Establishing Emotional Intelligence in Care Companion Robots for Dementia Patients

Mitigating Agitation through Empathetic Patient-Robot Interactions

Demonstration Session on July 1st, 2025

PEPPERDINE UNIVERSITY

PURDUE UNIVERSITY

naviGAIT

UCI Sue & Bill Gross School of Nursing

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Project Introduction
by Adey

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Research Team Members

Principal Investigators

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Co-Investigators

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Cheonkam Jeong

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The Challenge: Dementia Crisis in the U.S.

6.7M
Current US dementia patients

13.8M
Expected by 2060

4-5X
Higher fall risk

Key Gaps in Current Care:

- Limited understanding of time-variant emotions in dementia patients
- Unclear relationships between emotions, agitation, and falls
- Current robots lack emotional intelligence for empathetic interaction
- Unpredictable agitation onset despite close monitoring

Research Purpose & Innovation

Main Goal

Design and validate a foundational model of emotional intelligence for empathic person-robot interaction that mitigates agitation in P-MSD

Innovation Areas:

- New datasets for computational person-robot interaction
- Design statistical models focused on P-MSD
- Develop empathy-based conversational models using LLMs and linguistic theories

Research Aims

AIM 1: Data Collection

Collect and store real-time visual, audio, and physiological data using Personicle technology to understand P-MSD emotional states, agitation levels, and gait patterns.

AIM 2: AI/ML Modeling

Develop statistical models to understand and forecast emotional states, agitation levels, and gait in real-time using machine learning and artificial intelligence.

AIM 3: Empathy Design

Design an empathy-focused conversation model for successful person-robot intervention, incorporating personal stories and emotional states.

AIM 4: Field Testing

Pilot and evaluate the Care Companion Robot (CCR) in community settings using quasi-experimental design and mixed methods.

Key Technologies

Personicle

Personal chronological data collection system

NaviGAIT

Comprehensive gait analysis technology

AI/ML Models

Emotion & agitation prediction systems

CCR

Care Companion Robot with emotional intelligence

Technical Approach:

- Microsoft Kinect for motion sensing and video recording
- Remote photoplethysmography (rPPG) for physiological data
- Large Language Models (LLMs) for empathetic conversations
- Multimodal emotion recognition using speech, text, and video

Research Design & Methods

Data Collection (Aim 1)

- Real-time sensing with RGB cameras and voice recording
- Personal story collection through caregiver interviews
- Brief observation period for 2 P-MSD at a time

Modeling Approach (Aim 2)

- Multimodal emotion recognition model
- Objective agitation measurement modeling
- Comprehensive gait evaluation systems

Empathy Design (Aim 3)

- LLM alignment for empathetic conversations
- Personal knowledge graph integration
- User interface design with speech and text display

Study Setting & Participants

Location:

Residential Facilities

- Orange, California

Participant Criteria:

Inclusion:

- Board & Care facility residents
- Diagnosed with dementia
- Age 40 and older
- English speaking
- Consent from self or guardian

Exclusion:

- Severe medical conditions

Impact & Deliverables

Key Deliverables:

- P-MSD behavioral database
- Predictive models for emotions/agitation/gait
- Empathetic conversation system
- Validated CCR prototype

Expected Impact:

- Reduced agitation episodes
- Decreased fall risk
- Improved quality of life
- New paradigm for care robots

Community Advisory Board:

