

Interactive application of a virtual smart home

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Using **Virtual** Experimental Method for Eliciting Users Preferences of Smart Homes



Erfaneh Allameh, Mohammadali Heidari, Bauke de Vries, Harry Timmermans

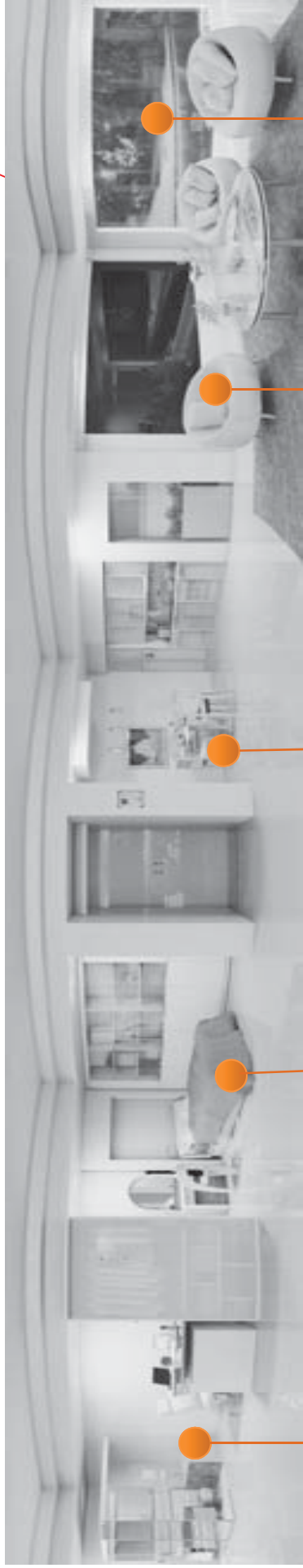
What are Smart Homes?



What are Smart Homes?



What are Smart Homes?



Smart Floor



Smart Furniture



Smart Kitchen Table



Smart Furniture



Smart Wall

Challenges in front of Smart Homes

- **Smart Homes are both predictable and achievable, but still not exist.**

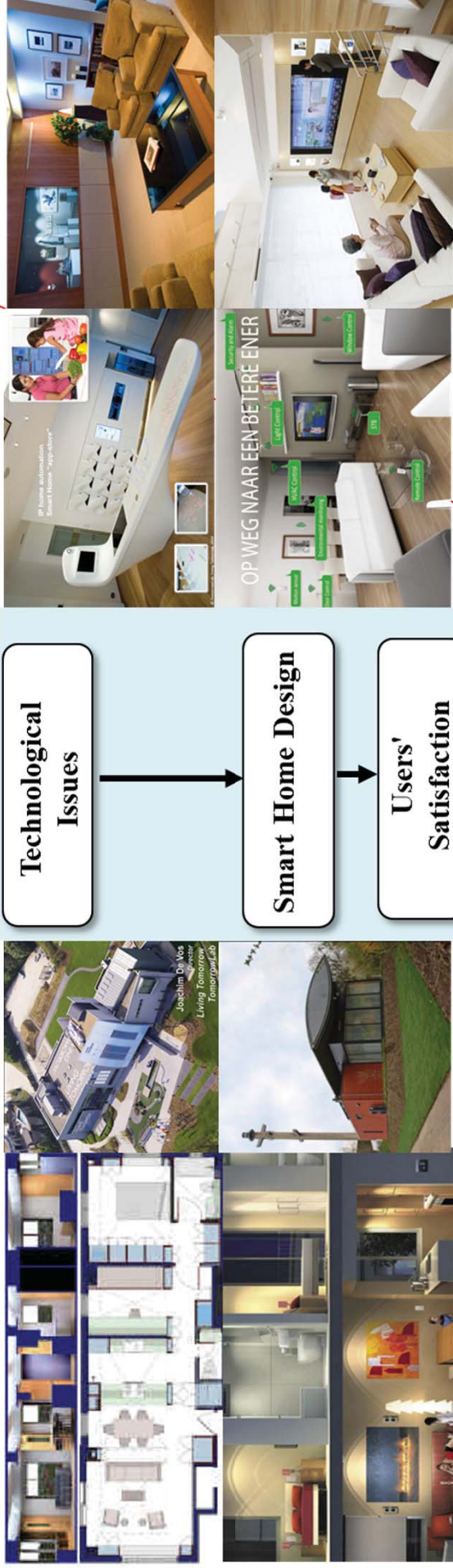
This is too luxury.

This is good only for lab not for real life.

This is not for them – their gender, age, income, background.

This does not fit into their values and daily routines.

This make their home complicated.



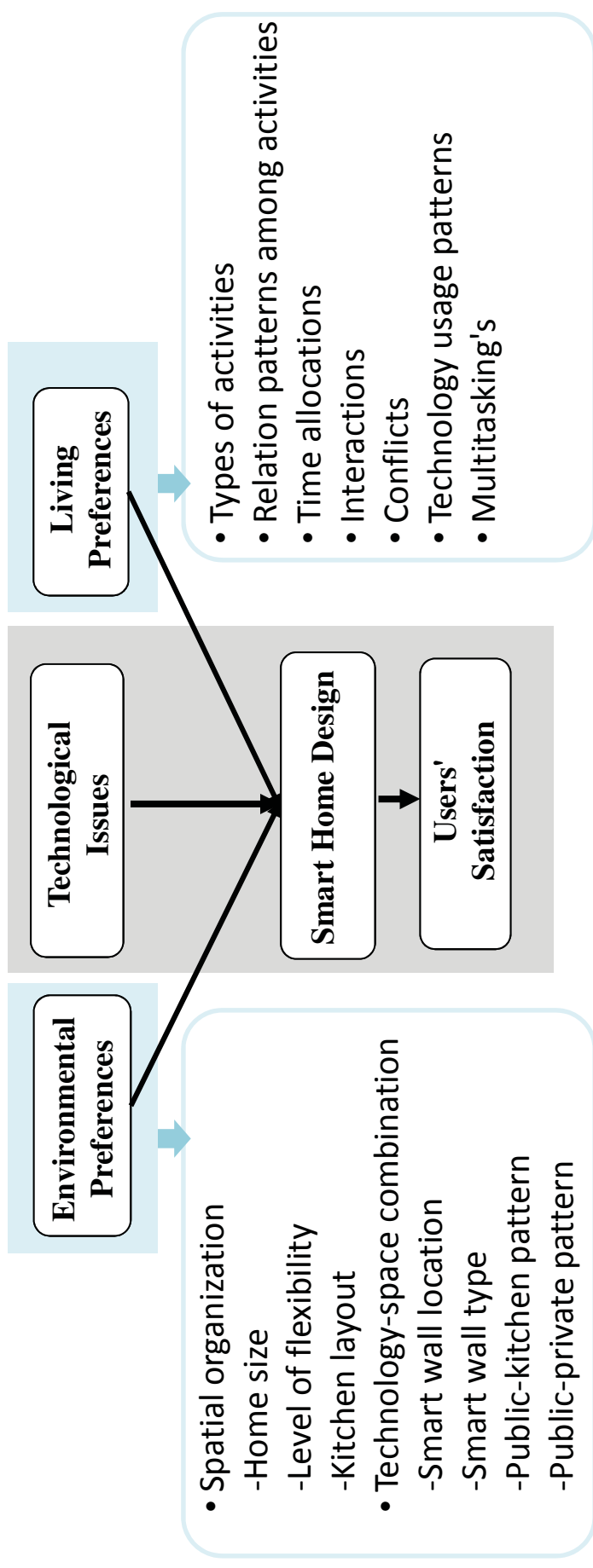
Involving Users Preferences in Smart Home Design

