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Shopping with a robotic companion

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ABSTRACT

In this paper, we present a robotic shopping assistant, designed with a cognitive architecture, grounded in machine learning systems, in order to study how the human-robot interaction (HRI) is changing the shopping behavior in smart technological stores. In the software environment of the NAO robot, connected to the Internet with cloud services, we designed a social-like interaction where the robot carries out actions with the customer. In particular, we focused our design on two main skills the robot has to learn: the first is the ability to acquire social input communicated by relevant clues that humans provide about their emotional state (emotions, emotional speech), or collected in the Social Media (such as, information on the customer's tastes, cultural background, etc.). The second is the skill to express in turn its own emotional state, so that it can affect the customer buying decision, refining in the user the sense of interacting with a human-like companion. By combining social robotics and machine learning systems the potential of robotics to assist people in real life situations will increase, providing a gentle customers' acceptance of advanced technologies.

1. Introduction

Shopping centers are becoming smart improving customers satisfaction with tangible services, reliability, responding promptly to the customers' needs, assuring the finest employees courtesy and trustfulness, providing a sense of empathy, in order to compete with the today advanced Internet of Things (I0T) platforms (Balaji & Roy, 2016). Not only they are equipped with the most recent technologies, with the fastest fiber internet connections, the facilities of cloud computing and analytic methods, but they also have autonomous robots performing the tasks of the sales assistants. All around the world, robots are entering the shopping centers, attesting that robotic technology is gaining ground. The rationale for this choice lies in the fact that retail shops need to offer trendy yet low-cost substitutes to e-commerce, reducing the operating costs of personnel management (Francis et al., 2013). A robotic alternative can automate the logistics of the retail operation, both at the front-end and back-end operations, thereby avoiding the out-of-stocks (Che, Chen, & Chen, 2012) and the related lack of profits, defining a set of activities that allow various high-level tasks to be achieved successfully. As competing with the innovations introduced by the e-Commerce, physical stores may have lower costs, and of course lower profits (Grewal, Roggeveen, & Nordfält, 2016; Guo & Hu, 2014). They must have trustworthy services that manage the shop, reducing the personnel costs. Other important aspects that retailers are facing are the challenge of having enough space to exhibit items from shelves, the manual allocation of goods and the real-time updating of the shelves. Therefore, researchers designed automated robot platforms that embed the above-mentioned functionality, to navigate autonomously the physical shops, integrating or partially substituting the staff tasks (Kumar, Anand, & Song, 2016). According to the International Federation of Robotics (IFR, 2016), a strong growth in the robot market is being achieved in the area of social services, with robot assistants, especially devoted to surveillance, monitoring, domestic use. The number of service robots rose considerably by 25% in 2015, compared to 2014. Service robots are used especially in supermarkets, but also in other exhibitions, in museums as guides or information providers, with edutainment aims in school settings (Bilotta et al., 2009; Bertacchini, Bilotta, Gabriele, Pantano, & Servidio, 2010; Gabriele, Tavernise, & Bertacchini, 2012). The service robotics sector is expected to grow in the medium term, both for professional and domestic use. (See the Executive Summary World Robotics 2016 - Service Robots). Robots and Robot-as-a Service

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(RaaS) are being used for solving different problems in the retailing industry (Kumar, 2016). Many humanoid robots have been exhibited in different shops of the world, from Japan to France, to the USA, which in part are RaaS systems, devoted to the customer assistance. Technological enriched environments allow for a huge variety of robot services. Customer assistance makes an innovative use of the data stored in the shop digital warehouse, or in the cloud computing facilities. Users can access, visualize, share, and, finally, capture in real time the data (Kejriwal, Garg, & Kumar, 2015). Given these already existing functionalities, service robots could carry out activities such as the creation of a shopping cart or discovering where the customers' desired products are located in the shop. These tasks are of great help for customers, especially older ones. This digital enriched system could also be displayed for the user, as a digital ready to use virtual shop, in the physical store. Shopper's purchases in different stores are annotated and the system maps the path for the more common items, thus speeding up the time of purchasing. Personal engagement could be also useful. In this future of robotic services, especially in fashion stores, a shopping humanoid assistant could collect the physical information about what a customer likes or dislikes gathering data from the customer behavior (Pratiba, 2013), which will be stored as a repository of Big Data to segment the customer's preferences (Vojtovič, Navickas, & Gruzauskas, 2016). Furthermore, users' physical attributes (height, hair and eye color, etc.) could be scanned, and the robot can then recommend items according to the users attribute, budget, previous shopping history and personal features. Other services are related to the paying activity, such as the currency exchange, the gift packaging, the price comparisons, and the dispensing of coupons. However, the great advantage of integrating robotic services in the retail sector has to be connected to the combined power of Robotics, Analytics, and Cloud (RAC), in this merging sector called *clouds robotics* (Proia, Simshaw, & Hauser, 2015) that connects robotics to the Internet for massively parallel computation and sharing of huge data resources. The advantages reside in three main points:

a. The minimal upfront costs, as the robots are connected to a cloud server;
b. Robots can be designed as part of an intelligent ambient system (Ultes, Dikme, & Minker, 2016), thus interacting with surveillance cameras, RFID antennae (Nur, Morenza-Cinos, Carreras, & Pous, 2015; Zhang, Lyu, Roppel, Patton, & Senthilkumar, 2016), or with all the items that have a sensor (as in the Internet of Intelligent Things IOIT paradigm);
c. Robots that use cloud computing and a reduced number of employees can eliminate overheads and related costs.

By making robots smart and endowing them with robust computational skills, cloud robotics could be the promoter for the increasing of the consumer robotics marketplace. In this way, retailing could exploit technological changes in the business, improving the customers -robot interaction.

However, what will be the future of Robotics in retailing? How robots will change their behavior by interacting with people?

Since the first, simplified humanoid robot, built at the Waseda University, Tokyo, Japan, in 1972, research has produced advanced, skilled robots. They control motor behavior and stability, have intelligent behavior that allows carrying out tasks in a human-like fashion, with social communication skills (Breazeal & Scassellati, 2002) and emotions (Picard & Picard, 1997; Fellous & Arbib, 2005). In fact, researchers are developing more socially competent robots that are able to collaborate with people, learning by interacting with other humans as infants do during their development (Merrick, 2017; Min, Luo, Zhu, & Bi, 2016). This approach requires that robots learn to interact with people in carrying out the tasks (Lehmann et al., 2013). So, what will happen in the near future in situations where humans and robots that share the same goals will collaborate in shops? Will be possible to create patterns of social and emotional behavior that will be useful for fulfilling the customers' needs? Until now, retail robots have been designed to do something for the humans.

However, if the aim is to create a more human-like social environment, the design of shop assistant robots has to connect in a very special way humans and robots, carrying out the purchase behavior together. As Takayama, Ju, and Nass (2008) found "people would feel more positively toward robots doing occupations with people rather than in place of people". Transposing this approach to market for the shop use, we developed a robot to help the consumer to select an item, considered one of the most important activities in the retail sector. According to our knowledge, despite several robotic applications have been created to provide technologically enhanced tools to customers, the development of a social interaction between robots and the customer has not yet been realized. In this paper, we present a Human Robot Interaction (HRI) architecture based on the development of empathy and friendship, thus developing a sense of satisfaction in the user and real social life. To develop such a robotic assistant, a cognitive and social task analysis is carried out in this paper. This will allow:

(i) to understand the social interaction between a robotic assistant and a customer;
(ii) to analyze the verbal and nonverbal communication and the expression of the emotions in both the actors of this interaction;
(iii) to define the specific cognitive architecture to be developed, thus improving the potentials of robots to assist people in real life situations,
(iv) to create a machine learning system, with many specific modules devoted to nonverbal behavior, such as hand and body gestures and a sentiment analysis for language, in order to correlate emotions and emotional language.

Given the previous theoretical and practical premises, the main aim of this paper is to present a prototypical robotic application in the retailing sector, with the specific objectives to help consumers to carry out the usual tasks in the shops. The main theoretical contribution is the design of an autonomous robot, endowed with advanced Artificial Intelligent and machine learning programs, tailored for a practical implementation with the NAO[1] robot.

The paper is organized as follows. After the Introduction, the current literature on the impact of robots in the retail setting is presented in Section 2. Sections 3 and 4 explain some models of social learning and the basic machine learning concepts. The NAO robot, used for this implementation, with its hardware and software architecture, is given in Section 5. Section 6 illustrates the cognitive architecture, realized as a coordinated machine learning system, providing information on the task realized by both customer and robot in the shopping environment. Empirical results are reported in Section 7. A discussion on the complexity of the technological and management scenario in the retail sector is presented in Section 8. Finally, some considerations and future developments on the acceptance of new technologies in the retail close work.

[1] The name NAO comes from the NAOqi Framework, which is the operating system used to program the robot.

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