12 members providing ongoing feedback

Stations and Robot
by Mahyar

UC Irvine

Stations and Robot

Project Introduction

Camera Stations

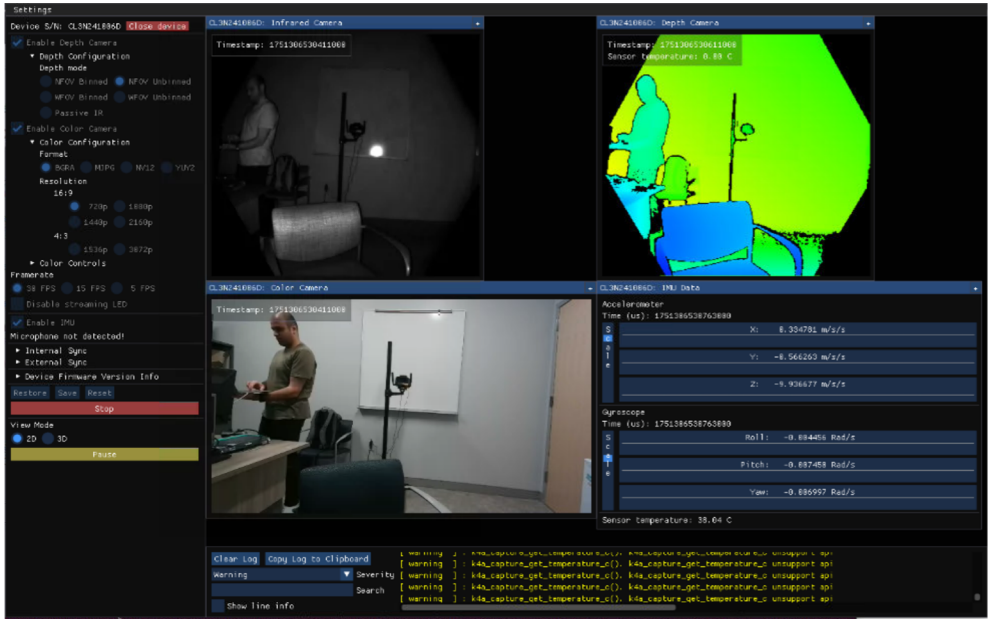
- Passive Data Collection and Recording
- Transition detection
- Agitation transitions

Robot Demo

- Navigation

Introduction - Recording Station

- Passive Data Collection and Recording
- Transition detection
- Agitation transitions