- It is essential to involve users preferences in smart home design.
- Smart home should be a home and a place to live.



Involving Users Preferences in Smart Home Design

- We propose to consider different features of users' preferences together with technology installations during the process of smart home design.



How Can We Elicit Users Preferences?

- To know users latent preferences, we need to:
 - Let users say what they want.
 - Observe users what they do inside a smart home.
 - Let users make changes in the environment of a smart home.

While making Flexible Living Lab with changeable settings is Cost-intensive & Time-consuming

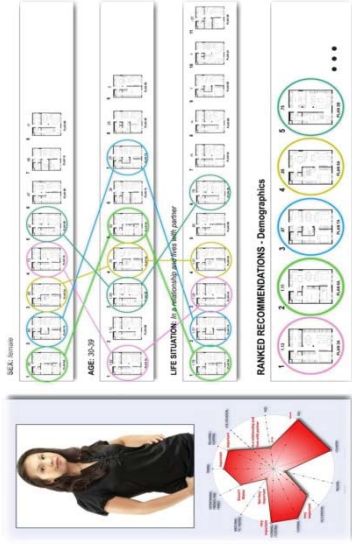
- We apply **virtual methods** for eliciting users' preferences.



Open Living Laboratory

Related works for applying virtual methods

**Non-smart environments
Spatial Preferences**



Home Genome Project
(Larson & Smithwick, 2010)

**Non-smart environments
Living Preferences**



Tabak Activity Simulator
(Tabak & de Vries, 2010)

**Smart environments
No User Preferences**



ISS
(Van Nguyen et al. 2009)

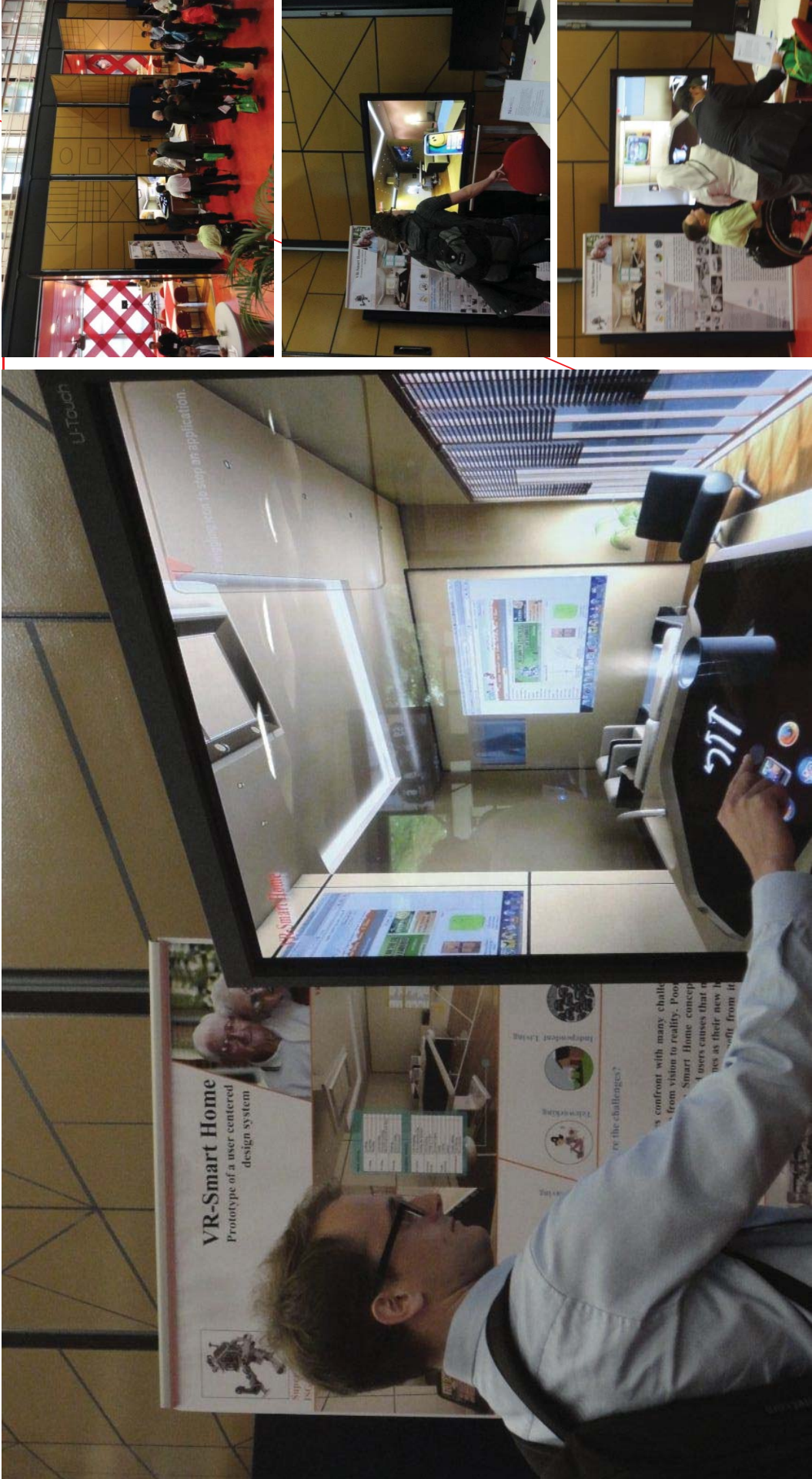
CASS
(Park et al. 2007)

