Final Report

Autonomous Software Agents - UniTn 2021/2022
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Introduction [2-3 paragraph]

My house was designed to support residents during daily activities, which are making life more comfortable and saving electricity costs since the electric price was increasing rapidly. The house has two floors, the ground floor was designed for social interaction, while the first floor was designed for resting activities.

The house was equipped with two agents. The first agent, **HouseAgent**, observes the smart device network and tries to reduce the electricity cost. The second agent, **MaidAgent** will try to enhance the living environment by observing the expressions of residents and taking actions that can make residents more comfortable. These two agents will communicate and share information synchronously since each can only partially observe the house environment.

House description and blueprint

This section presents the house plan.

Description of the house

The designed house is visualized as shown below. Two floors are connected by a stair room. In each room, there is a Heater, a Light and Windows. The light is automatically turned on whenever there are people in the room, however, it cannot be turned off automatically but needs the help of agents. Heaters and Windows are also controllable by agents to adjust room temperature. Other types of equipment are removed for clean visualization.

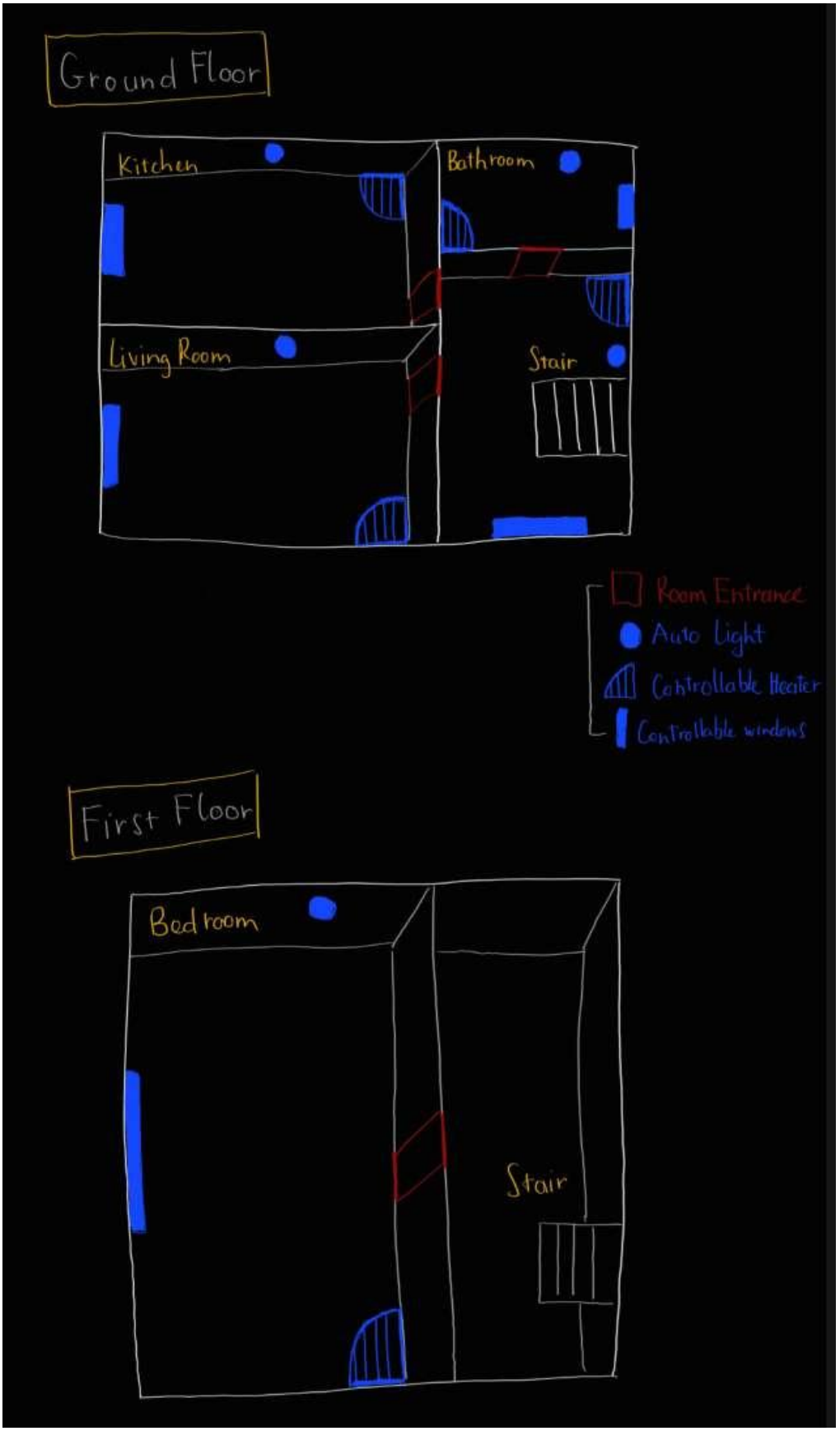

Figure 1. Blueprint of house environment

Rooms [at least 4]
This section provides more details for each room of the house…

Each room has an independent heater to control the temperature, controllable windows, and the main light source that can automatically turn on whenever a person is in the room but it cannot turn off itself.

Living room:
This room is in the front of the house. It has a big controllable window. There is a sofa, a large table and a TV in the middle of the room. Residents usually come here in the morning to have breakfast or enjoy a short rest during the day.

Kitchen:
This room is next to the living room. It has a big table with chairs in the middle and cooking equipment. In case residents do not want to have meals in this room, MaidAgent will deliver to any room residents want at any time of day.

Bathroom:
This room is located at the end of the stair room, which has a toilet, sink, and personal necessities.

Bedroom:
Residents come here to sleep at night and wake up in the morning. It has a big bed, a controllable window, a wardrobe and a mirror.

Stairs:
This room is the connection between two floors. Residents rarely stay here, just passing by when they want to move from the upper floor to the lower floor, usually in the morning

Devices [at least 4]
This section discusses (smart) devices available in the house.

