

An Adaptive Software Framework for Dementia-care Robots

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Content

The Problem

Our System

User Study

Conclusions

The Problem

How to better take care of people with dementia?

- Health
- Safe behavior
- ...

Family member experience **care burden**

Or

\$50,000 / year for a home health aide

\$100,000 / year for a 1bd nursing home



The Problem

How to better take care of people with dementia?

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- Can robot and current available technologies help?
- How to let lay users easily customize the robot?

Content

The Problem

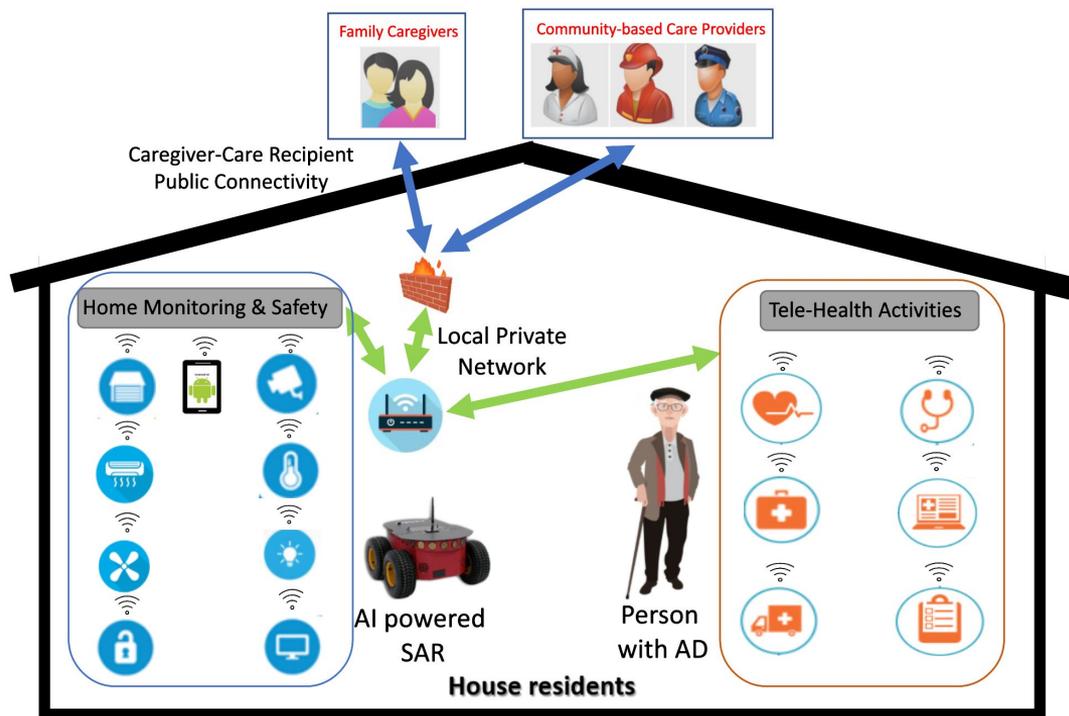
Our System

- **Smart Home Design**
- **The Robot**
- **The AI Planner**

User Study

Conclusions

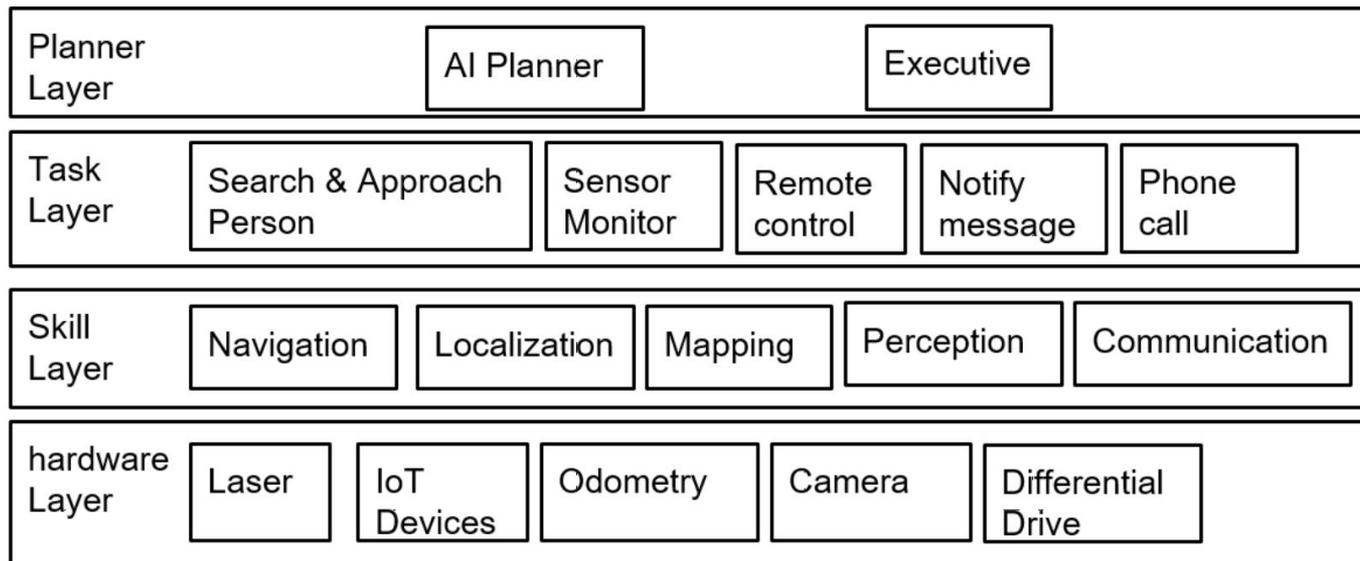
Our System - Smart Home Design



Our System - The Robot



Our System - The ROS Framework



Our System - The AI Planner

ROSPlan:

- PDDL
- Interfaces available for many planners
- Easy to use (no PDDL expert in the team)

We use:

- PDDL 2.1
- Contingent-FF

Our System - The AI Planner

- For each care-protocol, baseline PDDL are designed by clinician and roboticist together
- The lay user (caregivers) can customize the PDDL by filling the questionnaire forms
- Customized PDDL are used for the planner to find customized plan

Our System - The AI Planner - An Example

```
:: search and approach person success branch
(:action search_and_approach_person_success
  :observe (person_is_approached)
)

:: search and approach person fail branch
(:action search_and_approach_person_fail
  :observe (person_is_not_approached)
)

:: Notify message if person is approached
(:action notify
  :parameters (?msg - message)
  :precondition (person_is_approached)
  :effect (and
    (forall (?ss - sensor) (when
      (sensor_after_notified ?ss ?msg)