Visi/SM4All
(Lazovik et al. 2009)

V-Placesims
(Lertlakkhanakul et al. 2008)



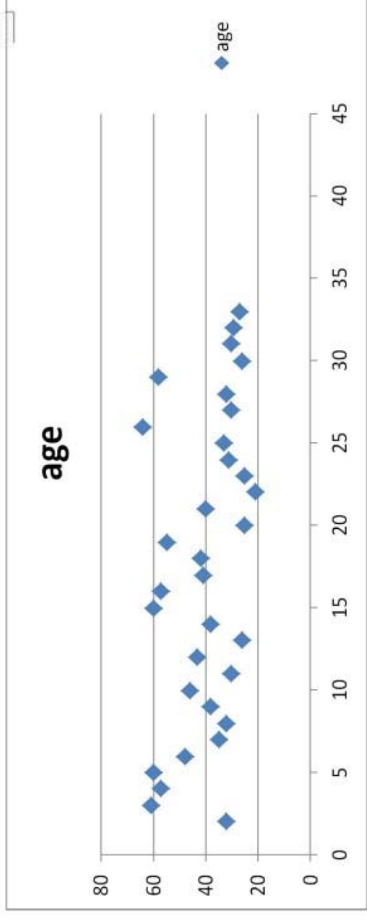
The First Virtual Experiment



Evaluation of the First Virtual Experiment

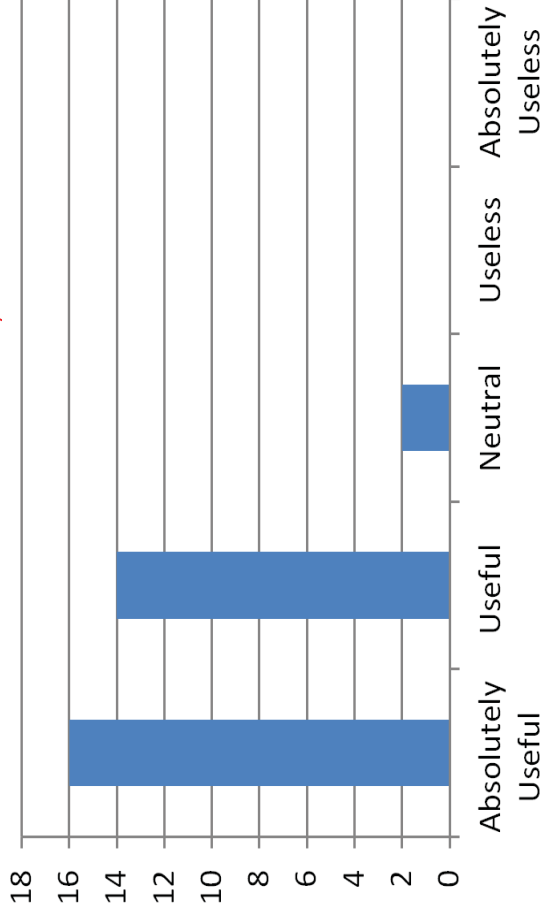
32 Participants with

- Different ages of 20 to 65 years old
- Different countries such as, Germany, Italy, Spain, Japan, America, England, Australia, Costa Rica, Albania, Iran and Netherlands



The majority of participants find the VR prototype useful in improving their understanding of Smart Homes.

There are also relation among perceived usefulness of application and the smart home acceptance.



Evaluation of the First Virtual Experiment

Meaning that the amount of perceiving smart home usefulness and accepting it is related to the explorations of participants during the tasks.

Referring to these findings, we conclude that applying virtual methods in smart home design can increase users' understanding of smart homes.

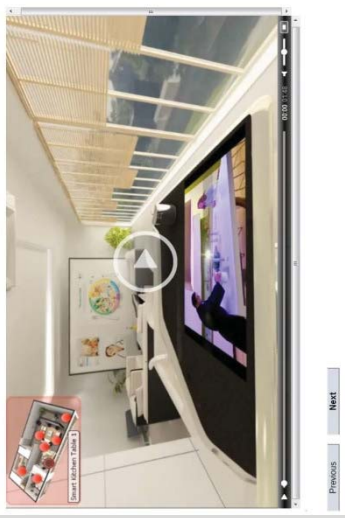
The better users understand the smart home, the better they can express their preferences.

The Implemented Virtual Experimental Method

TU/e Technische Universiteit Eindhoven University of Technology

"Smart Home Survey"

Move! Please Watch the Movie Completely.




Previous Next

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Task 1: Make your favorite 125 m² Smart Home

Using the toolbars, you can see multiple alternatives for each part. By selecting the alternative you like the most for each part, you can make your favorite layout. Be sure that you explore all the possible combinations of the presented Smart Home. When you reach into a final decision, click on the confirm button to continue the experiment. (The red objects show Smart technologies inside home).



Bedroom Layout

- Layout 1
- Layout 2
- Layout 3

Flexible Room

- Yes
- No

Smart Wall Location
(In relation with other Smart Technologies)

- Location 1
- Location 2

Smart Kitchen Layout
(Home size is the same in both cases)

- Integrated with living room
- Separate from living room

Smart Wall Type

- 1-sided
- 2-sided

Confirm

3

Task 1: Spending a weekday in a Smart Home

Assume today is a weekday. You have a smart home and possibility of working at home. It is your choice to stay at home or go out to work. Imagine now you would like to have inside the smart home. Follow the agenda to spend the whole day at night. When you complete the agenda for the whole day, the task will finish.

