed, in the NS modality, the robot detected the participant as a moving obstacle, thus keeping a close-to-straight trajectory. When exhibiting the EXT personality, the trajectory of the robot changed according to the participant's motion. The INT navigation mode was characterized by larger curvatures, which made the robot to most avoid crossing the participant's path. Since the participant was walking, it was observed that the robot found itself in the lethal zone causing misbehaviors, which decreased the success rate of the INT behavior to 75%.

The overall population slightly preferred the EXT modalities with 83.3 points. The NS and the INT behaviors were rated 82.7 and 83.1 respectively. Extrovert cohort preferred the INT modalities (GQ= 90.45), while while no extrovert people preferred the EXT modalities with 89.9 score. Statistically, extrovert EPI score was correlated with the SOI for the INT behavior (ρ= 0.45). Additionally, there were significant differences (ρ <0.05) in the answers between extrovert group and no extrovert group for the INT behavior for six GQ domains (i.e. LIK, PEI, PES, EMO, SOI and EXT). On the contrary, the EXT robot behavior was not correlated with any domains. These results provide a negative answer to RQ1. They do not highlight any user-robot personality matching, since the general trend followed the complementary attraction rule (i.e. non extrovert people tend to prefer the EXT personality of the robot, and vice-versa).

The interview highlighted that 19 participants detected some differences in the robot's behaviors. Namely, 14 participants noticed a difference among the three behaviors, in terms of velocity, proxemics, and avoiding phase. These results enforce the statistical analysis, providing a clear and positive answer to RQ2. Regarding the preferences, the EXT behavior liked the most (55%) with respect to the NS (15%) and the INT (25%) behavior. The robot exhibiting the EXT personality was perceived as aware of the presence of the person and very "humanlike" in the way it avoided the person. On the contrary, the INT personality was appreciated due to its smoother trajectory.

These results propose some guidelines for future works in the field. In details, the EXT configuration should be exhibited by a robot which is not aware of the personality traits of the people populating the environment. It is due the fact that the interview statements reported the EXT personality as the preferred one and there are not statistical differences in the rating among the two cohort of participants. On the contrary, when the personality traits of the people are known, it is advisable to endow the robot with the complementary personality.

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