Establishing the Foundations of Emotional Intelligence of Care Companion Robots to Mitigate Agitation among High-Risk Dementia Patients via Empathetic Patient-Robot Interactions

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Project Statement

- In the US, an estimated **6.7M** currently have dementia; a number expected to increase to **13.8M by 2060**.
- Among persons with dementia (PWD), agitation and fall risk is common.
- The onset of agitation is often unpredictable.
- PWD with moderate to severe dementia (P-MSD) are **4-5 times more** likely to fall than older people.
- The forms and the time-variant nature of emotions expressed by PWD are not sufficiently understood.
- Onboard sensing technologies, including cameras and motion sensors can sense the state of the PWD, and support verbal and non-verbal communication with the person.
- Existing social robots lack the emotional intelligence to respond to the person-specific emotional state through an empathic communication.
- Current research fails to address that agitation is associated with dynamically changing emotional disturbances.

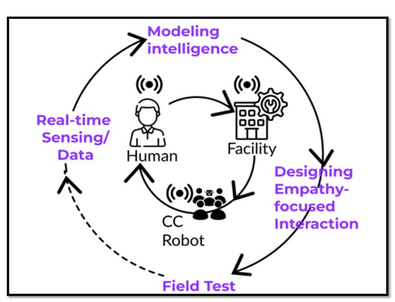
Project Goal

To design and validate a foundational model of emotional intelligence for empathic person-robot interaction that mitigates agitation in PWD.

Design

1. Use computational AI/ML methods to first collect non-invasive data, and develop models to forecast emotional status, agitation level and gait in real-time.

2. Evaluate the empathy-focused conversation model for the CCR in the community, using quasi-experimental and mixed method approaches.



Care Companion Robot

Formative Work

- Community Advisory Board (CAB) discussed the logistics of the study and relevancy of empathy focused conversational models delivered by the CCR.
- The CAB is composed of 6 members: 3 of whom are caregivers of PWD residing in the facilities, and 3 as directors of facilities caring for PWD, and their medical assistants/nurses.
- CAB will meet 3-4 times to help guide CCR observation and modeling; as well as over the 2-year study, every 4-6 months to provide ongoing evaluative feedback on usability and acceptability.
- Setting is Amore Senior Living Facilities located in Orange, Laguna Niguel, and Rancho Mirage; take care of 6 residents per facility.

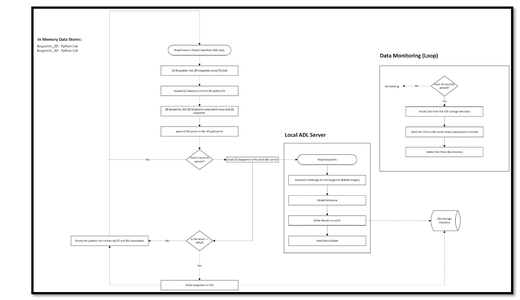
AIM 1

1.1 Collect personal chronological data (**Personicle**) using real-time visual and audio sensing technologies (including the CCR), to understand of PWDs' emotional state, agitation level, and gait over time.

Methods:

1. Using advanced computer vision techniques, monitor walking patterns such as stride length, walking speed, and balance, and identifying deviations that may signal mobility issues or an increased risk of falls.
2. Track 16 unique atomic actions related to ADLs, including aggressive actions (pushing hitting) as well as crucial transitions like sit-to-stand and lie-to-sit, providing caregivers with comprehensive insights into a patient's daily routine and level of independence.
3. Assess real-time movements during high-risk transitions and alerts caregivers when assistance may be needed, helping prevent falls and ensuring patient safety.

Results & Impact: These features for the CCR work together to promote both physical and emotional well-being of the PWD, enabling timely interventions and enhancing caregiver efficiency.



1.2 Collecting Personal Stories (**Persona**), Daily Activity Maps and storyboards: interviews with family and professional caregivers.

