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Proactive Interaction Management in Domestic Service Robots to Enhance Human-Robot Conversational Interaction

Robotics technology has long been renowned for its ability to handle complex, repetitive, and sometimes risky tasks that are impossible for humans. In industries, robots are preferred for precise operations in various manufacturing stages of a product. On the other hand, domestic service robot is the other side of robotic technology that brings the smart robotic system into our homes. Service robots are specially designed to interact and assist humans where they provide a range of services, including caregiving, companionship, and entertainment. In addition, service robots can elevate living standards by assisting with essential daily activities, especially for people with disabilities.

Nowadays, the incorporation of generative pretrained models in robotic systems to provide a fluid conversation between humans and robots is a highly researched topic. Though pretrained generative language models can be incorporated into conversational systems, they often fail to offer healthy conversations with users. Most pretrained models are trained on billions of data points from blogs, posts, and forums, where language quality is not a concern. However, language quality and clarity matter greatly when de-

signing robotic systems to interact with humans, especially the elderly and children [1]. To create a toxic-free conversation, directly incorporating pre-trained generative language models is ineffective. Our study proposes a proactive interaction manager that observes, profiles and understands the user's preferences. It can engage in context-specific, human-friendly conversations with or without a particular intention, while also caring for the user by monitoring their emotional state and engagement level changes. The proactive interaction manager is designed specifically for the Moratuwa Intelligent Robot (MIRob), a domestic service robot which is designed to regularly interact with humans and provide services. MIRob has a Kinect sensor to perceive both the environment and the user visually. Voice inputs from the user are obtained using the microphone array embedded with the Kinect sensor and voice output is delivered using two stereo speakers that are integrated with MIRob. By empowering MIRob with the ability to discern the context, emotions, and engagement level of the user, this system enables the robot to interact with humans in a more natural, nuanced, and effective manner.

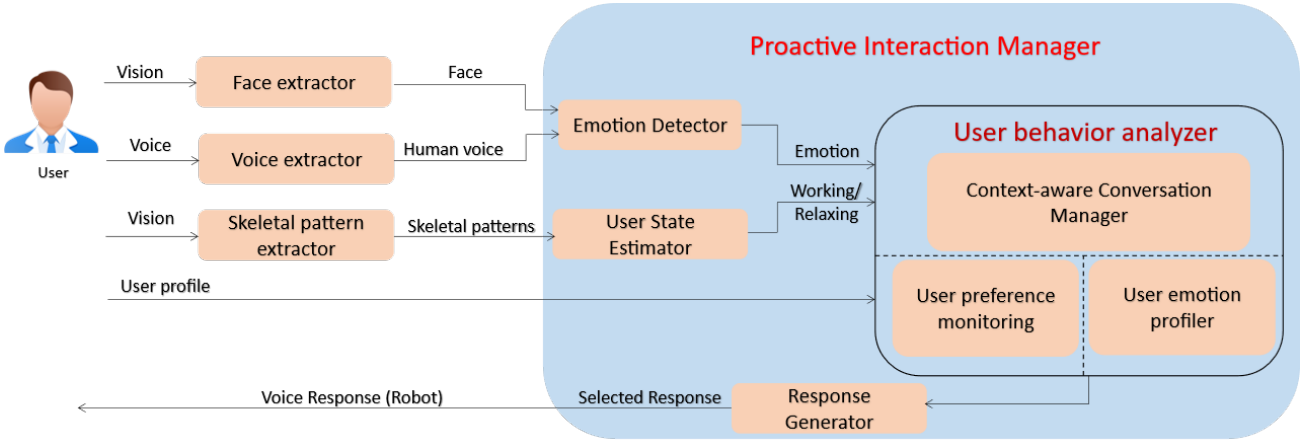

Figure 1: Overall System

The proposed proactive interaction manager system is illustrated in Figure 1. It analyses user behaviour, considering the current context, user preferences, and user emotions. Three separate subsystems for context awareness, user preference monitoring, and emotion awareness are designed to enable human-friendly conversation with users [2]. The features and capabilities of the three subsystems are detailed below.

1. Context-aware conversation management system for providing context-specific responses to users.

Context awareness enables robots to better understand and respond to user queries and commands. This system introduces a method for context awareness, which is primarily derived from verbal interactions between users and robots. It also incorporates a response cloud structure that is integrated into the conversation management system, allowing the robot to select and provide appropriate responses based on user queries and their specific context. Importantly, this response cloud structure is designed to be adaptable and updatable, aligning with the dynamic nature of human-robot interactions.

2. User profiling-based proactive suggestive system for suggesting reading materials for users.

We introduce a proactive interaction manager designed to suggest reading materials that cater the individual user preferences. The system observes the user prior to initiate the interaction with the user. Figure 2 depicts the working and relaxing positions of the user. The user is perceived using the Microsoft Kinect

(a) Working State

(b) Relaxing State

Figure 2: Users in working and relaxing states

sensor. Algorithms are designed to initiate and continue the proactive interaction with the user in a human-friendly manner. Figure 3 shows that the MIRob, a domestic service robot observes the user and user behaviour prior to go with a conversation. This system is based on the concept of user profiling, a technique that considers multiple user attributes to discern their reading genre preferences. Users' reading preferences, being dynamic, necessitate an adaptive approach where we proposed an algorithm that can seamlessly adjust and offer reading suggestions as users' preferences evolve. The performance of the system is validated with several experiments where the results strongly indicate that this approach is well-suited for domestic service robot applications. By personalizing reading recommendations, the system enhances human-robot interactions, ensuring a more engaging and user-friendly experience.

Figure 3: MIRob observing the user and user behaviour before starting any interactions.

3. Emotion-aware task-oriented companion type conversation management system with user caring.

A task-oriented conversation management system employs an innovative approach, utilizing Hierarchical State Transition Networks (HSTNs) along with a state-switching algorithm to dynamically adapt the conversation flow based on the user's emotional state and level of engagement. In this system, user interactions are more than mere information retrieval. Instead they reflect a genuine concern for the user's emotional well-being and involvement in the conversation. The proposed system was validated against a controlled system considering various factors that are needed to be

satisfied in a successful human-robot interaction scenario. This approach underscores the invaluable integration of emotion and engagement monitoring into user interactions, ultimately nurturing a more empathetic and user-friendly interaction with task-oriented conversational robots.

As service robots find their place in various domains, including education, healthcare, and home assistance, the ability to engage in context-specific, human-friendly conversations is crucial. Our study has presented three distinct proactive interaction management systems, each tailored to address specific aspects of human-robot interactions. Each of these proactive interaction management systems represents a significant step towards achieving more empathetic, user-friendly, and effective human-robot interactions. Future research in this field will likely bring further refinements and innovations, ultimately leading to even more seamless and natural interactions between humans and robots.

References:

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