Demo Abstract: AI Therapist for Daily Functioning Assessment and Intervention using Smart Home Devices

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ABSTRACT

In this demonstration, in collaboration with licensed therapists, we introduce an *AI therapist* that takes advantage of the smart-home environment to screen day-to-day functioning and infer mental wellness of an occupant. Our system can assess a user's daily functioning and mental wellness based on a combination of direct conversation with users and information obtained from smart home devices using psychological rubrics proposed in [1]. We demonstrate that our system can converse with a user in a natural way (through a smartphone or smart speaker) and analyze a user's response semantically and sentimentally. In addition, we show that our system can provide preliminary interventions to help improve the user's wellness. In particular, when abnormal behavior is detected during the conversation or by smart home devices, the system provides psychotherapeutic consolations during the conversation and will check on the occupant's condition by actuating a home robot.

CCS CONCEPTS

• **Computer systems organization** → **Sensor networks**; **Sensors and actuators**.

KEYWORDS

smart homes, mental health, edge computing, artificial intelligence

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1 INTRODUCTION

The COVID-19 pandemic made in-person therapist/doctor visits challenging and caused a global mental health crisis. Additionally, there are currently more than 300 million one-person households worldwide, and this number is continuing to grow. Researchers find routine monitoring to be helpful in mental health management and interventions. It has been suggested that there is a high correlation between mental health and daily functioning, suggesting that people with mental health adjustment issues in general have more challenges and limitations in their day-to-day functioning.

There are various evidence-based treatments that practitioners and therapists use, such as motivational interviewing (MI), dialectical behavior therapy (DBT), and cognitive behavioral therapy (CBT) [2]. As these treatments usually require open-ended responses from the user, they are conducted mainly during in-person visits. There is a lack of research focusing on providing psychological interventions or treatments through intelligent devices.

Smart devices can help people monitor and take care of their physical and mental health status [3–5]. Few studies have looked into environment-based and non-invasive assessments of daily functioning to evaluate the health of occupants. Leveraging existing smart home devices is a desirable solution to track the daily functioning and mental state of people living alone or suffering from particular mental health disorders. We propose an *AI therapist* for smart home environments to provide 24/7 daily functioning and mental status screening and precautionary interventions in one-person households. Our solution does not require the user to wear anything to avoid discomfort. In this work, we leverage the 37 dimensions introduced in [1] to screen day-to-day functioning and infer mental health status.

This system uses low-cost smart home devices to 1) assess a user's daily functioning and mental well-being and 2) provide precautionary interventions at home. To assess the user based on the 37 dimensions, our *AI therapist* primarily leverages privacy-aware sensors with lower fidelity and novel data-driven natural language processing (NLP) methods to "chat" like a therapist with the user through Alexa devices and smartphones. During the conversation, when *AI therapist* believes that the user needs further attention, it performs psychotherapeutic consolations. We propose a privacy-aware 2D LiDAR and camera-based architecture to localize the user in a single-person household to interact with and check on the user when any problematic behavior is detected through conversation or by smart home devices. *AI therapist* adjusts the smart home settings (e.g., lighting color) according to the screening results and reaches out to related personnel in an emergency. We introduce a recommender system based on reinforcement learning (RL) to learn from a user's responses and personalize the conversation and intervention strategies. We envision our system to be compatible with common sensors and home devices.

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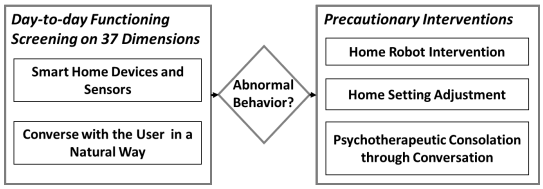

Figure 1: The system architecture of the proposed *AI therapist*, which supports two main functionalities realized using five interconnected modules.

