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DEMENTIA-PLAN: An Agent-Based Framework for Multi-Knowledge Graph Retrieval-Augmented Generation in Dementia Care

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Introduction

Individuals with dementia primarily experience two critical symptoms:

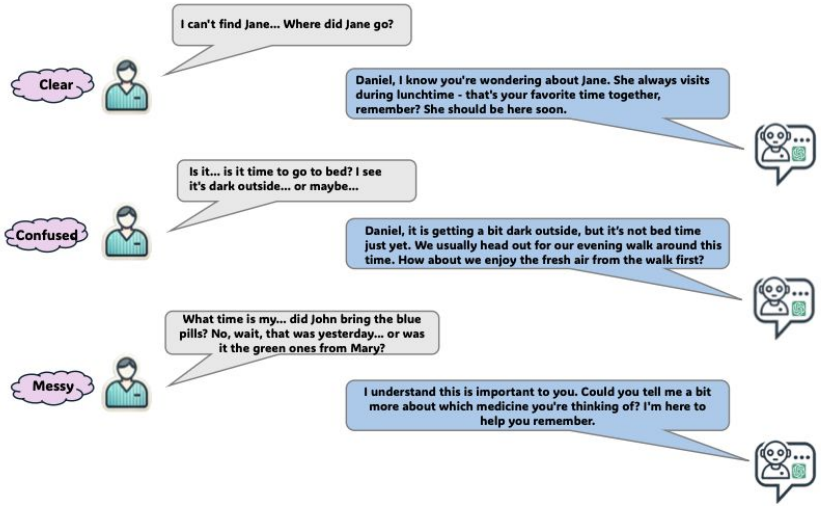
- Severe memory loss
- emotional instability

Memory loss causes patients to forget recent events, familiar faces, and daily routines, while emotional instability can lead to sudden agitation, anxiety, and confusion in hospital environments

Could LLM help with this problem in hospital caring setting?

Could LLM act as the caregiver and response with empathy?

Dialogue patterns and examples



Confusion Type	Example
Confuse Past and Present Events	"Did Tom come by earlier? I thought I heard him talking in the kitchen."
Misremember Scheduled Activities	"Don't we have the gardening club this morning? I should get my gloves ready."
Reference Non-Existent Appointments	"Will Sarah visit this afternoon? She usually comes around this time, doesn't she?"
Confusion About current dates	"Isn't it Christmas soon? I need to get the decorations out."
Reference Incorrect Location/Context	"Where are we right now? This doesn't look like my house."
Repeat Questions	"When is lunch? Did you say it's at 12? Or is it later?"
Confusion About Life Stage	"I have to prepare for school tomorrow. Have we packed my bag yet?"
Incomplete or Vague Statements	"That man... um... he said he would come today, didn't he?"
Environmental Confusion	"This garden feels familiar. Did we plant these flowers together last year?"

Table 1: Types of Confusion and Examples

Our Goal:

- Use LLM to act dementia patients in different dialogue scenarios (single turn in this work).
- Use LLM to act/react as the caregiver and help patients in comfortable way.

Knowledge graph Design

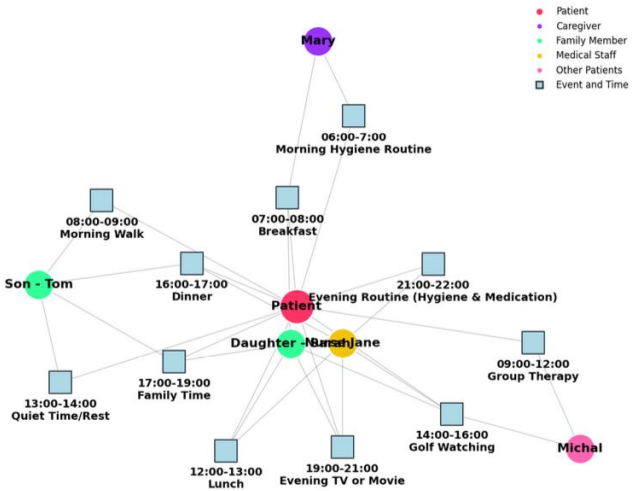


Figure 3: Daily routine KG of a patient

We everage two specialized KGs:

- a daily routine graph that maintains information about the patient's schedules and regular activities
- a life memory graph that preserves significant life memories and personal history.