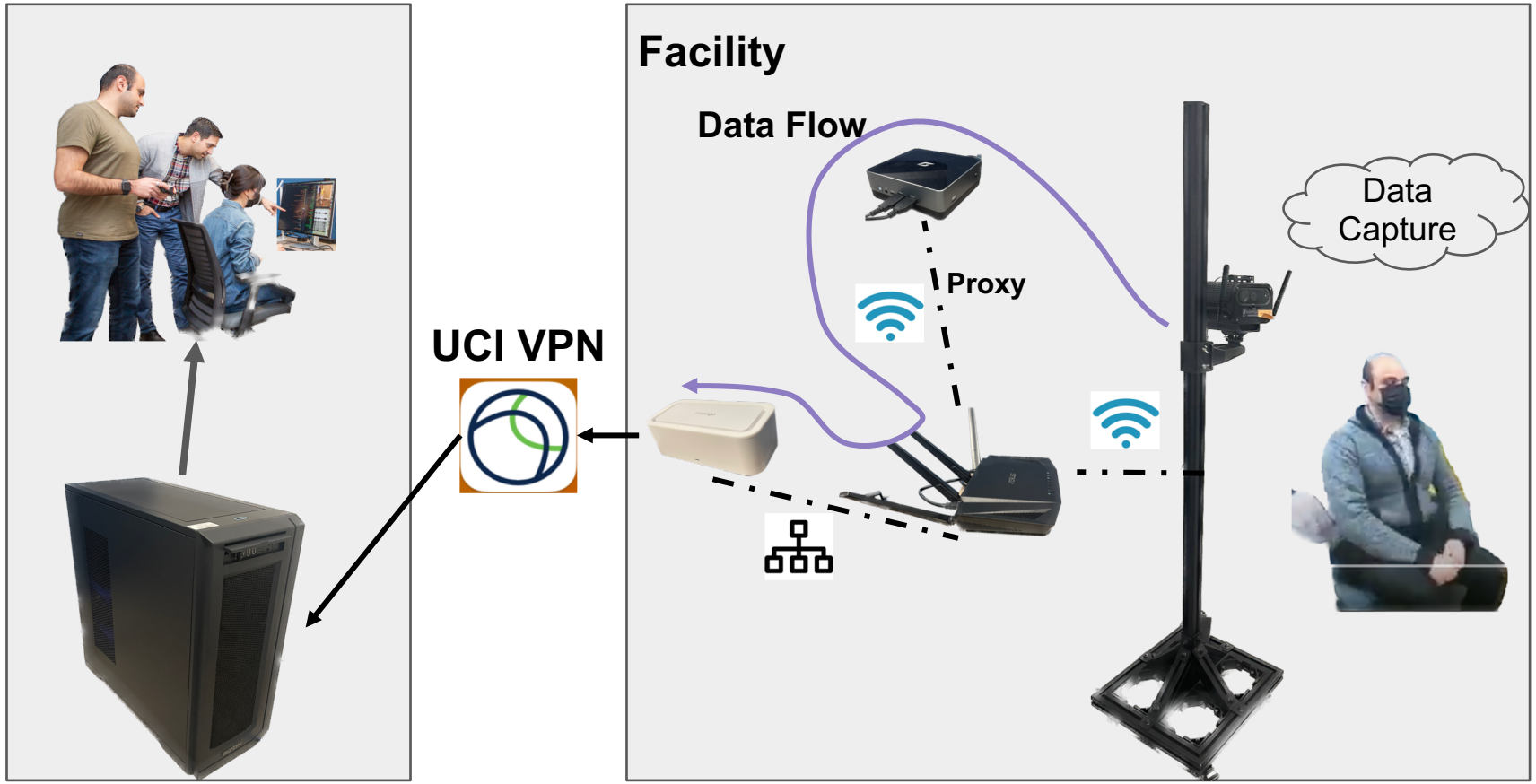
Introduction - Robot

- Empathetic Care Companion Robot
- Features
  - Smart navigation
  - Video-audio recording
  - Empathetic conversation
- Detect Agitation from sound, movements, facial expressions

Introduction - Facility

Passive Data Collection and Recording

- UCI students to train model for transitions
- Ready to be deployed on the facilities for passive observation and data collection so we can test our trained models and learn from their behaviour
- Steps:
  - Detecting a person
  - Records for 5 minutes
  - Sends the data to the server
  - Researchers have access to data in a secure way
  - Repeat
  - Types of data: audio, point cloud, and image


