EkoBot: Task Analysis and Design Sketches

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Overview of Problem and Solution

It is common knowledge that responsible, working parents have busy lives. To stay on top of things, these parents need to stay organized. For example, they they have to keep the house clean and make it easy to find belongings when they are in a rush. These organizational demands prevent parents from doing more desirable activities. Our domestic robot system aims to decrease the time parents spend organizing the house. Parents could automate this robot to periodically pick up and store objects in their designated storage locations. The system allows the users to schedule cleaning, which enables them to remove this task from their daily planning. The parents can also order the robot to clean on demand through a mobile tablet interface.

Task Analysis Questions

1. Who is going to use the system?
This system targets working parents with children under the age of 13. These parents have the highest organizational demands because their young children typically aren't able to handle lots of responsibilities.

2. What tasks do they now perform?
Parents engage in grocery shopping, transporting kids to and from school/activities, laundry, cooking, cleaning, organizing, scheduling, communicating with each member of the family, helping with homework/ projects, and exercising.

3. What tasks are desired?
Tasks from the above list that are enjoyed: cooking, spending time with family, helping with projects, and exercising.
In addition, parents desire free time for personal hobbies and time to relax.

4. How are the tasks learned?
Most homemaking task are learned from childhood from family.

5. Where are the tasks performed?
All these tasks are primarily performed around the home.

6. What's the relationship between customer & data?
Through observation of the environment, the robot learns behavior to fit the family structure and organization and provides data about the cleanliness of the space.

7. What other tools does the customer have?
Parents have physical organization tools like storage units/cubbies, calendars, and notebooks.

8. How do customers communicate with each other?
Parents communicate with one another through common methods (face-to-face, phone, etc...) but also use calendars to communicate schedules asynchronously.

9. How often are the tasks performed?
These types of tasks are performed every day.

10. What are the time constraints on the tasks?
Working parents can only do these tasks when they are at home. Work and transportation limits the times they can perform these tasks.

11. What happens when things go wrong
When things go wrong, family tension and disorganization builds and important tasks don't get accomplished.

Current Versions of Tasks

Our three tasks changed only slightly from the originals. In particular, we tried to describe them in more specific terms and explain the capabilities of the robot more clearly.

Easy Task: Scheduling nightly cleaning
In this task, the participants must schedule a nightly organizing routine for the robot. This task occurs frequently across all of the families we observed. The kids regularly return from school and leave their clothes and toys strewn about the house. This means a quick arrangement of the space must be done each evening so the house is clean the next day. By scheduling the robot to organize the house each evening, the parents can get assistance doing this. The kids' typical clean-up time is 7:30pm, so a parent schedules the robot to organize during that time. Since this is mostly a problem on weeknights, the parent selects for this to run on weeknights. The total clean up time should be no longer than 30 minutes. To clean up for the coming week, the parent also schedules it to run for an hour at 7:00pm on Sunday evening. Since the children will be home during these times, they should do the organizing themselves and the robot should only play a supporting role.

Medium Task: Remotely cleaning a room on-demand for a dinner party
Our parents often find themselves on the run from one place to another, making it occasionally impossible to clean the house when need be. This task represents that challenge. In this task, the parents intend to throw a dinner party in the evening, but they do not have time to clean the house in the morning before they leave. They need to run to the market to pick up some items for the party immediately beforehand, making cleaning the place themselves impossible. The kids will not be home this evening, so they cannot simply call the kids to ask them to do the cleaning. The parents will use a remote interface to request information about which rooms are dirty and need cleaning. Once they receive this information, they will command the robot to clean rooms, specifying the order to clean in. The robot will have already been taught by the user what "clean" means for each dirty room (see task 3) and will proceed to return the rooms to that state. Since the kids will not be home, the robot will do the cleaning itself instead of suggesting it to the children. The party starts at 8pm, but the robot should be finished with cleaning by 7pm so they have time to set up without the robot in the way.