TU/e Technische Universiteit Eindhoven University of Technology

"Smart Home Survey"

start room activity dur. iner. conflict

05:00	(6) Master Bedroom	Sleeping	05:10	yes	sound
05:10	(1) Smart Kitchen Table	Entertainment, Other	05:30	yes	visual

Time 06:10

Location (1) Smart Kitchen Table

Duration 0 hr 0 min

Interaction

- No interaction
- Interaction

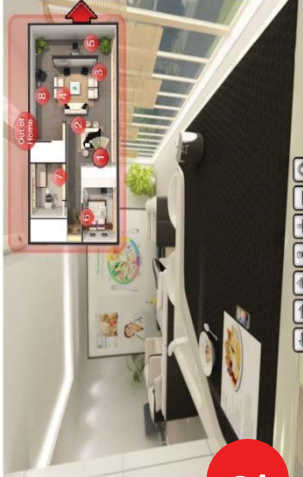
Conflict

- No Conflict
- Sound Conflict
- Visual Conflict
- Functional Conflict

Activity

- Food preparing
- Cooking
- Dishwashing
- Cleaning
- Washing
- Studying
- Watching TV
- Entertainment
- Child related activity
- Internet surfing
- E-meeting
- Tele-health caring
- Tele-educating
- Tele-shopping
- Entertainment
- Available after walking in
- Other
- Out of home activities

Add Activity Undo last Activity End of Day



2

TU/e Technische Universiteit Eindhoven University of Technology

"Smart Home Survey"

Please tell us to what extent the following statements apply to you.

I usually have tight schedule to manage all my inside-home activities (e.g. cooking, taking care of family, social life activities, personal activities, etc.) during a day.

Not at all Very little Little Neutral Somewhat Very much Extremely

I usually have lack of time to do all my outside-home activities (e.g. shopping, picking up child from school, visiting family or friend, etc.)

Not at all Very little Little Neutral Somewhat Very much Extremely

I usually have lack of time to spend with my family or to do my favorite activities.

Not at all Very little Little Neutral Somewhat Very much Extremely

In general, I would like to have more time-saving to handle my daily activities efficiently and comfortably.

Not at all Very little Little Neutral Somewhat Very much Extremely

Previous Next

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Part1: A Virtual Tour Through The Smart Home

“Smart Home Survey ”



Movie1: Please Watch the Movie Completely.



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Part2: Activity Arrangement

Task 1: Spending a weekday in a Smart Home

Assume today is a weekday. You have a smart home and possibility of working at home. It is your choice to stay at home or go out for work. Imagine how you would like to live inside your Smart Home. Follow the experiment until the time you go to sleep at night. When you complete the agenda for the whole day, the task will finish.

start	room	activity	dur.	inter.	conflict
03:00	(6) Master Bedroom	Sleeping	03:10	yes	sound
06:10	(1) Smart Kitchen Table	Entertainment, Other	02:00	yes	visual



Time

3:00

Location

(3) Smart Wall

Duration

0 hr 0 min

Interaction

- Interaction
- No Interaction

Conflict

- No Conflict
- Sound Conflict
- Visual Conflict
- Functional Conflict

Activity

- Food preparing
- Cooking
- Dishwashing
- Eating
- Working
- Studying
- Entertainment
- Watching TV
- Family gathering
- Child related activity
- E-meeting
- Internet surfing
- Tele-communication
- Tele-health caring
- Tele-educating
- Tele-shopping
- Personal activity
- Rest
- Sleeping
- Other
- Out of home activities

Add Activity

Undo last Activity

End of Day

Part2: Activity Arrangement

Task 1: Spending a weekday in a Smart Home

Assume today is a weekday. You have a smart home and possibility of working at home. It is your choice to stay at home or go out for work. Imagine how you would like to live inside your Smart Home. Follow the experiment until the time you go to sleep at night. When you complete the agenda for the whole day, the task will finish.

start	room	activity	dur.	inter.	conflict
03:00	(6) Master Bedroom	Sleeping	03:10	yes	sound
06:10	(1) Smart Kitchen Table	Entertainment, Other	02:00	yes	visual



Time

08:10

Location

(1) Smart Kitchen Table

Duration

0 hr 0 min

Interaction

Interaction

No Interaction

Conflict

No Conflict

Sound Conflict

Visual Conflict

Functional Conflict

Activity

- Food preparing
- Cooking
- Dishwashing
- Eating
- Working
- Studying
- Entertainment
- Watching TV
- Family gathering
- Child related activity
- E-meeting
- Internet surfing
- Tele-communication
- Tele-health caring
- Tele-educating
- Tele-shopping
- Personal activity

Available after waking up

Other

Out of home activities

Add Activity

Undo last Activity

End of Day

Part2: Activity Arrangement

Task 1: Spending a weekday in a Smart Home

Assume today is a weekday. You have a smart home and possibility of working at home. It is your choice to stay at home or go out for work. Imagine how you would like to live inside your Smart Home. Follow the experiment until the time you go to sleep at night. When you complete the agenda for the whole day, the task will finish.

start	room	activity	dur.	inter.	conflict
03:00	(6) Master Bedroom	Sleeping	03:10	yes	sound
06:10	(1) Smart Kitchen Table	Entertainment, Other	02:00	yes	visual