Lights:
Description: *Provide light to rooms.*
Possible status: *on, off*
Possible actions: on *light, off light.*
Prerequisites: *The light will be automatically turned on when people enter the room. However, it cannot be turned off automatically. Lights should be turned off if the room is empty, which can only be observed by MaidAgent.*
Consumption: *Each light consumes 5Wh of electricity when switched on*

Windows:
Description: *Open for fresh air and reduce room temperature, close to keep room temperature.*
Possible status: *opened window, closed window*

Possible actions: window_*open, window_close*
Prerequisites: *It should be opened when residents need some fresh air and want to reduce the room temperature. It should be closed when agents want to turn on the heater. Windows can be used with Heaters to adjust the temperature*
Consumption: *None*

MaidAgent:
Description: *A robot that can move between rooms and observe residents expression*
Possible status: *move, stay.*
Possible actions: *move, observe.*
Prerequisites: It will be controlled by Houseagents when it needs to know what happens in the rooms or to locate people. It can also have to take actions that make residents feel comfortable.
Consumption: *None*

Heater:
Description: Turn on or off to adjust room temperature
Possible status: on heater*, off heater*
Possible actions: heater_*on, heater_off*
Prerequisites: It should be used to adjust the temperature when residents are in uncomfortable states (residents may feel too cold, or hot ..)
Consumption: *Each light consumes 20Wh of electricity when switched on*

Metrics

Cost of electricity
- **Description**:

The less electricity consumed, the less expensive. Each device produces a different amount of electricity (listed above). This goal is assigned to HouseAgent, using the observation from MaidAgent to turn off unnecessary devices.
- **Measurement**: *Accumulated consumed electricity in a day.*

Number of comfortable and uncomfortable events
- **Description:**

Comforts include the following actions:
- ***Control appropriate light:***
  - Agent in charge: *House Agent*
  - Comfortable: *Residents in rooms with light*
  - Uncomfortable: *Residents in rooms without light*
- ***Deliver meal in time:***
  - Agent in charge: *MaidAgent*
  - Comfortable: *Residents can eat as soon as possible when hungry*
  - Uncomfortable: *Wait more than 30 minutes without food*
- ***Adjust temperature when residents are in uncomfortable states:***
  - Agent in charge: MaidAgent
  - Comfortable: T*urn on the heater and close the window when too cold; open the window and turn off the heater when too hot; open the window when residents need fresh air*

    - Uncomfortable: *Residents in uncomfortable states but agents don't take any action*
- **Measurement:** count the number of comfortable/uncomfortable states every 30 minutes.