Hard Task: Teaching the robot to clean the living room

Since different families organize things differently, the interface must provide a way for users to teach the robot how to clean a particular space. The families we observed tend to have particular spaces for particular classes of objects. In this task the parents will define the robot's policy for cleaning the living room, which specifies the mapping between objects and the place where they would be if the room were clean. This task plays a similar role to explaining the layout of a space to a maid. The room has many toys, school supplies, eating utensils, and books strewn throughout it. The toys belong in a toy chest which is located in the children's bedroom, school supplies belong in the closet in the childrens' room, the eating utensils belong in a particular drawer in the kitchen, and books belong on the book shelf.

Storyboards for Three Interface Designs

These three storyboards present alternative designs for completing the hard task (Teaching the robot to clean the living room, see Fig.1, 2, and 3). It should be noted that many of these depend upon the capabilities of the robot, which will certainly improve in the coming years.

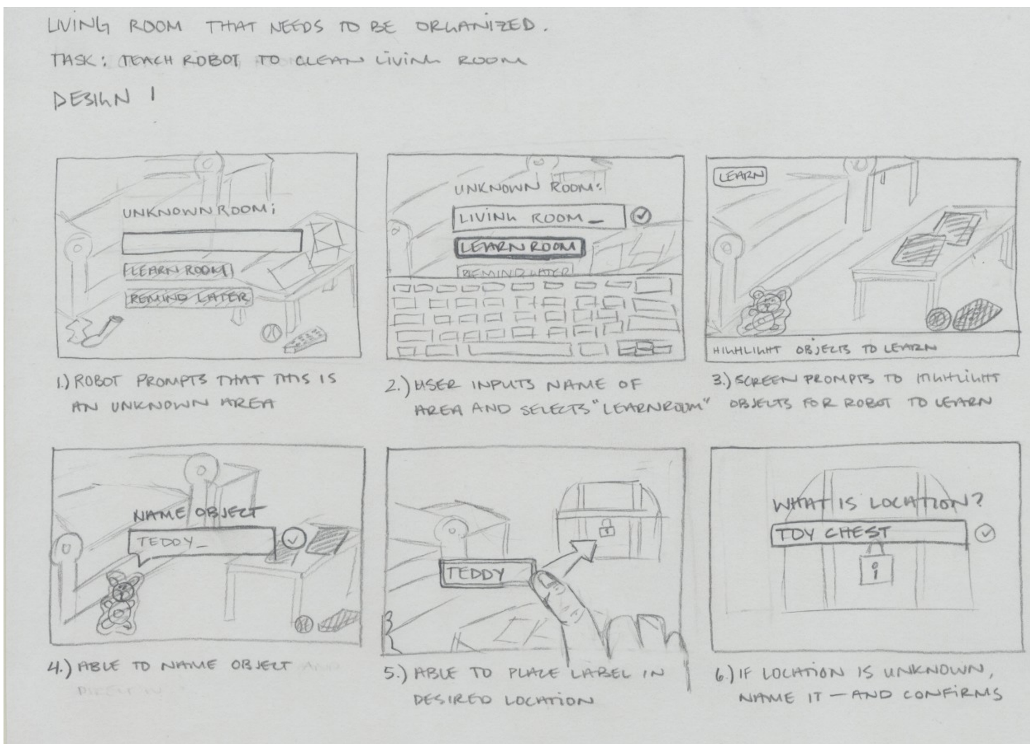


Figure 1: Design 1
Users drag and drop objects into their containers

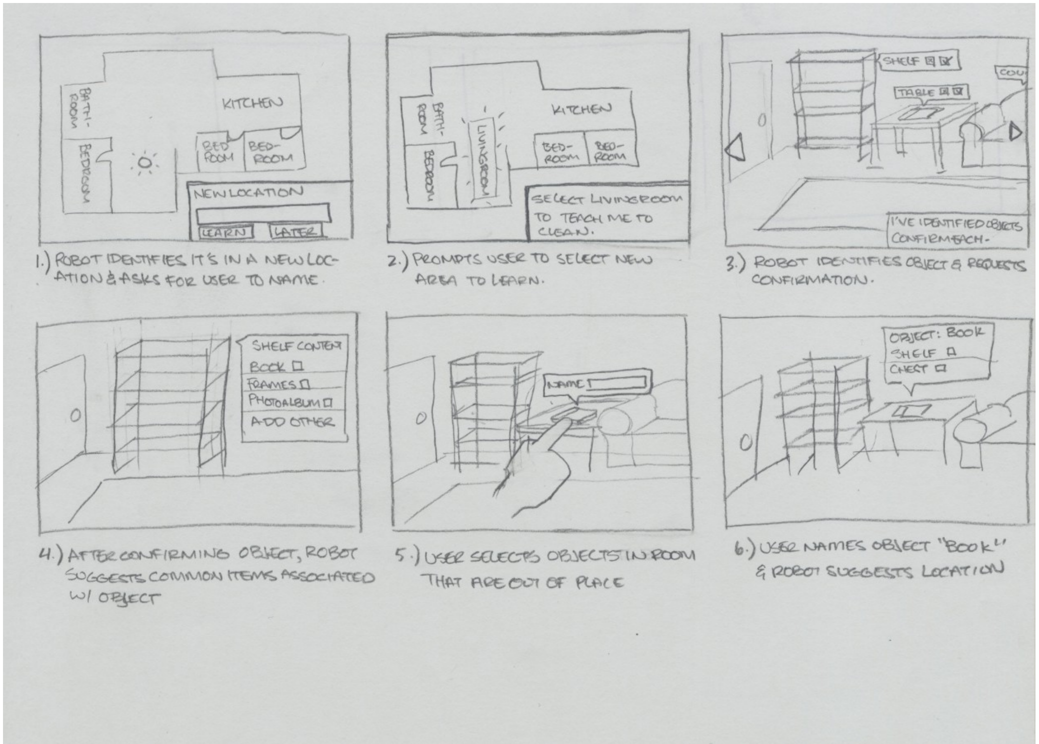


Figure 2: Design 2
Uses a top-down map of the house, users categorize storage locations and label objects

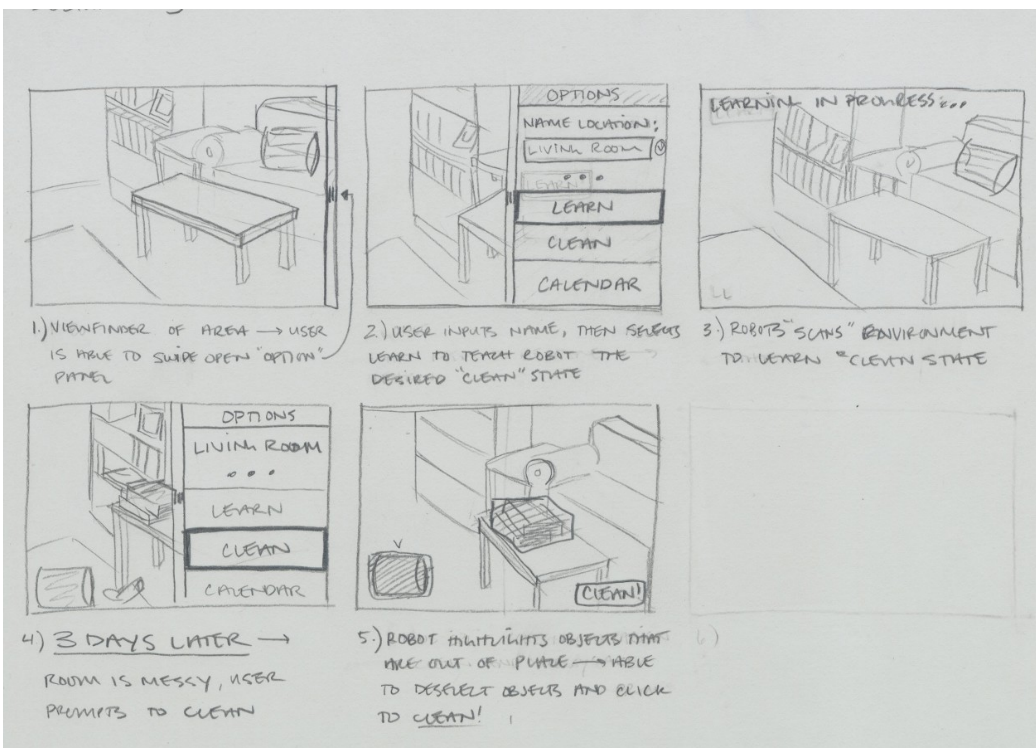


Figure 3: Design 3
Robot examines the room in the clean state and learns the arrangement (this would involve it opening containers and examining the contents).