Time

08:10

Location

(1) Smart Kitchen Table

Duration

0 hr 0 min

Interaction

Interaction
 No Interaction

Conflict

No Conflict
 Sound Conflict
 Visual Conflict
 Functional Conflict

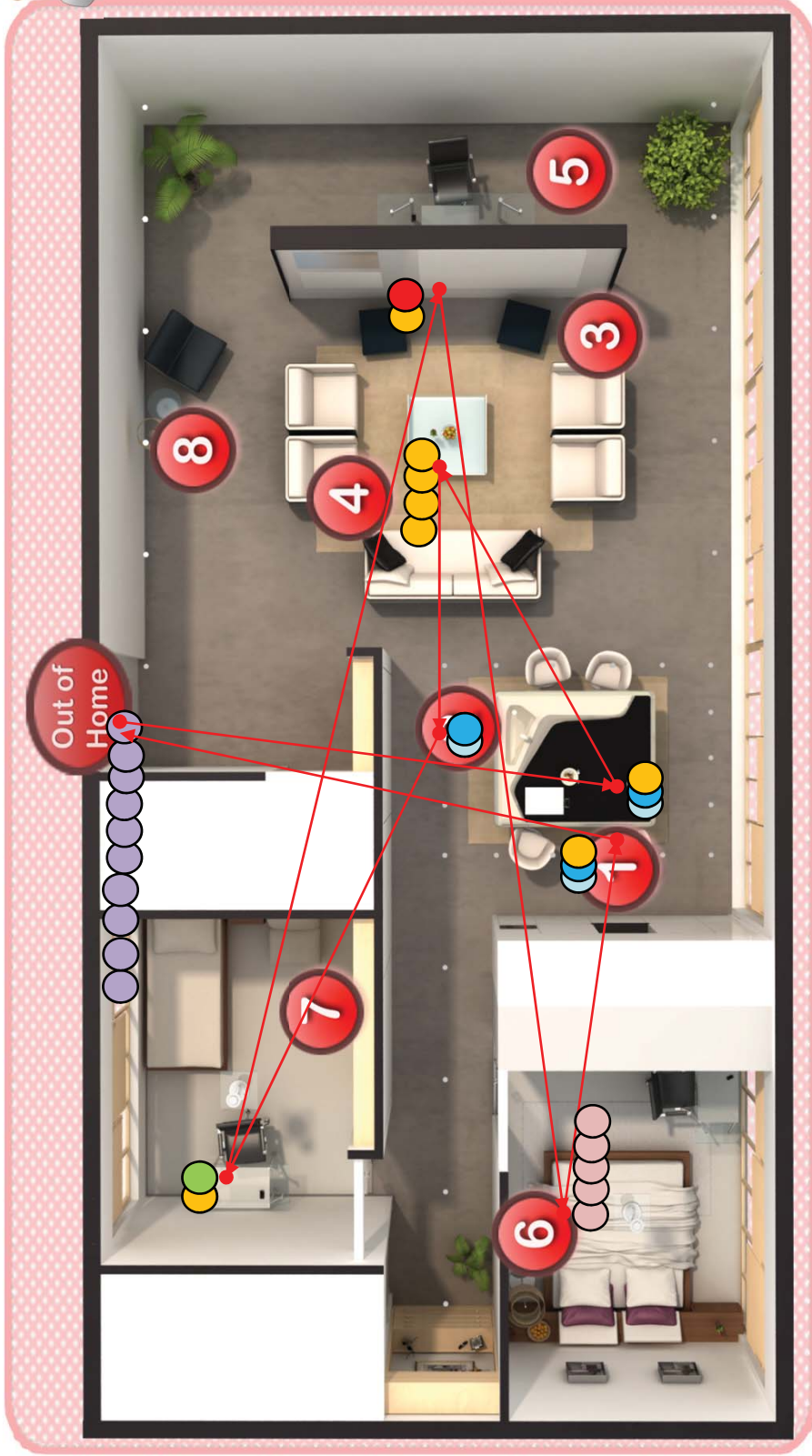
Activity

- Food preparing
- Cooking
- Dishwashing
- Eating
- Working
- Studying
- Entertainment
- Watching TV
- Family gathering
- Child related activity
- E-meeting
- Internet surfing
- Tele-communication
- Tele-health caring
- Tele-educating
- Tele-shopping
- Personal activity
- Available after waking up
- Other
- Out of home activities

Add Activity

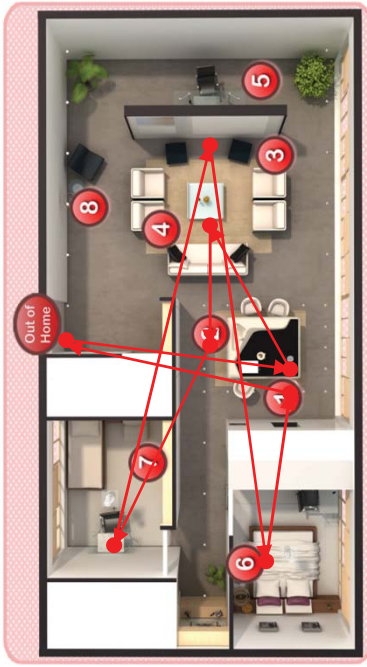
Undo last Activity

End of Day

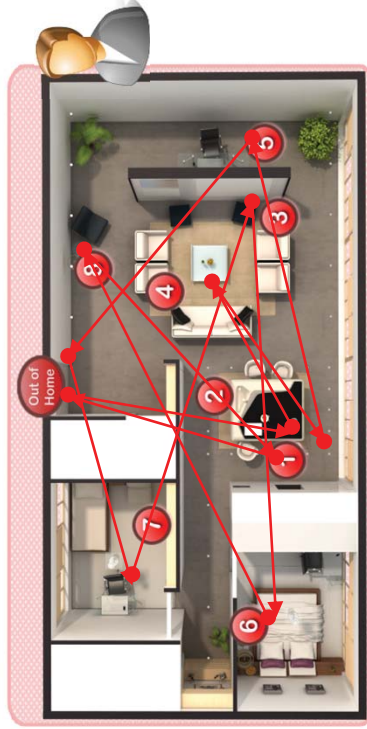


- Kitchen related activities**
 - Eating
 - Secondary
 - Work
- Out of home**
- Tele activities**
- Sleeping**