      (available_to_check_s ?ss)))
    (notified ?msg))
)

:: check if sensor ss is on
(:action check_sensor_on
  :parameters (?ss - sensor)
  :precondition (available_to_check_s ?ss)
  :observe (is_on ?ss)
)

:: check if sensor ss is off
(:action check_sensor_off
  :parameters (?ss - sensor)
  :precondition (available_to_check_s ?ss)
  :observe (is_off ?ss)
)
```

```
(define (problem task_conditional_medical)
  (:domain shr_contingent)
  (:objects
    door kitchen bedroom home - landmark
    medicine_robot_msg - message
    medicine_phone_msg - phonemessage
    mediciness - sensor
  )
  (:init
    (robot_at home)
    (is_home home)
    (message_at medicine_robot_msg kitchen)
    (phonemessage_about_sensor medicine_phone_msg mediciness)
    (sensor_after_notified mediciness medicine_robot_msg)
    (is_safe_when_on mediciness)
    (unknown (is_on mediciness))
    (unknown (is_off mediciness))
    (oneof
      (is_on mediciness)
      (is_off mediciness)
    )
    (is_not_safe)
  )
  (:goal (is_safe)
  )
)
```

Content

The Problem

Our System

User Study

- **The Focus Group**
- **Care-protocols**
- **Customized Plan**

Conclusions

User Study - The Focus Group

Characteristics	Informal Caregivers							
	1	2	3	4	5	6	7	8
Relation	Wife	Wife	Daughter	Wife	Husband	Daughter	Wife	Husband
Care recipient's age	78	88	98	59	72	84	69	80
Care recipient's disease stage	Late	Middle	Early	Middle	Early	Middle	Middle	Late
Employed	No	No	No	Full time	Part time	Full time	No	No
Living with care recipient	Yes	Yes	No	Yes	Yes	No	Yes	No

User Study - Two Example Care-protocols

- Medication reminder
- Preventing from wandering out

User Study - Questionnaire

Questionnaire 3: Programming an Alerting Protocol

To Prevent Wandering

This form is to demonstrate how you can set up an alerting protocol for the robot to prevent your family member from wandering outside.

