An Adaptive Software Framework for Dementia-care Robots

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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

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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

(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

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<th>5</th>
<th>6</th>
<th>7</th>
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<tbody>
<tr>
<td>Relation</td>
<td>Wife</td>
<td>Wife</td>
<td>Daughter</td>
<td>Wife</td>
<td>Husband</td>
<td>Daughter</td>
<td>Wife</td>
<td>Husband</td>
</tr>
<tr>
<td>Care recipient’s age</td>
<td>78</td>
<td>88</td>
<td>98</td>
<td>59</td>
<td>72</td>
<td>84</td>
<td>69</td>
<td>80</td>
</tr>
<tr>
<td>Care recipient’s disease stage</td>
<td>Late</td>
<td>Middle</td>
<td>Early</td>
<td>Middle</td>
<td>Early</td>
<td>Middle</td>
<td>Middle</td>
<td>Late</td>
</tr>
<tr>
<td>Employed</td>
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<td>Full time</td>
<td>Part time</td>
<td>Full time</td>
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<tr>
<td>Living with care recipient</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>
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

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OR

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User Study - Wildcard PDDL Template and Instance

```prolog
(:types
  object
  as_object
  af_object)
(:predicates
  (ACTION_OBJECT_AVAIL ?ob - object)
  (ACTION_OBJECT_FAIL ?ob - object)
  (ACTION_OBJECT_SUC ?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_SUC ?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_SUC ?ob)
  :effect (AS_ACTION_OBJECT_AVAIL ?asob)
)

;; 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 ?afob)
)
```

```prolog
(define (domain shr_contingent_medication_enhanced_instance)
  (:types
   )
  (:predicates
   (available_to_find)
   (bottle_is_found)
   (bottle_is_not_found)
  )

  (action find_bottle_suc
    :precondition (available_to_find)
    :observe (bottle_is_found)
  )

  (action find_bottle_fail
    :precondition (available_to_find)
    :observe (bottle_is_not_found)
  )

  (action notify_bottle
    :parameters (?msg - message)
    :precondition (and
                  (bottle_is_found)
                  (arg_about_bottle ?msg))
    :effect (and
             (notified ?msg)
             (forall (?rs - reason)
                   (available_to_check_s ?rs))
             )
    )

  (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

- CallCaregiver (people_missing)
- NotifyMsg (medication_msg)
- ReadSensor (medication_sensor)
- MoveTo (home)
- CallCaregiver (medication_not_taken)

Customized Plan

- Search & Approach Patient
  - CallCaregiver (people_missing)
  - NotifyMsg (medication_msg)
  - ReadSensor (medication_sensor)
  - MoveTo/Home
  - Find (medication_bottle)
  - CallCaregiver (medication_not_found)
  - NotifyMsg (bottle_msg)
  - ReadSensor (medication_sensor)
  - MoveTo (home)
  - CallCaregiver (medication_not_taken)
User Study - Response of The Caregivers

- **PC** - This technology will be worthwhile investment for my caregiving: 2 Strongly Disagree, 2 Disagree, 5 Neutral, 4 Agree, 4 Strongly Agree
- **SI** - My family will be supportive of my use of this technology: 1 Strongly Disagree, 2 Disagree, 5 Neutral, 2 Agree, 2 Strongly Agree
- **FC** - This technology can be installed at my home: 1 Strongly Disagree, 2 Disagree, 3 Neutral, 2 Agree, 2 Strongly Agree
- **PT** - The technology will work reliably to meet my caregiving needs: 1 Strongly Disagree, 1 Disagree, 5 Neutral, 2 Agree, 2 Strongly Agree
- **TA** - I will be comfortable using this technology at my home: 1 Strongly Disagree, 1 Disagree, 5 Neutral, 2 Agree, 2 Strongly Agree
- **EE** - I can set up and use the technology to meet my caregiving needs: 2 Strongly Disagree, 6 Disagree, 5 Neutral, 2 Agree, 2 Strongly Agree
- **PE** - Technology will support my caregiving needs: 2 Strongly Disagree, 5 Disagree, 5 Neutral, 2 Agree, 1 Strongly Agree
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?