Selected Interface Design

Design Selection and Reasoning for Choice

We chose a hybrid version of two of our previous designs. Specifically, we kept the top-down house map from the second and used the automatic room scanning idea from the third. The first two designs were heavy on user input. Interaction time is important to reduce because these families are trying to save time in the first place. Also, it's safe to assume that it's possible for a robot to scan a room and detect objects in it. Object recognition is tractable, just a bit slow on current technology. The robot could also communicate with the user to request clarification for things it's not sure about, if that's a problem.

In addition, we elected to use a tablet for the interface. Having a lot of screen space is important for this application, because visual feedback is a big part of this interface (and that won't work well on a small screen). Portability is another factor important to this application - users should be able to interact with the robot from anywhere. With a tablet, that's possible. And, in general, more screen space is better as long as portability isn't really affected. Since tablets are relatively easy to transport, this will be fine.

(Further reasoning for specific design decisions continues in the next section)

Interface Description and Functionality

With this design, users can perform the three tasks we came up with, among other things. When a user first interacts with the robot, they need to teach it the clean state of each room. They can modify this and have the robot re-learn as their organization tactics change. Additionally, users can view the home through the robot's camera. The interface will provide functionality for navigating the robot and panning the camera. There's also a scheduling screen (essentially similar to Google Calendar) where users can set up the frequency and timing of organizing. Along with the scheduling screen, users would see a top-down, schematic-like view of the house with different colors indicating different rooms. From this screen the user can schedule an on-demand cleaning if there's a need for one due to special circumstances. Our interface, as it is, has 3 main panes (see Figures 4,5, and 6): The viewfinder/main screen, the map, and the schedule.

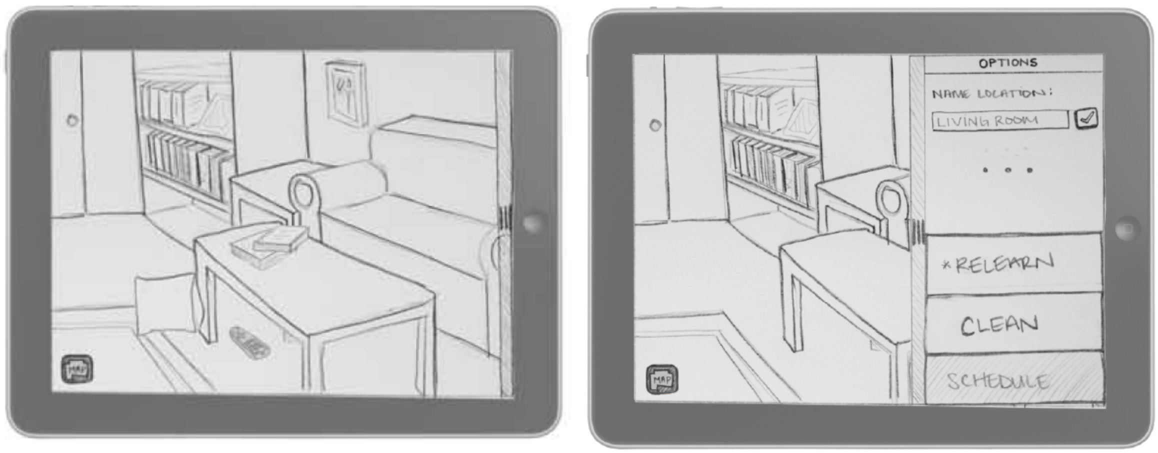


Figure 4 - Viewfinder/Home Screen and Menu

The home screen (Fig. 4) is just a video feed of the robot's camera. The user can pan the camera by holding their finger a distance away from the center of the screen (essentially, they are telling the camera to pan in the given direction). The user can pull up a menu at any time by dragging from the side. From this menu, the user can tell the robot to learn or re-learn the clean state for the current room, clean the current room, or access the schedule. In addition, they can access a top down map of the house.

The viewfinder made sense as the home screen because it immediately communicates the state of the robot - users immediately know where the robot is and what it's doing (if the screen is moving). The option pane dragging interaction is also a common way to hide options when users don't care about them while maximizing screen space. Even if users aren't familiar with this interaction, the lines on the edge of the pane afford grabbing and dragging. Furthermore, the big buttons on the option pane make it easy to push buttons without missing. Also, the map button makes it easy to quickly switch access the map, which is definitely a frequently-performed task.

