Specific Aims

Significance. Alzheimer's disease and related dementias (ADRD) remain a major and growing public health burden, and the disease's multifactorial biology continues to outpace the impact of available therapies[1]. Current U.S. Food and Drug Administration-approved symptomatic treatments offer modest benefits, while newer disease-modifying anti-amyloid immunotherapies are limited to biomarker-confirmed early Alzheimer's disease and are accompanied by restricted patient eligibility and significant treatment burden with cost-effectiveness concerns[2]. Thus, it is important to develop accessible and affordable prevention strategies early in the disease course.

Critical Barriers. Limited social interaction is a recognized, modifiable risk factor for cognitive decline in older adults[3–8]. For example, cognitively stimulating interactions with diverse social groups can maintain cognitive function, more than emotional bonding[9]. The recent clinical trial (I-CONECT; NCT02871921) showed that **frequent social interactions via semi-structured conversational engagement aimed to provide cognitive stimulation** can mitigate cognitive decline among older adults with limited social interaction and mild cognitive impairment (MCI) or normal cognition[10]. Yet, *such interventions are constrained by workforce availability and high cost*, rendering a persistent barrier to broad dissemination. In response to this challenge, conversational AI has the potential to provide scalable conversational engagement and enhance cognitive reserve; however, most existing AI systems[11] have not encoded essential scientific methods for dementia prevention. In our preliminary study (AI-CONECT)[12], we showed that Large Language Models (LLMs) can be customized to follow the I-CONECT protocol in simulated textual conversations. However, compared with human-led conversations, the system remained under-optimized for engaging older adults, including limited interactivity; technical barriers for older adults to operate computers; unverified compliance with I-CONECT protocols and safety; and unvalidated feasibility.

Solutions. To enhance the accessibility and affordability of the I-CONECT intervention, we propose to develop a Conversational AI with Multimodal Interaction (AIMI-CONECT) to simulate human-led conversational engagement (I-CONECT). To address the limitations of prior arts, our specific aims are:

Aim 1: Develop a conversational AI with multimodal interaction (AIMI-CONECT) to execute the I-CONECT intervention. We will use an agentic AI system driven by an LLM to follow the efficacy-proven I-CONECT protocol. (i) *Multimodal interaction* augments user engagement by enabling human-AI collaborative recreation and exploration of 3D reminiscence scenes, voice chat, and visual affective responses[13]. (ii) *Usability*: To reduce barriers for older adults, we will integrate a ready-to-go social robot with a real-time, responsive audio interface that does not require typing or frequent button presses. (iii) *Protocol Compliance*: We will utilize machine learning algorithms to align LLM behavior with the protocol and adopt real-time, in-conversation guardrails to monitor critical situations, including protocol drift, negative affect, and other safety risks.

Aim 2: Conduct a feasibility study to evaluate the AI among 40 older adults (age $\geq$ 75) with limited social interaction and with MCI (n=20) or normal cognition (n=20) and identify areas for refinement. We will recruit participants to use our chatbot and complete brief surveys. Each participant will receive 24 sessions in 6 weeks (4 sessions per week). Each session will be an independent 15-minute conversation with the chatbot. A staff member will complete weekly 10-minute check-in phone calls to assess emotional status, potential risks and technical challenges (if any) in using AI. We will collect both objective data and subjective surveys: recruitment ratio (ratio of contacted to enrolled participants), adherence rate (the proportion of participants who complete $\geq$80% of sessions), user engagement level (participant's word ratio in a conversation), and user satisfaction (Client Satisfaction Questionnaire–8, CSQ-8)[14]. We will also collect surveys to understand participants' concerns and preferences for the different components and security in the system design, to inform future design.

Impact. Our team is highly interdisciplinary, comprising computer scientists, a neurologist, a gerontologist, and a statistician in study design and analytics, all with extensive experience in Alzheimer's disease research. This proposed project is especially timely, addressing the growing demand for complementary alternatives to traditional human-led interventions. If feasible and acceptable, AIMI-CONECT will enable scalable conversational engagement for older adults with limited social interaction and inform future, large-scale studies.