Facility
Data Flow
Data Capture
Proxy
UCI VPN

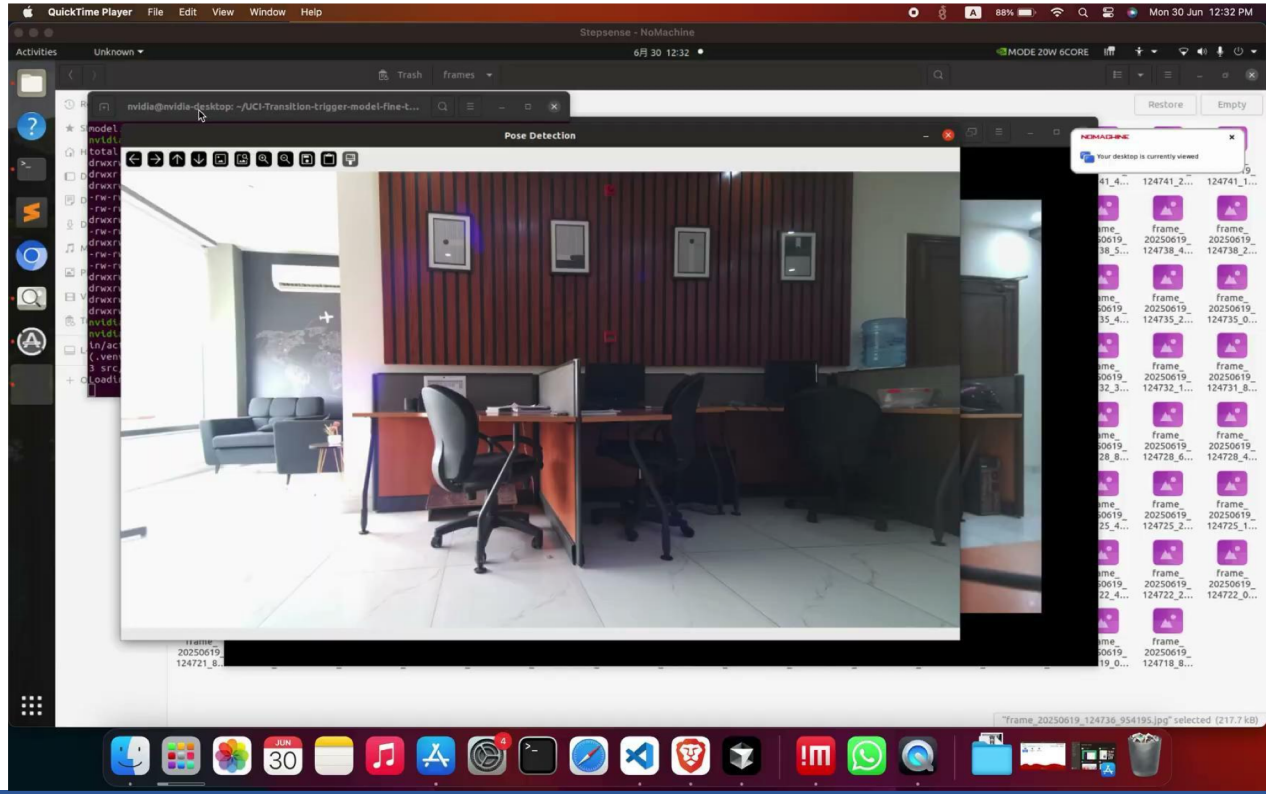
Transitions

Class Name	Dataset	Class
Sit	Custom	Atomic Action
Stand	Custom	Atomic Action
Lie	Custom	Atomic Action
Walk	Custom	Atomic Action
Standing Up	NTU-60	Transition
Sitting Down	NTU-60	Transition
Sit to Lie	Custom	Transition
Lie to Sit	Custom	Transition
Eating Something	NTU-60	Other
Drinking Something	NTU-60	Other
Punching / Slapping Someone	NTU-60	Agitation Marker
Kicking a Person	NTU-60	Agitation Marker
Kicking Something	NTU-60	Agitation Marker
Pushing a Person	NTU-60	Agitation Marker
Throwing Something	NTU-60	Agitation Marker
Falling	NTU-60	Other