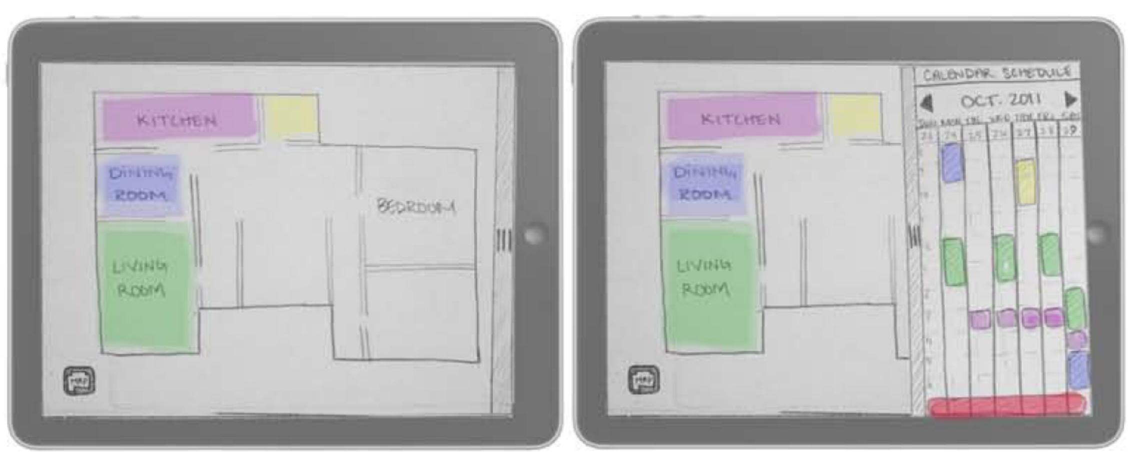


Figure 5 - Map screen and schedule pane

The map screen (Fig. 5) provides a top-down view of the house. Users can click on points in the house to have the robot navigate to that area and access the schedule pane by dragging the pane out on the right. In addition, to schedule a cleaning, users can press and hold the screen to bring up that dialog.

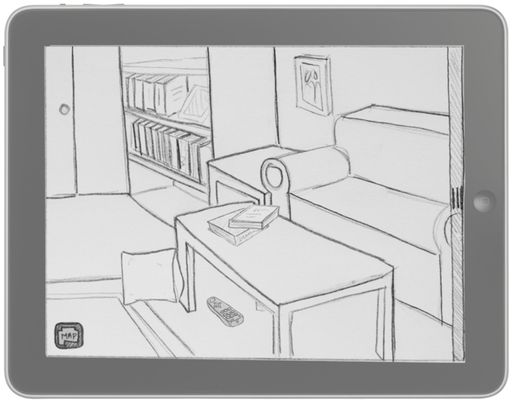
On the schedule pane (Fig. 5, on the right) users see a weekly schedule of the robot's activities along with a top-down map of the house. On the top-down map, the rooms are colored (these colors are specified by the user when they have the robot learn a room). Organization tasks appear as colored blocks that match the colors of the rooms on the map.

The color coordination between the map and schedule makes it easy for users to quickly see what the robot is doing and where they are doing it. Also, a weekly view works better than a daily or monthly calendar view. With a monthly view, users wouldn't see as much time-of-day information, which is definitely important to parents who have to schedule their days in terms of hours (which is common). With a daily view, parents can't immediately see what's coming up in a few days - something which is likely to be more important to them than seeing what's happening a few weeks ahead. The weekly view maximizes the relevant (for parents) information it is capable of effectively communicating. Finally, being able to schedule something by holding the screen is quick (which is good because it's likely to be performed frequently) and takes advantage of the special gestures that can be performed on a tablet.