Please fill in the information below

To prevent your family member from stepping out

1. What time duration should your family member not go out?
From: _____ To: _____
2. Who is the person I should call if your family member does not come back after the reminder?
Name: _____
Phone: _____
3. Should the robot call emergency personnel too?
 Yes
 No
4. If yes, how soon after the family member does not come back? _____ minutes
5. If your family member is not back, what is the likely place the emergency personnel need to look for?
6. Is there anyone else you want the robot to call? What is the phone number?
Name: _____
Phone: _____

Questionnaire 2: Programming a Reminder Protocol

Medication Intake

This form is to demonstrate how you can set up a reminder protocol for the robot to help manage your family member's medication.

Please fill in the information below

For medication intake

1. What time do you want your family member to take his or her medications?

 2. Where is the medication bottle kept? e.g. kitchen table

 3. Will the medication bottle get moved from where it is kept usually?
 Yes
 No
 4. What should the robot do if your family member cannot find the medication?
 Locate the medication in the house and
 Remind your family member or
 Call you
- OR
- Call you
 5. How many times you want the robot to remind your family member before calling you and asking you to communicate with the family member?
_____ times every _____ minutes

User Study - Questionnaire

Questionnaire 3: Programming an Alerting Protocol

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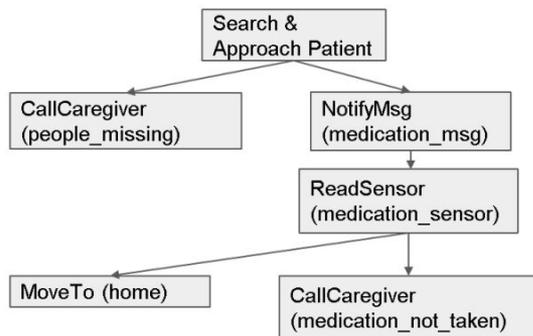
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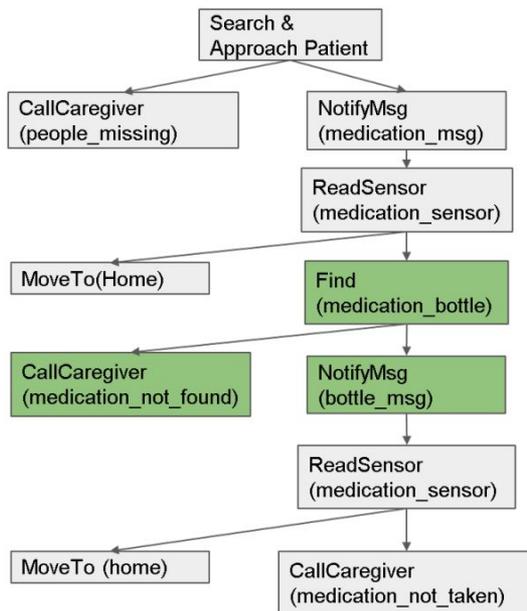
User Study - Wildcard PDDL Template and Instance

```
-----  
(:types  
  object  
  as_object  
  af_object  
)  
  
(:predicates  
  (ACTION_OBJECT_AVAIL ?ob - object)  
  (ACTION_OBJECT_FAIL ?ob - object)  
  (ACTION_OBJECT_SUCC ?ob - object)  
  
  (AS_ACTION_OBJECT_AVAIL ?ob - as_object)  
  (AF_ACTION_OBJECT_AVAIL ?ob - af_object)  
)  
  
;; Do action and check result success  
(:action ACTION_success  
  :parameters (?ob - object)  
  :precondition (ACTION_OBJECT_AVAIL ?ob)  
  :observe (ACTION_OBJECT_SUCC ?ob)  
)  
  
;; Do action and check result fail  
(:action ACTION_fail  
  :parameters (?ob - object)  
  :precondition (ACTION_OBJECT_AVAIL ?ob)  
  :observe (ACTION_OBJECT_FAIL ?ob)  
)  
  
;; enable AS_ACTION if success  
(:action ENABLE_AS_ACTION  
  :parameters (?ob - object, ?asob - as_object)  
  :precondition (ACTION_OBJECT_SUCC ?ob)  
  :effect (AS_ACTION_OBJECT_AVAIL ?as_ob)  
)  
  
;; enable AF_ACTION if fail  
(:action ENABLE_AF_ACTION  
  :parameters (?ob - object, ?afob - af_object)  
  :precondition (ACTION_OBJECT_FAIL ?ob)  
  :effect (AF_ACTION_OBJECT_AVAIL ?af_ob)  
)  
)  
  
(define (domain shr_contigent_medication_enhanced_instant)  
  (:types  
  )  
  
  (:predicates  
    (available_to_find)  
    (bottle_is_found)  
    (bottle_is_not_found)  
  )  
  
  (:action find_bottle_succ  
    :precondition (available_to_find)  
    :observe (bottle_is_found)  
  )  
  
  (:action find_bottle_fail  
    :precondition (available_to_find)  
    :observe (bottle_is_not_found)  
  )  
  
  (:action notifyBottle  
    :parameters (?msg - message)  
    :precondition (and  
      (bottle_is_found)  
      (msg_about_bottle ?msg))  
    :effect (and  
      (notified ?msg)  
      (forall (?ss - sensor)  
        (available_to_check_s ?ss)))  
  )  
  
  (:action call_caregiver_when_medication_is_not_found  
    :parameters (?msg - phonemessage)  
    :precondition (and  
      (phonemessage_about_bottle ?msg)  
      (bottle_is_not_found))  
    :effect (and  
      (is_safe)  
      (not (is_not_safe)))  
  )  
)
```

