Visualization and Communication for indoor Location-based Services

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Nowadays indoor location-based services (indoor-LBS) are getting more and more attention. Various data are captured while little work has been done to investigate visualization methods for those data to an optimal communication for indoor-LBS. Compared with outdoor navigation, indoor route navigation is more difficult that the form of presentation is depending on technical limitations of output media, accuracy of location information, and cognitive restrictions of the user [17]

Indoor Scene Recognition

- It‘s hard to find a good indoor scene recognition method
  - Many current methods have very low performance for indoor scene
  - Megha and Svetlana [2] addressed this key problem by using deformable part-based models (DPM’s) with latent Support Vector Machine (SVM) training [10].

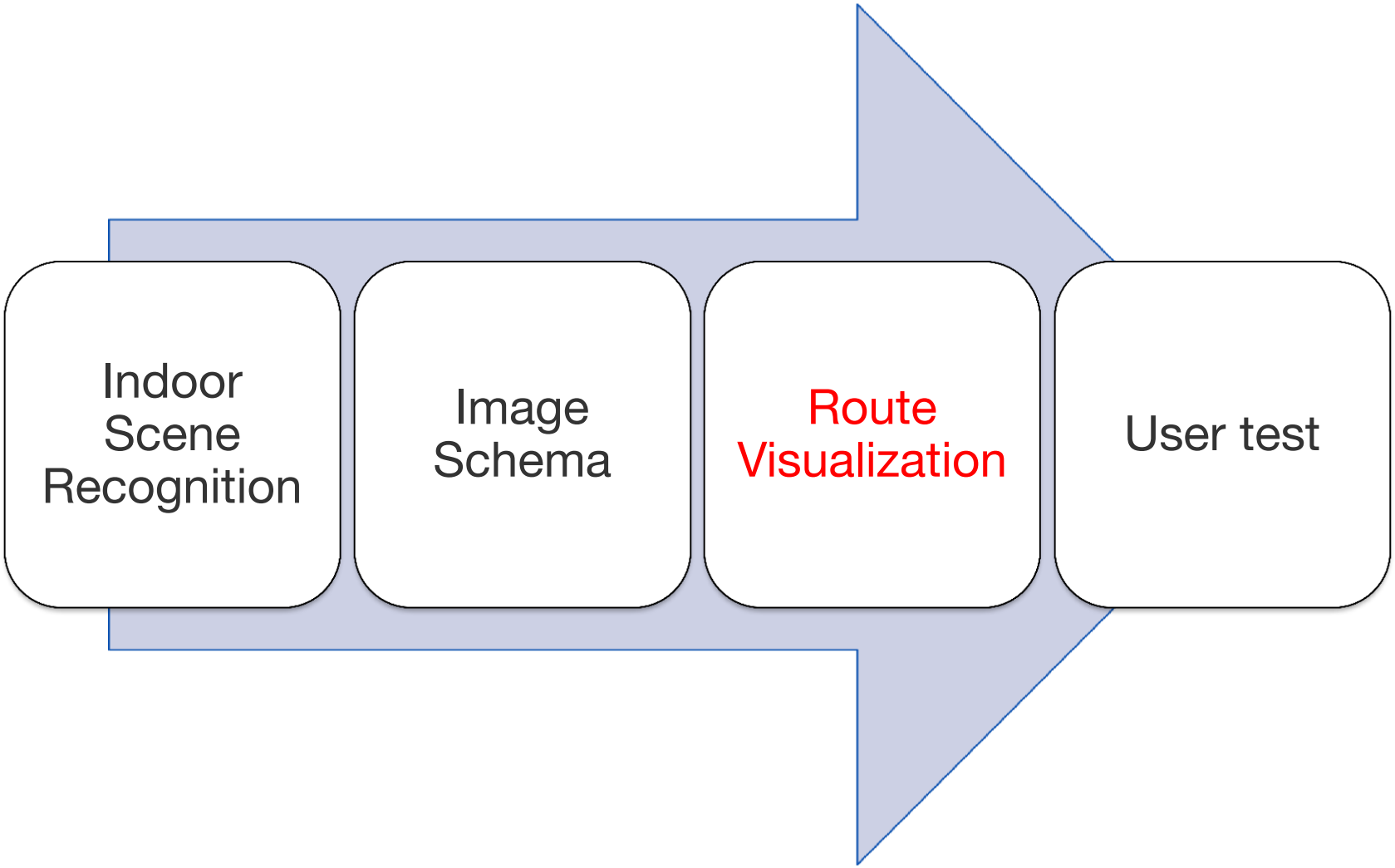
Image Schema

- mental representations are not sufficient to find route, instead, image schemata and affordance are useful to represent people’s perceptual and cognitive structures. [5]

Route Visualization

- Text only descriptions are notoriously inadequate for expressing complex spatial relations [17]
- Inig et al. [11] suggested to combine image augmenting audition hints, textual instructions, map, photographs, landmarks pictured on images, automatic map rotation and situating geotagged images on top of a map to improve visualization effect