People and agents

[List residents living in the house and describe their behavior]
Each person has their expressions during the day, including feel_hot, feel_cold, need_fresh_air, hungry and comfort. These expressions can only be observed by MaidAgents

1. **Dad (retired):**
   He usually wakes up at 6.00 and takes showers. Dad has lunch at 12.00 in the living room and goes to the bedroom at 17.00

2. **Mom:**
   Mom usually wakes up at 6.00 and enjoys a morning in the living room. She has lunch in the bedroom at 12.00 and stays there for work. She usually feels hungry at 17.00

3. **Child:**
   The child usually wakes up at 6.00 and plays in the living room. He takes lunch at 12.00 in the kitchen and goes to the bedroom with his dad at 17.00

[List of agents - at least one main house agent, plus one device-specific agent]

1. **MaidAgent:**
   Observations:
   - Cannot observe the status of electronic devices
   - Can **observe the environment in a specific room only when entering**
   - Can observe the expression of residents only when in the same room
   - Can communicate with **HouseAgent** for global devices information

   Actions:
   - Turn on / off heaters
   - Open / close windows
   - Deliver food for residents when residents feel hungry
   - Move around the house and search for missing information as requested by **HouseAgent**

2. **HouseAgent:**
   Observations:
   - Cannot observe residents' expressions, nor know their location.
   - Can only observe the status of **in-house electronic devices**
   - Can communicate with **MaidAgent** for partial scenery information

   Actions:
   - Control electricity consumption by light, heaters
   - Control **MaidAgent** to obtain additional scenery information to turn off unnecessary devices

Planning agent [at least one planning agent is required]

1. **HouseAgent:**

The goal of HouseAgent is to decrease the amount of electricity used, by turning off unnecessary devices, meaning that devices should be turned off when there is no one in the room. Since HouseAgent can only observe the device status information, it needs to control the MaidAgent to move to give observed information of each room and decide accordingly.

Action set of HouseAgent contains: turn_off devices, move MaidAgent in the room to check if that room is empty

The desired target of HouseAgent is to turn off every device if it is possible.

2. **MaidAgent**

The goal of MaidAgent is to take action when residents are in uncomfortable states. Since MaidAgent cannot observe the status of devices, it needs to communicate with HouseAgent to get this information. Based on device status, obtained from HouseAgent, and current observation, it will take action that makes residents feel comfortable.

Action set of MaidAgent contains: adjust temperature by turn_on/turn_off heater and open/close window, adjust air by open/close windows, deliver foods if residents hungry

The desired target of MaidAgent is to make everyone more comfortable.

Implementation [Following sections are part of the final project submission]

1. **Sensors and agent perception**

HouseAgent receives information through electronic sensors in the house. It can have the status signal of any device, but it cannot know exactly who is in the room, the expression of residents, and whether residents leave that room or not. However, with the support of MaidAgent, it can acquire such partial information by sending MaidAgent to that specific room to check. Thus the knowledge of HouseAgent is partial which only contains device status and scenery information given from MaidAgent.

MaidAgent cannot know if devices changed status or people moved to other rooms. MaidAgent can only receive information by observing the current scenery in the room in which it is currently in. With the guidance of HouseAgent, MaidAgent can move efficiently to obtain valuable information, which can help both agents to produce good action to achieve their specific goals. Since MaidAgent can only observe information inside the current room, its knowledge only represents partial information about the house world.

2. **Agents interacting and acting in a shared environment**

HouseAgent and MaidAgent shared their information to achieve their specific target. In the perspective of HouseAgent, when the light turns on, this agent does not know whether residents are still inside that room or not, since residents move through many rooms and turn many lights on at once. Thus, HouseAgent needs to obtain room information from MaidAgent observation. By sending MaidAgent to check the room, MaidAgent can observe the room and communicate its findings to HouseAgent.