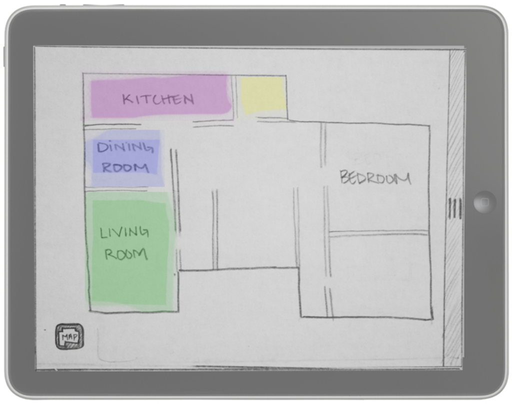
Three Scenarios for Each Task

The following pages depict how the user would use the interface to complete our three tasks: setting up a nightly cleaning schedule, initiating a cleaning remotely, and teaching the robot to clean the living room.

Easy Task: Scheduling Nightly Cleaning

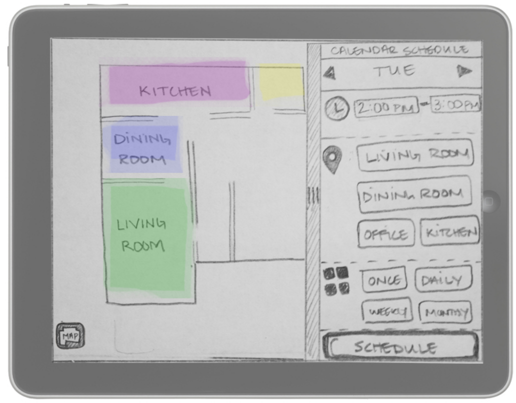


1. Viewfinder of the area where user can access map option.



2. User sees overview of map & can access schedule by swiping right panel.

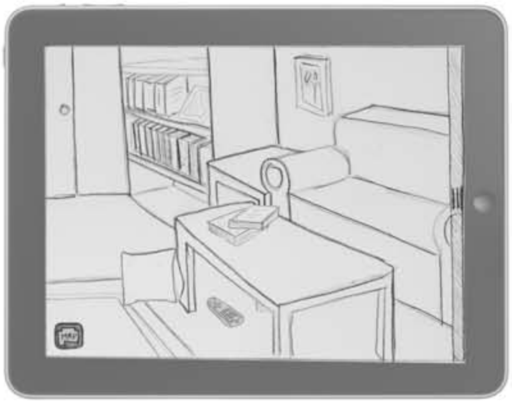
3. Once schedule has been opened, user can touch and hold to schedule new task.



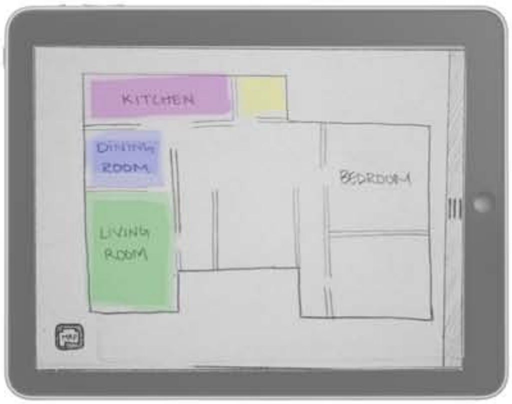
4. User can edit time, location, and fequency of task. Then selects 'Schedule' to confirm.

5. New task is added to calendar.

Medium Task: Remotely Cleaning a Room.

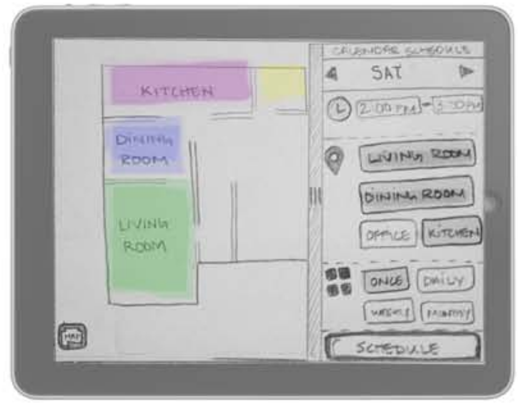


1. Viewfinder of the area where user can access map option.



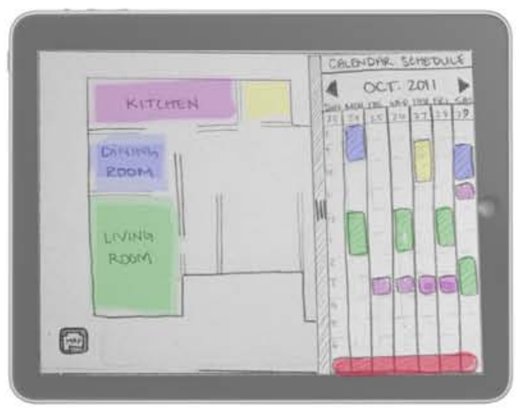
2. User sees overview of map & can access schedule by swiping right panel.