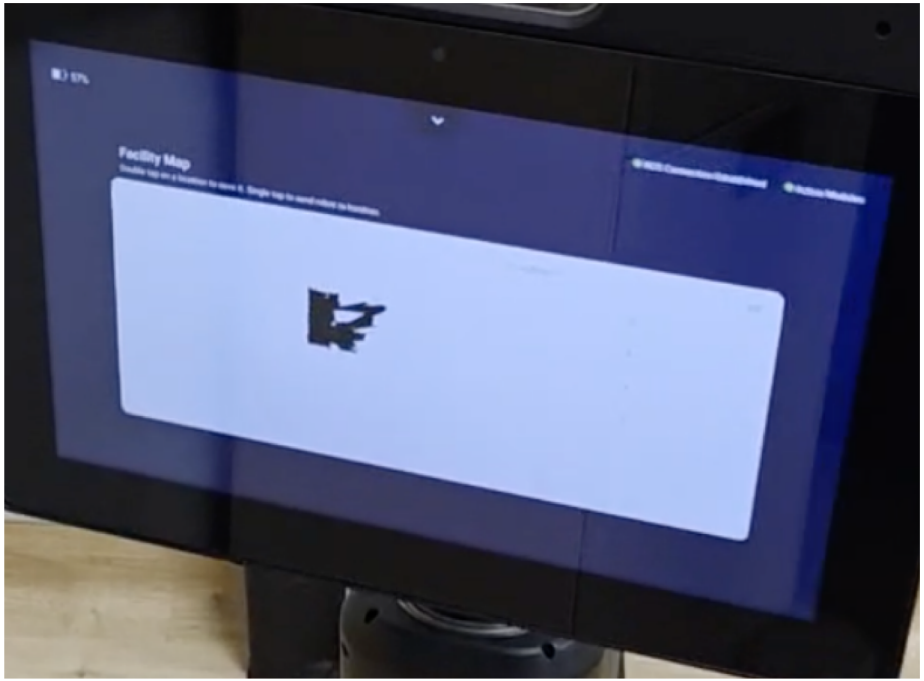

EXIT
drive

Passive Data Collection and Recording

- Angle of Camera matters
- Trained on the same level as the robot view



Care Companion Robot



Care Companion Robot Navigation

Emotion-Aware Empathetic Assistant
By Cheonkam

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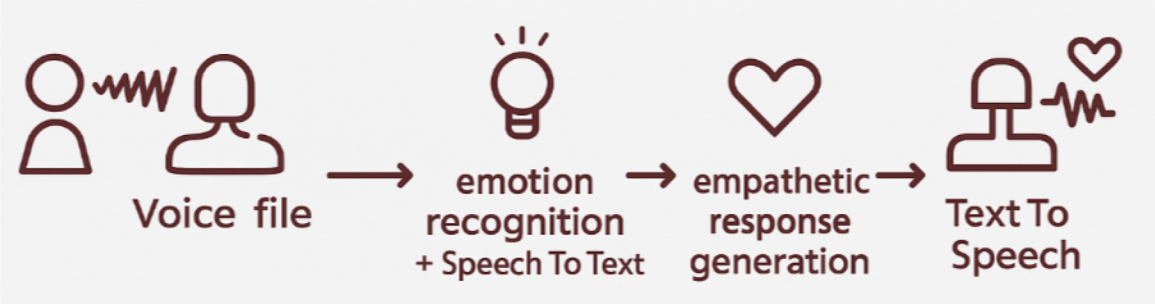
PEVAS - Persona-based Empathetic Voice Assistant System



Persona-Based Dementia Care Conversation Generation

- **Goal**: Generate realistic therapeutic conversations between dementia patients and caregivers
- **Approach**: Leverage detailed personas and clinical scenarios for authentic dialogue
- **Output**: Multi-turn emotion-aware conversations incorporating linguistic and paralinguistic features from patient personas
- **Application**: Training dataset for AI-assisted dementia care

Scenario Example: Bell-Ringing Agitation Scenario from Adey

Perry is an 80 year old male who is in a board and care facility. He seems to be agitated when the caregiver is not in the room, regardless if he has the TV on or was just fed, or bathed. He then starts ringing the bell excessively. When Jeremy, the nurses aid arrives at Perry's door, Perry looks up and says, "Oh, I don't know. I don't remember ringing the bell. And now that you're here, hi. How are you?". Perry just wanted to engage in conversation; he loved talking about what he did as a soldier in the military. He stated, "I was an engineer." Jeremy would then open up the conversation and say, "tell me a little bit about your job; did you really like doing that?" Would you have done anything else? Perry would respond, "Oh, yes, I really enjoyed it". Jeremy would continue to ask him questions such as, "Do you still want that Cadillac you've been telling me about? Perry would respond, "I sure do. I'm looking for it.". Perry was totally lost interest in pushing the button. The frustration pulling away. He then lied back down in the bed. No more sitting up and angry. He just wanted conversation about himself

```
Example pattern:
Patient: "Help! Where am I?"
Caregiver: [Uses persona-specific calming strategy]
Patient: [Response based on dementia severity]
```

Extracting Information from Personas

Category	Extracted Data	Application
Demographics	age, gender	voice pitch/tone
Dementia level	mild/moderate/severe	conversation complexity
Personality	past/current traits	emotional patterns
Interests	hobbies, career	redirection topics
Behaviors	triggers, responses	scenario design
What makes happy	son visits, music	calming strategies