Example 1: Dad moves from bedroom through stair to kitchen, and through stair to living rooms. As a result, lights in the bedroom, stairs, kitchen and living room will be turned on, and HouseAgent doesn't know where dad or other people are located. In order to turn off the light without affecting the comforts of residents, HouseAgent needs to send MaidAgent to check which room is empty. When the stair is empty, HouseAgent turns off the light-stair which reduces unnecessary electricity costs.

On the other hand, MaidAgent also needs the device status information to locate rooms that have people and will be the precondition to take action. Since MaidAgents can

only observe the environment inside its current location, it needs suggested location information to move there and observe. After the observation, MaidAgents can take actions that make residents feel comfortable.

Example 2: Child goes to the living room and feels cold. Through the light signal (turned on), provided by HouseAgent, MaidAgent comes to the living room to check and observe that the child is cold (increase the belief set of MaidAgent). It can turn on the heater so that the child will feel less cold and will be more comfortable.

3. Scenarios

Residents make moves and have different expressions at each time step. Since many lights turn on, HouseAgent instructs MaidAgent to go and check each room so that HouseAgent can turn off unnecessary lights. By moving and observing rooms, MaidAgent increases its belief sets, which are helpful for achieving its goal, to make people feel comfortable.

Running the scenarios - Logs

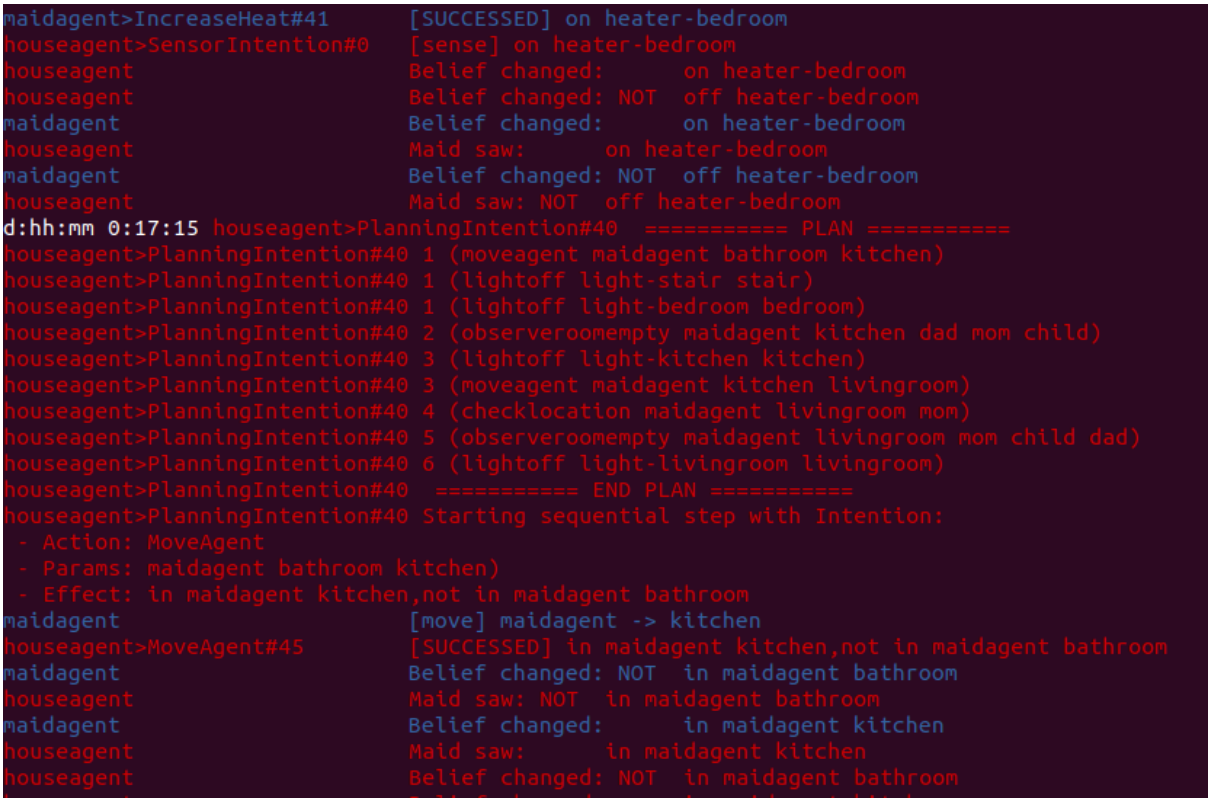

Figure 2. Result log of agents exchanging information, HouseAgent plan

