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POSTER

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Adaptive End-User Development for Social Robotics

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ABSTRACT

This article outlines an approach to democratizing interactions between humans and robots, focusing on the development of a user-friendly solution for the Pepper humanoid robot. It emphasizes a multimodal End-User Development programming style to make robotic systems more accessible and adaptable for individuals with limited technical skills. By incorporating multimodal programming, smart systems, system adaptability, and emphasizing social interactions, this research aims to refine the interface between humans and robots, enhancing user engagement and acceptance. The envisioned system integrates the Trigger-Action Programming paradigm with vocal authoring to overcome expressiveness limitations and facilitate a more intuitive user experience.

CCS CONCEPTS

• **Human-centered computing** → **Human computer interaction (HCI)**; • **Computer systems organization** → *External interfaces for robotics.*

KEYWORDS

End-User Development, Human-Robot Interaction

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1 INTRODUCTION

Robots are becoming increasingly integrated into daily life, displaying more social and human-like behaviors. A recent forecast predicts a $6 billion humanoid robot market by 2035, targeting labor and elder care shortages [1]. In the sphere of social robotics, particularly where end-users may not possess extensive programming expertise, it becomes imperative to democratize robot-user interactions. This entails rendering robotic systems user-friendly and adaptable by those with minimal technical proficiency, thus endorsing the End-User Development (EUD) paradigm. Such an approach empowers users to tailor and modify robot functionalities intuitively, catering to their individual needs [18].

This article presents a doctoral research project on Adaptive Human-Computer Interaction to be executed at the HIIS-CNR laboratory[1], focusing on developing a multimodal EUD application for a Pepper humanoid robot[2]. Initial studies have assessed the current EUD development status, pinpointing prevalent challenges, potential solutions and requirements. Thus, this project aims to augment the EUD framework by addressing these gaps, thereby broadening the application scope of social robots.

2 REQUIREMENTS

Aiming to develop an innovative and comprehensive EUD solution, construction efforts of the envisioned system will focus on specific requirements. These have been identified through an extensive literature review and will be further validated by a detailed subsequent user study.

Multimodal programming. The implementation of a multimodal interface is perceived to offer significant benefits. Research [23][29][31] has illustrated that a multimodal strategy can enable more natural, intuitive, and efficient user interactions. This approach can diminish the complexity and ambiguity inherent in communication, thus enhancing user engagement, acceptance, and accessibility by catering to a wide range of preferences and requirements. Additionally, a multimodal interface can improve the robustness and reliability of user interactions, overcoming limitations or failures of single-mode interfaces and facilitating superior management of activities in dynamic and heterogeneous environments.

Smart Systems. The advancement of intelligent systems, proficient in anticipating user actions through initial insights or information garnered from planned activities, is recognized as a promising research trajectory poised to substantially refine End-User Development. This proposition not only resonates with [2] emphasis on the imperative for robotic systems to assimilate learning from their environments for the orchestration of more sophisticated tasks but also underscores the importance of staying abreast of the latest technological evolution, notably in the domains of artificial intelligence and user programming preferences [15]. The goal is to develop a system that enables users to start tasks from the ground up and suggests adaptable actions. This system will leverage built-in primitives and insights from user interactions to improve recommendations according to the user's programming habits. It also aims to help users foresee and fix programming mistakes.

System Adaptability. Tailoring the system to accommodate the unique habits and capabilities of its users constitutes an essential requirement, transcending the mere adherence to EUD principles as

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[1]https://giove.isti.cnr.it/
[2]https://www.aldebaran.com/it/pepper

outlined by [18]. Such adaptability is crucial for enhancing the user-friendliness of the system, with adaptive programming methodologies serving as instrumental in assisting users to both anticipate and manage errors, thereby aligning with their varying proficiencies. Furthermore, as validated by [28], social environments entail a wide range of participants, significantly expanding the diversity of user variables and complicating the prediction of user profiles and preferences. Thus, future research could focus on creating robots that offer personalized interactions to individual users. Moreover, incorporating the previously mentioned learning and AI technologies could significantly enhance the system's adaptability.