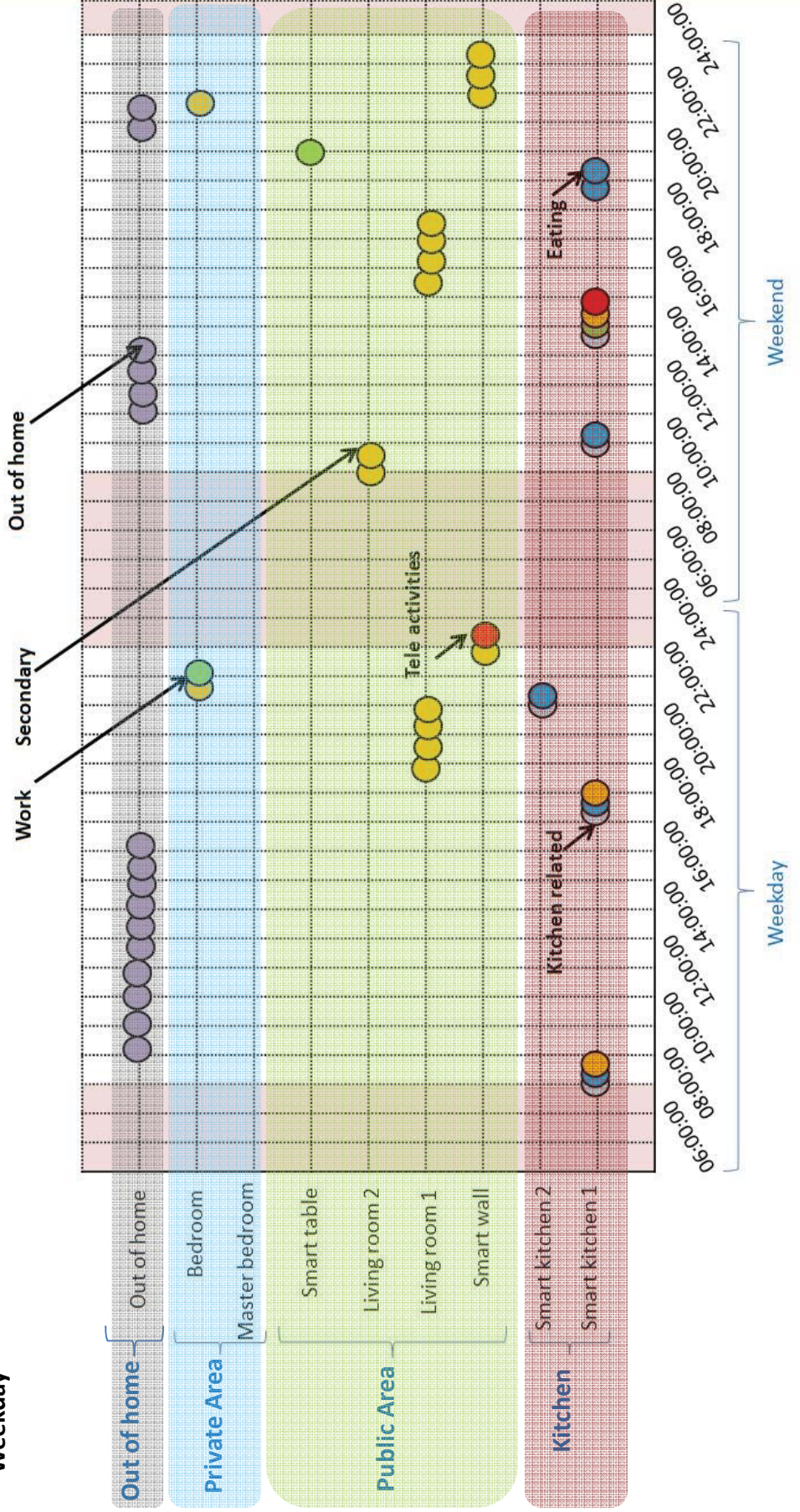
Weekday



Weekday



Weekend



Part3: Environment Arrangement

Task 1: Make your favorite **125 m²** Smart Home

Using the toolbars, you can see multiple alternatives for each part. By selecting the alternative you like the most for each part, you can make your favorite layout. Be sure that you explore all the possible combinations of the presented Smart Home. When you reach into a final decision, click on the confirm button to continue the experiment. (The Red Objects show Smart technologies inside home).



Bedroom Layout

- Layout 1
- Layout 2
- Layout 3

Flexible Room

- Yes
- No

Smart Wall Location

(In relation with other Smart Technologies)

- Location 1
- Location 2

Smart Kitchen Layout

(Home size is the same in both cases)

- Integrated with living room
- Separate from living room

Smart Wall Type

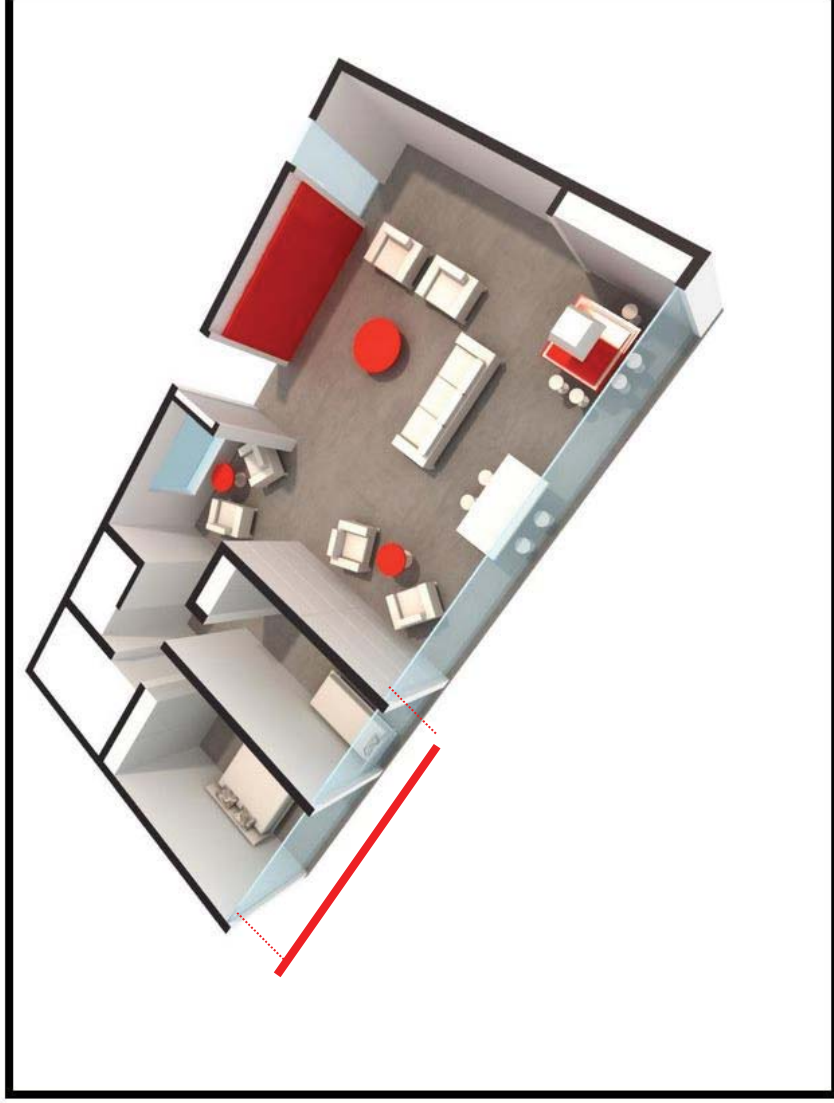
- 1-sided
- 2-sided

Confirm

Part3: Environment Arrangement

Task 1: Make your favorite 125 m² Smart Home

Using the toolbars, you can see multiple alternatives for each part. By selecting the alternative you like the most for each part, you can make your favorite layout. Be sure that you explore all the possible combinations of the presented Smart Home. When you reach into a final decision, click on the confirm button to continue the experiment. (The Red Objects show Smart technologies inside home).