3. Once schedule has been opened, user can touch and hold to schedule new task.



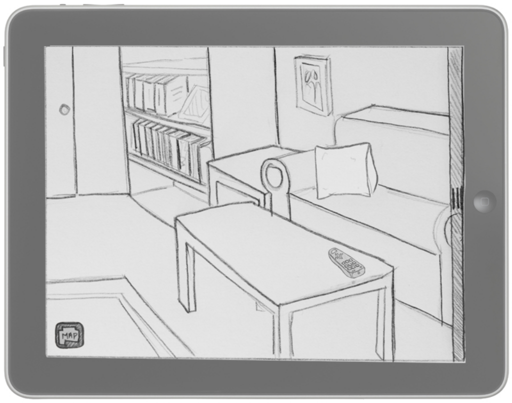
4. User selects Living Room, Dining Room and Kitchen to be sheduled once on Saturday.

5. New task is added to calendar.

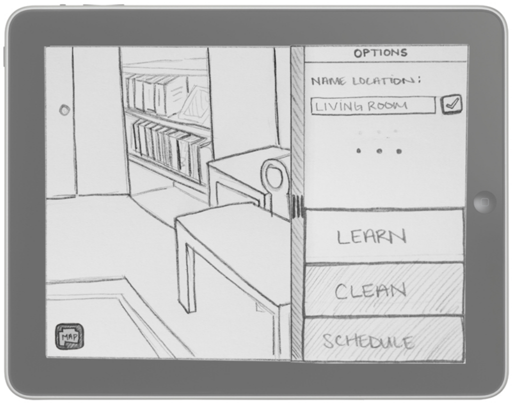


6. The User is able to drag and re-order tasks after they have been added.

Difficult Task: Teach Robot to Clean Livingroom



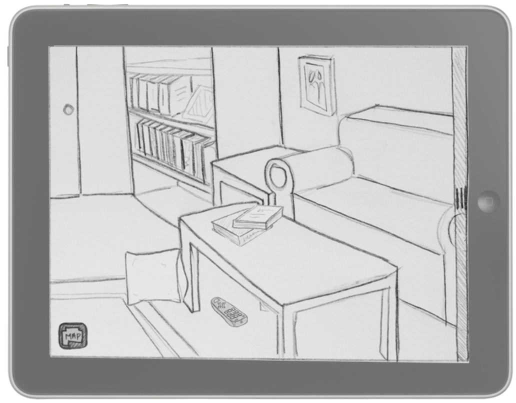
1. Viewfinder of the area where user can swipe open option panel



2. User inputs name of location and selects the learn button to teach Robot 'clean' state.

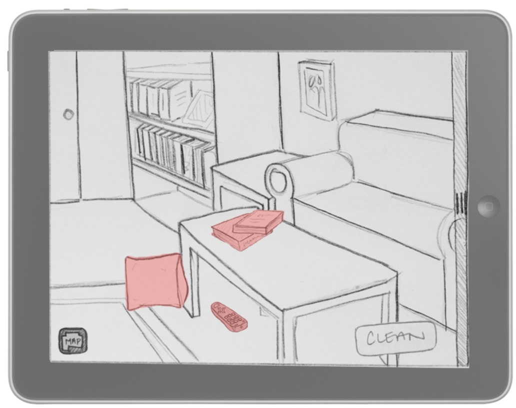
3. The robot scans the environment to learn 'clean' state.

4. Robot has learned clean.



5. 3 Days Later: Room is messy.

6. User selects 'Clean' on menu.



7. Robot highlights objects that are out of place. User is able to deselect objects or continue clean by pressing 'Clean.'

8. Robot replaces highlighted objects to learned 'clean state' locations.