2 SYSTEM ARCHITECTURE

Figure 1 shows the architecture of the proposed *AI therapist*, which aims to realize two functionalities: (1) screen day-to-day functioning on the 37 dimensions, including items such as healthcare practices and communication, proposed in [1], and (2) provide precautionary interventions. Five modules are included to achieve the two functionalities.

The proposed system leverages *Smart Home Devices and Sensors*, such as commercial-off-the-shelf (COTS) devices and common ambient environment sensors (e.g., particulate matter and alcohol sensors), to detect and monitor daily activities that correspond to the 37 dimensions. Our system prioritizes using more privacy-aware sensors unless specified by users.

Our *AI therapist* can *Converse with the User in a Natural Way* and evaluates users based on the 37 dimensions. Unlike traditional paper/web-based surveys and questionnaires, our system takes advantage of smart speakers (e.g., Amazon Echo) and smartphones to "talk and chat" with the user in a more human-like way with open-ended questions. The user can respond freely with open-ended responses. The *AI therapist* will collaborate with smart home sensors to evaluate the 37 dimensions. An RL-based recommender system is used to learn the user's preferences and generate conversations to make it more preferable.

The system implements preliminary interventions if any abnormal behavior is detected after sensing daily activities and conversing with the user. The interventions include: 1) *Home Robot Intervention* to check on the user; 2) helping the user feel better by *Home Setting Adjustment* (e.g., adjusting the light color); and 3) provide *Psychotherapeutic Consolation through Conversation* to help the user cope. *AI therapist* also notifies family members, healthcare providers, and other personnel during emergencies. The intervention policy will be generated according to the historical assessment results and the available smart devices in the user's home. Figure 2 shows: (1) smartphone App interface for conversation and psychotherapeutic consolation, (2) the example smart home sensor and devices to detect daily activities and screen day-to-day functioning, and (3) home robot to interact and check on the user.

3 DEMONSTRATION DESCRIPTION

In this demonstration, we will show the proposed system in a smart home environment from three aspects:

Sensor-based Daily Activity Assessment: We will show five activities that can be sensed by our system: (1) detecting significant weight changes using weight sensors embedded in couch cushions; (2) sensing particles in the air to determine whether the user is smoking or drinking; (3) checking the personal hygiene of the user by ambient environment sensors; (4) sleeping quality evaluation

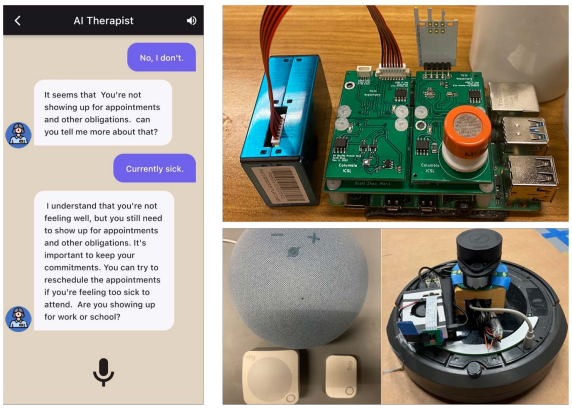

Figure 2: The smartphone App interface for conversation (left), and example smart home sensors, COTS smart home devices (e.g., Amazon Echo), and the home robot (right).

and exercise monitoring using inertial measurement units (IMUs); and (5) monitoring user mobility using contact and motion sensors.

Conversation-based Screening: We will demonstrate how our system can converse with users in a natural way through Amazon Echo and a smartphone platform. In particular, the developed *AI therapist* responds and asks follow-up questions when necessary, and can also understand open-ended responses from the users and give scores to the 37 dimensions.

Precautionary Interventions: With the scores from the screening, we will demonstrate that our system can: (1) intervene/"talk" to the user if abnormal activities are sensed; (2) drive a robotic vacuum machine to check on the user, which will use lidar to localize and a camera to analyze the user; and (3) adjust the lighting accordingly when the user does not feel well.

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