User Study - A Result Contingent Plan

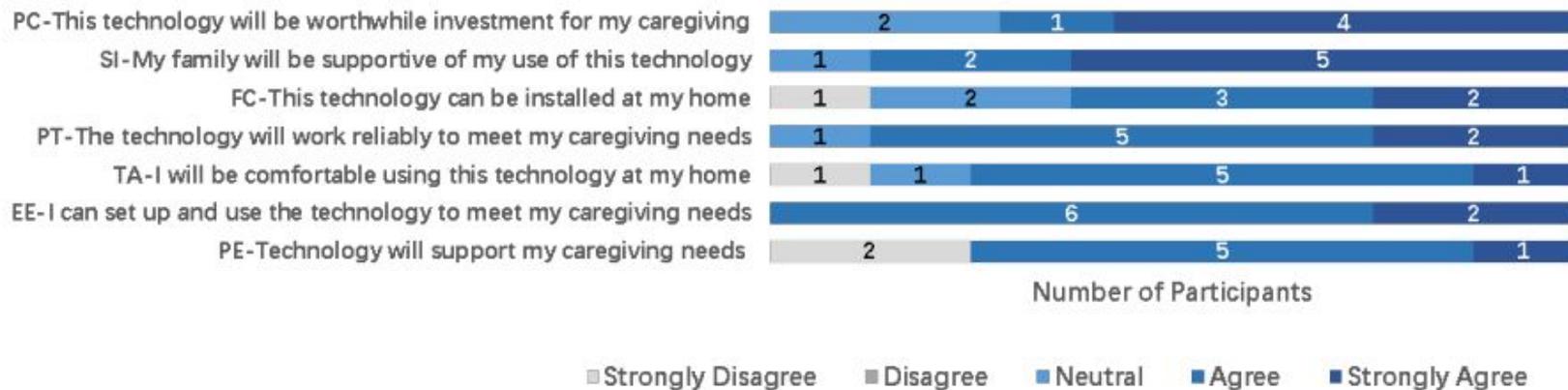


Baseline Plan



Customized Plan

User Study - Response of The Caregivers



Conclusions

- A novel software framework for a dementia-care robot
- User-driven domain customization

More broadly:

- Planning enables **lay user** to deeply customize the robots' behavior in complex HRI setting
- Planning techniques are **easy to use**, very handy for actual world painful problems!

Questions?