In figure 2, HouseAgent controls MaidAgent to check the kitchen in statement: ***(moveagent maidagent bathroom kitchen)*.** The observed information was sent back from MaidAgent to HouseAgent in statements: ***(Maid saw: in maidagent kitchen')*** and ***(houseagent: Belief changed: NOT in maidagent bathroom)***

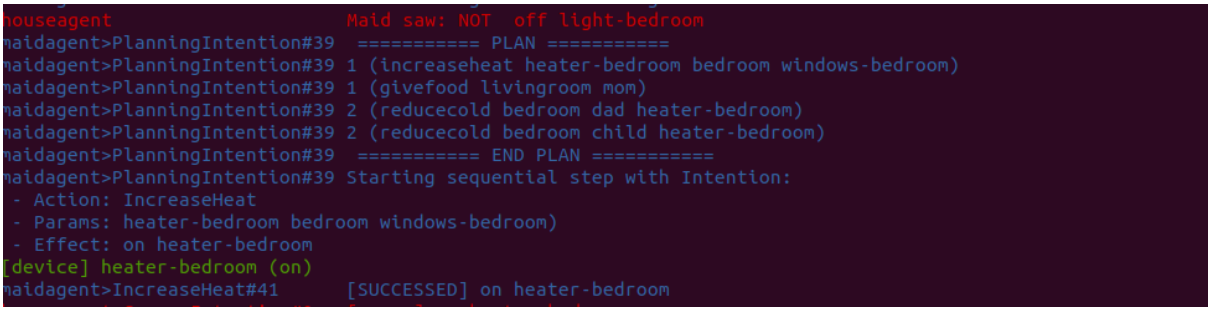

Figure 3. Result log of MaidAgent plan

In figure 3, MaidAgent successfully turns on the heater in the bedroom in a green statement: ***([device] heater-bedroom (on)).*** This statement is logged from the house environment to debug if action is successfully applied in that environment. After taking real action to the environment, the belief will be updated through a sensor system (SensorIntention)

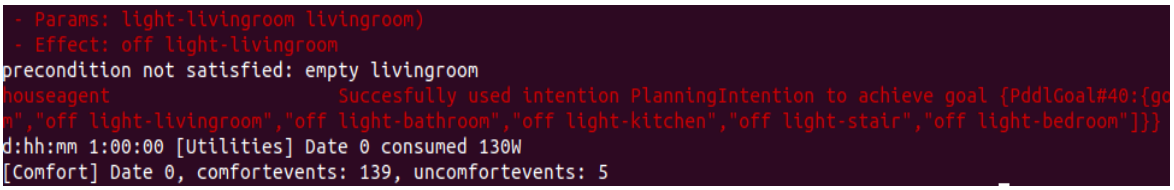

Figure 4. Result log of metric tracker

In figure 4, at the end of each day, the metric tracker will visualize the metric calculated the whole day. For example, **electricity_tracker** will visualize total consumed power (130W), while **comfort_tracker** visualizes the total count for comfortable and uncomfortable events. Each event is a status checking in every 30 minutes

Source code organization

Change log of original source files are mentioned in README.md

List of modified original source files:

- src/pddl/Blackbox.js
- src/pddl/actions/pddlActionIntention.js
- src/bid/Intention.js
- src/bdi/Beliefset.js
- src/bdi/Agent.js

Produced code:

- **src/myworld/**
  - **cfg_rooms.json:** rooms map
  - **house.js:** house environment
  - **myscenario.js:** scenario
  - **pddl/:** pddl_actions of each agent and function to take real actions in env
  - **person/person.js**: person actions and expression
  - **rooms/:** devices and rooms properties
    - **base_rooms.js:** contains device actions
  - **sensors/:** SensorIntention to update beliefs
  - **utility_trackers/:** trackers for each metric defined

Github Link: https://github.com/Dung-Van/ASA_FINAL.git