Daily routine graphs focus on care patterns through person nodes (patients and caregivers) and activity nodes (medications, meals, therapy ses-
sions), linked by edges indicating participation types ('participates', 'supervises'). Activity nodes include time slots,locations, and descriptions.

Framework

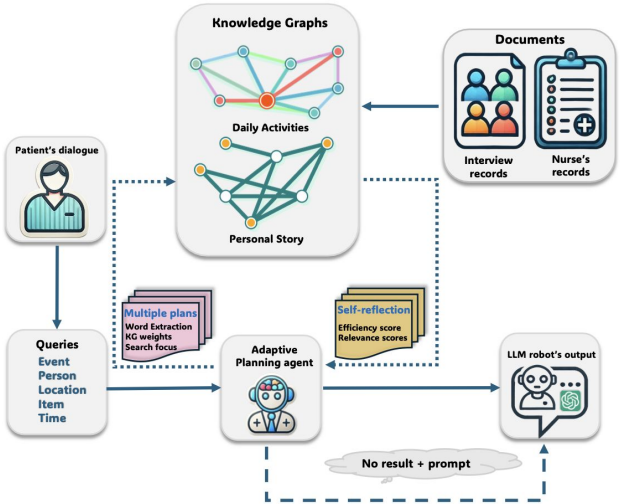


Figure 2: DEMENTIA-PLAN framework

Knowledge Graph Architecture:

- Uses two complementary knowledge graphs (KGs): Daily Routine KG and Memory KG
- Daily Routine KG focuses on immediate, time-sensitive activities
- Memory KG contains social connections and broader patient information

Processing Steps:

- **Decomposition:** Analyzes dialogue and breaks queries into semantic components (person, location, item, event)
- **Search Planning:** Searches both KGs with adaptive weighting based on relevance
- **Evaluation Feedback:** Uses a dual-scoring mechanism to evaluate retrieved information
- **Adaptive Learning:** Refines search strategy when efficiency scores fall below threshold

Response Generation:

- Continues search process until sufficient information is found or maximum attempts are reached
- Can generate follow-up prompts to gather more specific information if needed

Results

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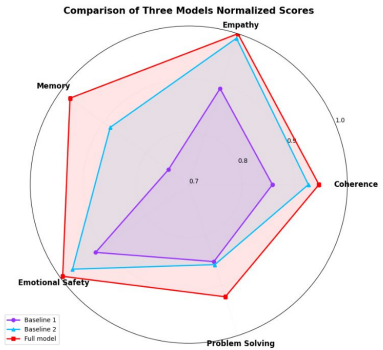
	Routine KG	Memory KG	Planning Agent	Coherence	Empathy	Memory	Safety	Problem Solving
Baseline 1	✓	×	×	8.12	7.56	6.03	8.71	7.95
Baseline 2	✓	✓	×	8.76	8.40	7.12	9.22	8.01
Full	✓	✓	✓	8.95	8.48	7.88	9.44	8.60
Gold	-	-	-	9.46	8.48	8.06	9.49	9.32



Gold Standard: Human caregiver responses serving as he performance benchmark.

Coherence: The model's ability to maintain clear, logical communication—adapting to topic changes and keeping conversations understandable despite patient confusion.

Empathy: How well the model understands emotions, shows patience with repeated questions, and maintains a warm, understanding tone.

Memory Support: Effectiveness in helping with daily memory tasks, recognizing individual memory patterns, and providing gentle reminders for important activities.

Emotional Safety: Ability to create a secure conversation environment by avoiding sensitive topics, navigating around potential triggers, and offering reassurance during confusion without dismissing patient experiences.

Problem Solving: Capability to provide clear step-by-step guidance for daily activities, offer practical solutions to common challenges, and adapt support to individual needs.

Discussion and Future Work

1. Extend our work to multi-turn reposense dialogue system.
2. Build up a dynamic KG based on the patient's dialogue/recognition and deal with the conflict among data retrieval from different data resources.
3. LLM agent to simulate the patient's life and introduce more roles in.

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Thank for listening!

Any suggestions are welcomed!