Persona-Based Voice Generation

Rachel (Severe Dementia)

- Conversational ability: Very difficult
- Voice characteristics: Fragmented speech, high anxiety
- Implementation: `pitch: +15Hz when distressed`, `<break time="500ms"/>` for confusion

Jolene (Moderate Dementia)

- Conversational ability: Monotone, expressionless
- Voice characteristics: Flat affect, slow speech
- Implementation: `style: "sad"`, `pitch: -20Hz`, `rate: -25%`

Ralph (Significant Dementia)

- Conversational ability: Appears conversational but confused
- Voice characteristics: Normal pace with occasional confusion
- Implementation: `Add "uh" hesitations`, `pitch variations for uncertainty`

Model Deployment on the Robot
by Mahyar/NaviGAIT/AI-ML Team

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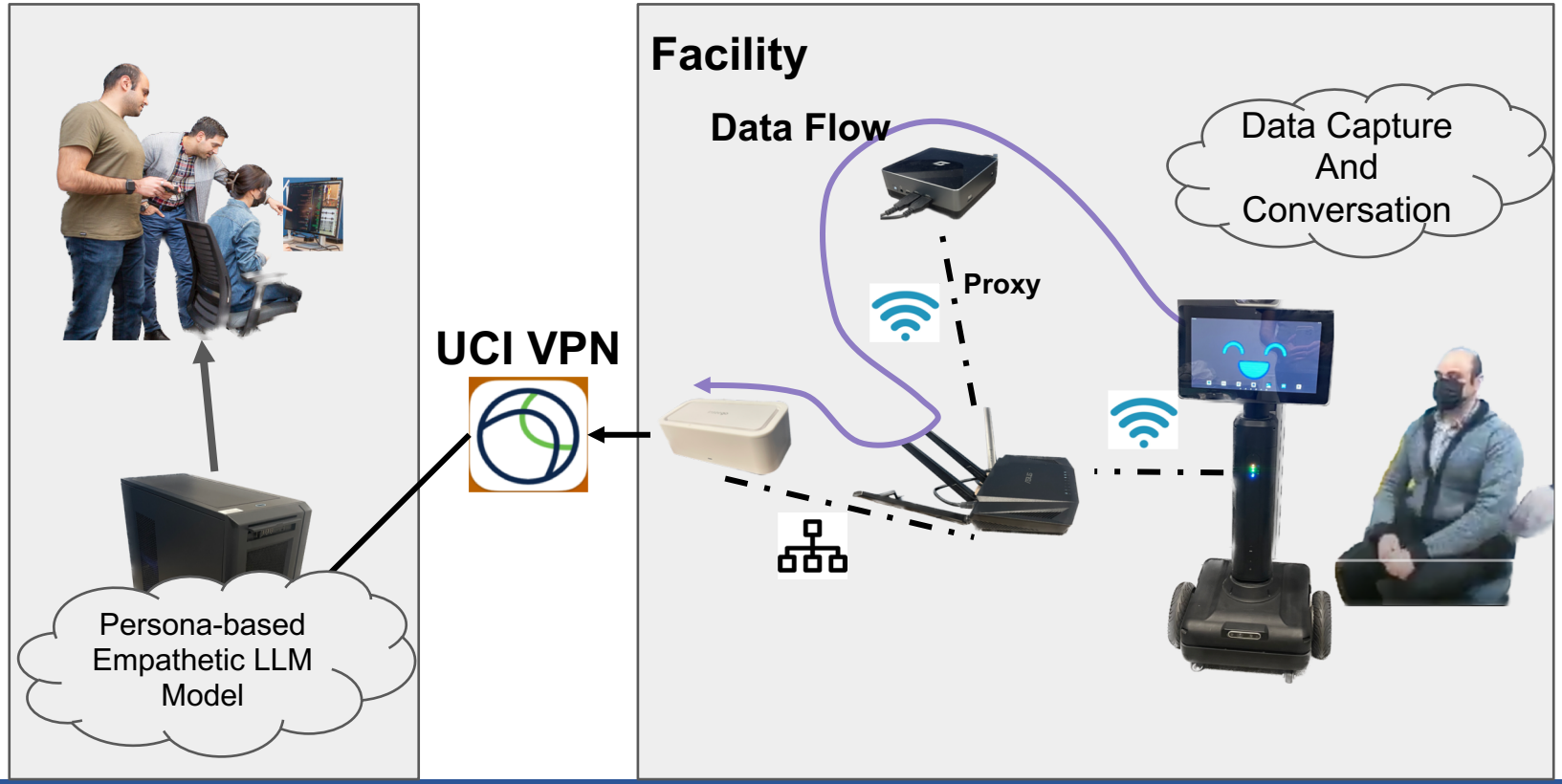
Data Flow