Bedroom Layout

- Layout 1
- Layout 2
- Layout 3

Flexible Room

- Yes
- No

Smart Wall Location

(In relation with other Smart Technologies)

- Location 1
- Location 2

Smart Kitchen Layout

(Home size is the same in both cases)

- Integrated with living room
- Separate from living room

Smart Wall Type

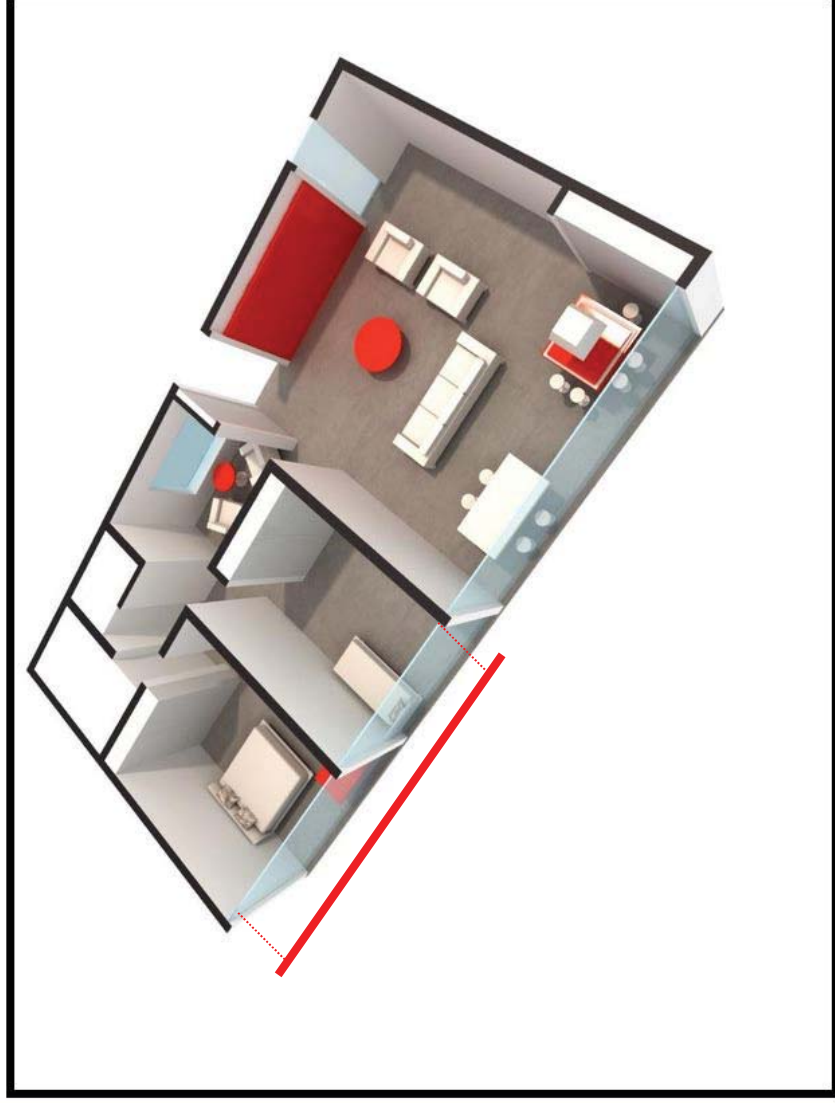
- 1-sided
- 2-sided

Confirm

Part3: Environment Arrangement

Task 1: Make your favorite 125 m² Smart Home

Using the toolbars, you can see multiple alternatives for each part. By selecting the alternative you like the most for each part, you can make your favorite layout. Be sure that you explore all the possible combinations of the presented Smart Home. When you reach into a final decision, click on the confirm button to continue the experiment. (The Red Objects show Smart technologies inside home).



Bedroom Layout

Layout 1

Layout 2

Layout 3

Flexible Room

Yes

No

Flexible room is not compatible with Layout 3

Smart Wall Location
(In relation with other Smart Technologies)

Location 1

Location 2

Smart Kitchen Layout
(Home size is the same in both cases)

Integrated with living room

Separate from living room

Smart Wall Type

1-sided

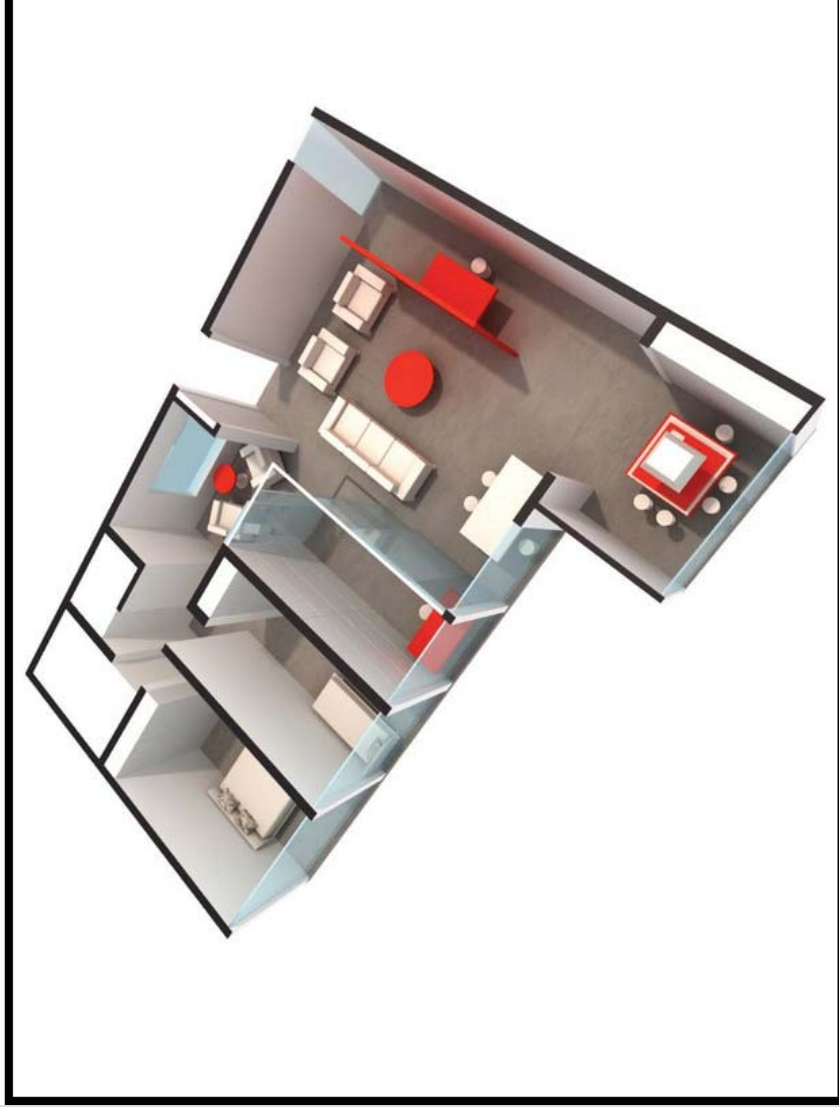
2-sided

Confirm

Part3: Environment Arrangement

Task 1: Make your favorite 125 m² Smart Home

Using the toolbars, you can see multiple alternatives for each part. By selecting the alternative you like the most for each part, you can make your favorite layout. Be sure that you explore all the possible combinations of the presented Smart Home. When you reach into a final decision, click on the confirm button to continue the experiment. (The Red Objects show Smart technologies inside home).



