Designing Social Robots for Mental Heath Care

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***Abstract*— Mental health is a growing socio-economic burden worldwide and leads to negative ramifications including mortality and poor quality of life. Successful prevention, detection, and intervention of mental illness will make a significant, positive economic and societal impact. This research explores how social robots may contribute to effective mental health care. In this work, we present our initial effort in designing and developing a social robot that detects emotional states through multimodal sensing of human behavior and provides affective companionship. We describe a pilot study exploring how people might interact and perceive the robot. Our preliminary results show that participants treated the robot socially and engaged in affective interactions with the robot.**

I. INTRODUCTION

Mental health is a growing concern globally. Around 1-in-6 people in the world experience one or more mental illnesses [1]. The financial burden associated with mental illness is substantial and costs America approximately $193.2 billion per year [3]. Individuals living with mental illness face an increased risk of chronic medical conditions, increased risk of suicide, and involvement in anti-social activities. Despite being critical to overall well-being and physical health, diagnoses and treatment of mental illnesses remain low. Emerging research indicates that intervening early can interrupt the negative course of some mental illnesses and may, in some cases, lessen long-term disability [2].

As evidenced by successful applications in care for individuals with autism (e.g., [5]), Socially Assistive Robots (SARs) [] represents a promising tool for mental health care. While prior research has explored how SARs might provide social, emotional support and companionship (e.g., []), this work investigates how a social robot may be used for early detection of mental health risks. In particular, we focus on multimodal sensing of human behavior.

II. ROBOT DESIGN

The developed robot called "DOT" can be seen in figure. The physical dimensions of the robot are 17x15x30 cms and weighs about 2.36 lbs. The robot has 6 DOF, eye-lids open and closing mechanism (2 DOF), eyeballs pan and tilt mechanism (2 DOF) and neck rotation similar to human head (2 DOF). The entire robot is covered with artificial fur to encourage the users to make physical contact with the robot. DOT is equipped with camera, microphone, IMU, and tactile sensors which help it interpret the environment and its user.

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Fig. 1. caption.

The gesture recognition system makes use of the contact information obtained from the tactile sensors that cover the robot to classify the contact into a gesture cue that the robot can recognise and respond. In addition, the IMU data is analysed to infer gestures and the robot position relative to the user. The haptic gesture include Stroke, Contact, Hug, Hold, Rub, Pat, and Squeeze. The identifiable posture of the robot including toss, rock, and lift.

DOT has two layers to generate its proactive behavior: a behavior-planning layer and a behavior generation layer. Depending on its internal states DOT generates behavior. However, the internal state of the robot is influenced by the users mood and emotions. The behaviour-planning layer takes input from the face tracking and emotion detection frameworks to generate the robot's internal state. This layer then decides a particular response from a pool of pre-defined responses and sends basic behavioral patterns to the behavior-generation layer. The behavior-generation layer generates control references for each actuator to perform the determined behavior. The behavior-generation layer adjusts parameters of priority of behaviors based on the internal states. This creates lifelike behavior that the user will be able to interpret.

The face tracking module is designed to track the user across a room. The Single Short MultiBox detector(SSD) is trained to detect faces and a control law is implemented to maintain the detected face at the centre of robot's vision field. The emotion recognition framework is implemented to take the sensor(camera, microphone, and tactile) inputs and interpret the emotional state of the robot. The vision based emotion recognised using the mini-Xception network and the

Fig. 2. caption.

audio based emotions obtained from a train DNN network are combined to obtain the emotional state. The complete software architecture and design features of the robot can be found in [4].

III. PILOT EXPERIMENTS

To study the effectiveness of the robot an experiment was conducted. During the experiment, artificial emotions including anger, neutral, happy, fear, amusement, and sadness were simulated and the interaction between the robot and user under different emotions was observed. This was achieved by the participant watching a video for 22mins which was created using the Ravdness and International Affect Picture System data-sets [].

IV. RESULTS

Results of Video analysis - Analysis of the video recorded showed continuous interaction between the subjects and DOT. It was also observed that participants held the robot facing their point of observation for most parts of the experiment. Further, it was noted that the subjects turned the robot to face them at points when they wanted to talk to the robot or were checking on the robot.

Response of Participants to DOT - The participants were excited to meet DOT and greeted it like a friend or a new person during the introduction. The participants interacted with DOT willingly from the beginning, speaking to it, stroking and hugging it. During the study, though they watched a video, the participants continuously held the robot on their lap and kept stroking or patting.

V. FUTURE WORK AND CONCLUSION

In our research work, we seek to explore the use of social robots for early detection of mental illnesses and provide artificial emotional support. To this effect, a social robot was designed and a haptic, visual and audio based emotion recognition, and reactive responses were implemented. Further, in investigating how to provide artificial emotional support, a proactive nonverbal behavior set has been developed and experimented though a pilot study. This work informs future research on the design of robots and motivates the integration of social robots for early detection of mental illnesses. In the future, we aim to conduct field deployment of robots in hospitals and individual homes to understand how people with mental conditions live in their natural environments and how robots might be integrated. Such inclusion of field studies will bridge the gap between controlled laboratories and real-world environments.

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