Emphasizing Social Interactions. In the deployment of robots in social settings, it is crucial to emphasize their intrinsic properties to enhance their capabilities in recognizing and adapting to human emotions. Consider, for instance, the use of robots in the field of rehabilitation. In this context, the significance of emotional and empathetic proximity during patients' interaction with the robot cannot be overstated, as noted by [11], underscoring the necessity for a robot's empathetic engagement over more conventional digital interfaces like tablets or computers. Fostering empathetic connections would enhance aspects related to rehabilitation performance, given that it is well-established that motivating patients requires a situational approach based on the character and emotional needs of them [9]. Consequently, a robot capable of identifying challenges and adjusting its behavior or demonstrating empathy would greatly benefit therapeutic outcomes.

Integrating enhanced social interaction with adaptive learning systems, as previously discussed, enables the robot to remember and reference past emotional states, leading to more nuanced interactions in future encounters. This approach is analogous to retail experiences where the value customers find in being remembered is evident [3][7]. It is proposed that this mechanism could similarly boost user engagement across all social contexts. Ultimately, creating a robot with enhanced sensitivity is expected to increase user acceptance, addressing issues widely reported in the literature [22][26].

3 ENVISIONED SYSTEM

The envisioned system will be based on a multimodal EUD programming modality. On one hand, it will employ the Trigger-Action Programming (TAP) paradigm. As illustrated by [17], TAP enables the customization of humanoid robot behavior through simple, event-driven rules, making it accessible for non-expert users to tailor interactions within dynamic environments. However, TAP faces limitations in expressiveness for complex behaviors and user difficulties in correctly interpreting program behaviors, often leading to errors during task creation when trigger-action distinctions are unclear [14]. Moreover, users may find it challenging to identify and debug errors due to the often implicit and non-linear nature of rule interactions [4].

To address these issues, the system's multimodality will be achieved by integrating TAP with a vocal authoring mode. As demonstrated by the study on Tabula [23], incorporating vocal programming can overcome TAP's expressiveness limitations by providing a more natural and intuitive means for specifying complex behaviors. Vocal programming allows for more intuitive and natural expression of intentions, potentially enhancing expressiveness through a richer and more flexible language capable of capturing complex nuances and specific conditions not easily represented through TAP interfaces. Furthermore, vocal interactions may offer immediate feedback on programmed actions, improving understanding and facilitating the debugging process through vocal suggestions or confirmations.

Echoing [23], this programming solution allows users to create tasks linking events or conditions (triggers) to responses (actions). According to [17] definitions, a *trigger* initiates robot actions, stemming from user interactions, environmental shifts, or technological signals. An *action* is the robot's reaction to a trigger, leveraging its capabilities from communication to movement and more, either as simple tasks or complex sequences. This system converts user-defined rules into robot-executable code, enabling tailored interactions without conventional programming. Therefore, triggers and actions are primitives defined by the developer during the system design phase. However, as we will see, the system can also suggest tasks or rules based on adaptations to the user's habits or needs.

4 CONCLUSION AND FUTURE WORK

By offering a multimodal programming interface, intelligent systems, adaptability, and a focus on social dynamics, the described system aims to make user interactions smoother and more intuitive. Intelligent systems could anticipate user needs and recommend tasks, reflecting the importance of environmental learning. Adapting to user habits and emphasizing emotional connections are expected to significantly increase user engagement. Employing a TAP paradigm with vocal authoring, the system addresses issues of expressiveness and interaction, facilitating a more user-friendly EUD experience. This approach intends to enable users of various abilities to more effectively utilize the technology, broadening its applicability and acceptance across different applications.

In collaboration with the CNR Institute of Neuroscience[3], Socially Assistive Robots (SARs) emerge as a significant application of our project, particularly in social assistance. SARs' capacity for meaningful social interactions can greatly benefit individuals' emotional and physical health [12]. Their use spans elderly care [19][21], education [10][30], rehabilitation [8][25], support for disabilities [13][27], and cognitive therapies [16][20]. Particularly, SARs address personnel shortages in cognitive rehabilitation, crucial for scaling therapy availability—a challenge exacerbated in Italy by service disparities [6] and the care needs of international migrants [5], signaling a global demand for more skilled workers. Thus, SARs complement human therapists, improving therapy access [24].

Moving forward, the project's critical initial step involves stakeholder engagement to examine the previously discussed requirements. This is essential, as [28] underscores, for fully understanding interface needs in complex social domains and deploying autonomous robots effectively, necessitating a deep knowledge of end-users, their requirements, and environmental complexities. Additionally, the project's design approach is human-centric, with plans for iterative refinement until the prototype achieves satisfactory utility and acceptance.

[3] http://www.in.cnr.it/index.php/it/

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