Bedroom Layout

- Layout 1
- Layout 2
- Layout 3

Flexible Room

- Yes
- No

Smart Wall Location

(In relation with other Smart Technologies)

- Location 1
- Location 2

Smart Kitchen Layout

(Home size is the same in both cases)

- Integrated with living room
- Separate from living room

Smart Wall Type

- 1-sided
- 2-sided

Confirm

Part4: Complementary questionnaire

“Smart Home Survey ”

Please tell us to what extent the following statements apply to you.

I usually have tight schedule to manage all my inside-home activities(e.g. cooking, taking care of family, social life activities, personal activities, etc.) during a day.

Not at all	Very little	Little	Neutral	Somewhat	Very much	Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I usually have lack of time to do all my outside-home activities(e.g. shopping, picking up child from school, visiting family or friend, etc.)

Not at all	Very little	Little	Neutral	Somewhat	Very much	Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

I usually have lack of time to spend with my family or to do my favorite activities.

Not at all	Very little	Little	Neutral	Somewhat	Very much	Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

In general, I would like to have more time-saving to handle my daily activities efficiently and comfortably.

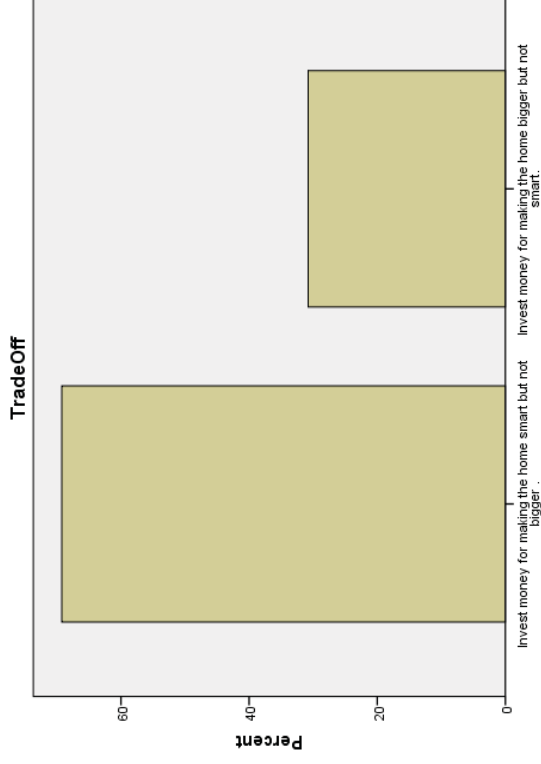
Not at all	Very little	Little	Neutral	Somewhat	Very much	Extremely
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Previous

Next

Outcomes

If you have limited budget, would you like to invest money for making your home smart or bigger?

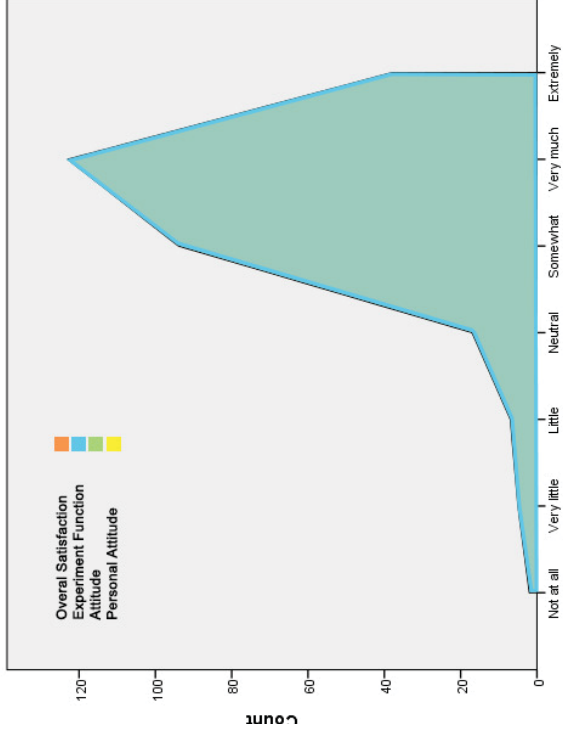


TradeOff

	Frequency	Percent	Valid Percent	Cumulative Percent
Valid				
Invest money for making the home smart but not bigger .	198	63.7	69.2	69.2
Invest money for making the home bigger but not smart.	88	28.3	30.8	100.0
Total	286	92.0	100.0	
Missing	25	8.0		
Total	311	100.0		

Outcomes

To what extent do you think the virtual experiments you performed in this questionnaire improve your understanding of a smart home?



	Frequency	Percent	Valid Percent	Cumulative Percent
Valid				
Not at all	2	.6	.7	.7
Very little	5	1.6	1.7	2.4
Little	7	2.3	2.4	4.9
Neutral	17	5.5	5.9	10.8
Somewhat	94	30.2	32.9	43.7
Very much	123	39.5	43.0	86.7
Extremely	38	12.2	13.3	100.0
Total	286	92.0	100.0	
Missing	25	8.0		
Total	311	100.0		

Discussion

Benefits

Virtual methods can be applied in smart home designs. They can be considered as virtual living labs:

- For evaluating design alternatives
- For testing the functionalities of smart technologies
- For eliciting users preferences
- For training users

Drawbacks

- Users should be able to interact with the computers, iPad or any other touch screens.
- It seems that the real living labs can not be replaced by virtual labs for analyzing the real users behavior inside a smart space but they can be complemented by virtual methods.

Thank You Very Much for Your Attention.

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