Methods:

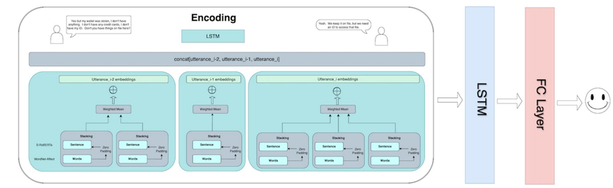
1. Using dementia care experts, design Personas and Daily Activity Maps, and engage stakeholders with domain expertise in dementia, conversational AI, and Design Use to evaluate Personas and augment Design Use Requirement heuristics.
2. The characteristics captured include medical conditions, personal preferences. Cultural aspects, mobility issues, level of dementia, fall risk situations, etc.

Results & Impact: The designed materials would be used by the developers to understand the needs of PWDs.

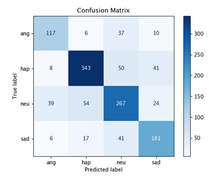
Challenges & Opportunities: The Personas and Daily Activity Maps are in the process of evaluation by domain experts and caregivers. As a new area of science, it is hoped that the team has Engaged the domain experts skilled in adequately capturing the characteristics of PWD. If so, these additions will be an exciting advancement in training.

AIM 2

Pilot an empathy-focused intervention model for the CCR using a quasi-experimental intervention design and evaluate the conversational intervention longitudinally using mixed method approaches.



- **Methods:** We propose a hierarchical model to capture emotional information at the word, sentence, and utterance levels.
- **Dataset**: IEMOCAP with 4 emotion labels (neutral, happy, angry, sad)
- **Hierarchical embeddings**: WordNet-Affect for words and Sentence RoBERTa for sentences, combined into utterance-level vectors using weighted means.
- **Model**: These embeddings are processed by two transformer blocks with self-attention, followed by classification with a feedforward layer.
- **Results & Impact:** We compare our own previous models with the new one. The new model achieves a weighted F1 score of 65.19%, outperforming the word- and utterance-level model (63.58%) and fine-tuned RoBERTa (60.84%). Vanilla RoBERTa scored 31.40%. The new model improves accuracy for "angry" and "happy" predictions, but slightly decreases performance for "neutral."

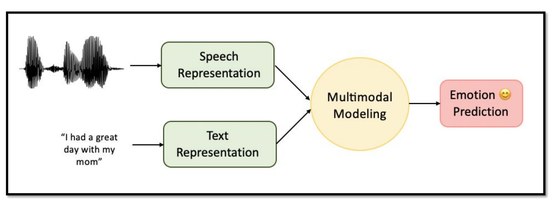


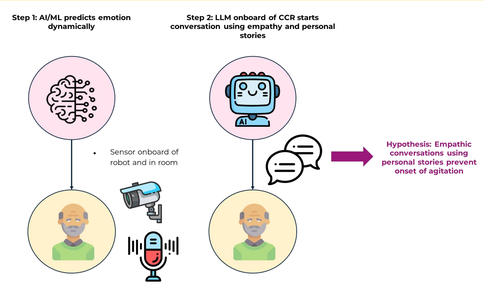
Levels	Weighted F1
{1} RoBERTa	31.40%
{2} EmoRoBERTa	44.35%
{3} BERT	58.70%
{4} Fine-tuned RoBERTa	60.84%
{5} WNA	61.58%
{6} S-RoBERTa	65.19%
{7} WNA, S-RoBERTa	66.69%
{8} WNA, S-RoBERTa, SimpleLSTM	72.14%
{9} **WNA, S-RoBERTa, ContextualLSTM**	**73.25%**

- **Challenges & Opportunities:** While our new model shows promise, the text-only approach is limited. Our next step is to explore the contributions of each modality to build a multimodal model. Additionally, we aim to improve the model by incorporating turn-level context in conversations.

AIM 3

Develop statistical models to understand and forecast a PWDs' emotional state, agitation level and gait in real-time using ML/AI. (using outcomes of Aim 1)





AIM 4

Design an empathy-focused conversation model that considers a PWDs' emotional state and associated events. (Using outcomes of Aims 1 and 2)

Challenges & Opportunities: Testing the CCR in Board & Care facilities in its ability to predict agitation and if recognized, carry on an empathetic conversation is challenging; however if successful, this CCR will be scientifically advancing opportunities for care of PDW to come.

Acknowledgement

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