Facility
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And
Conversation
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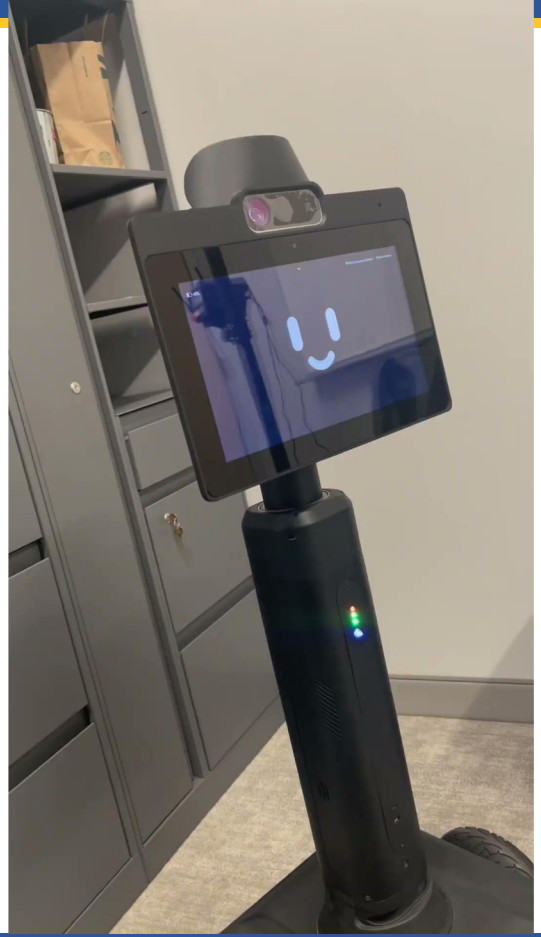
UCI VPN
Persona-based
Empathetic LLM
Model

Demo



What is next?

- Record in facilities to get more detailed understanding of the scenarios and what we should keep in consideration
- Train our models on the recorded dataset for transitions to improve their accuracy and add new transitions if needed
- Identify clear role and scenario for CCR after recordings
    - How to navigate?
    - When to intervene?
    - How much latency is accepted?
- Design a better conversation algorithm for when to listen to the person and when start talking
- Improve network related response delay for CCR
- What do we want to show to the patient on the CCR screen? An avatar? Images they relate to?

What is next? (Continued)

- **Expand multimodal emotion recognition -** Integrate acoustic features with current text-based emotion recognition system
- **Fine-tune LLM on empathy datasets -** Use Reinforcement Learning with Symbolic/Human Feedback for more human-like empathetic responses
- **Create synthetic multi-turn conversation data -** Generate and validate multi-turn conversational data between patients and caregivers by leveraging personas and scenarios
- **Enhance voice with Coqui TTS fine-tuning -** Train specialized therapeutic speaking styles and emotional prosody beyond current Azure prompt engineering approach
- **Integrate knowledge graph RAG -** Build healthcare/therapy knowledge graph and implement Retrieval-Augmented Generation to improve factual accuracy and domain-specific reasoning

Discussion and Q & A

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Thank you so much!

If you need any comment and questions, please feel free to contact us (cheonkaj@hs.uci.edu)

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