Workflow


Indoor Scene Recognition
Image Schema
Route Visualization
User test

Indoor Scene Recognition workflow

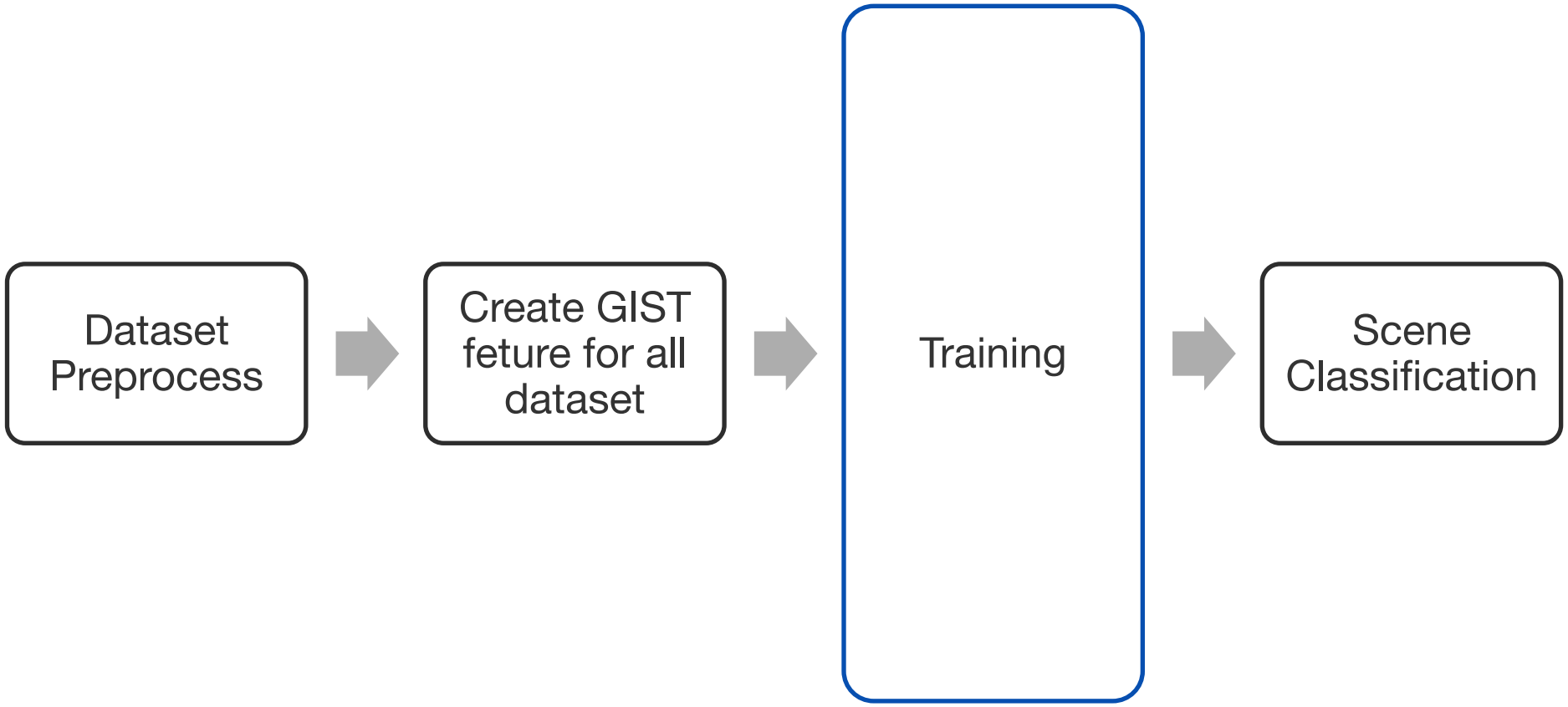


Image Schema

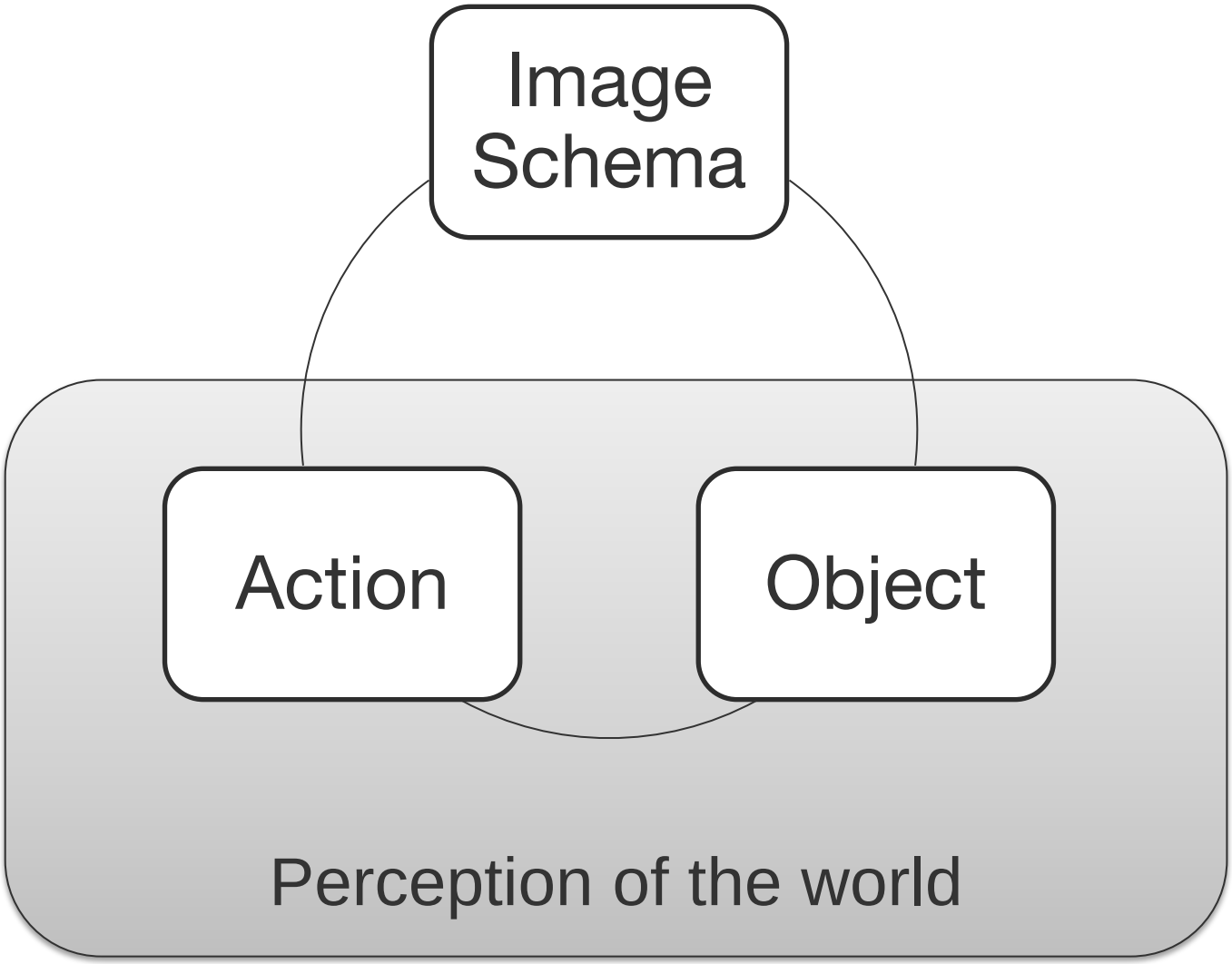


Image Schema workflow

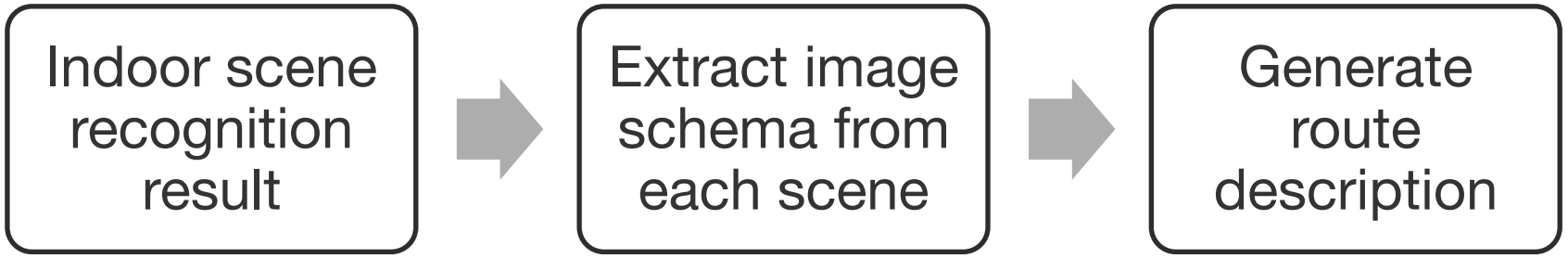
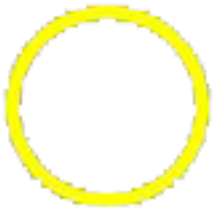


Image Schema etraction rules

- **Hypothesis 1**: The given amount of images for one path is large enough to describe the path
- **Hypothesis 2**: All critical scenes can be recognized
- **Hypothesis 3**: Each scene is front-view scene

- **Rule 1**: MODE is first given (1 represents up, 0 represents down) as an indication of up/down direction when walking staircase.
- **Rule 2**: One path schema starts with START(I) and ends with END(I).
- **Rule 3**: The first corridor will be extracted as ON_SURFACE schema and the first staircase will be extracted as LINK schema.
- **Rule 4**: When there are more than one subsequent “corridor/staircase” in indoor scene recognition result, all those subsequent “corridor/staircase” will be treated as one and be derived into PATH_ALONG schema

Symbol Design



Start

End

You are here

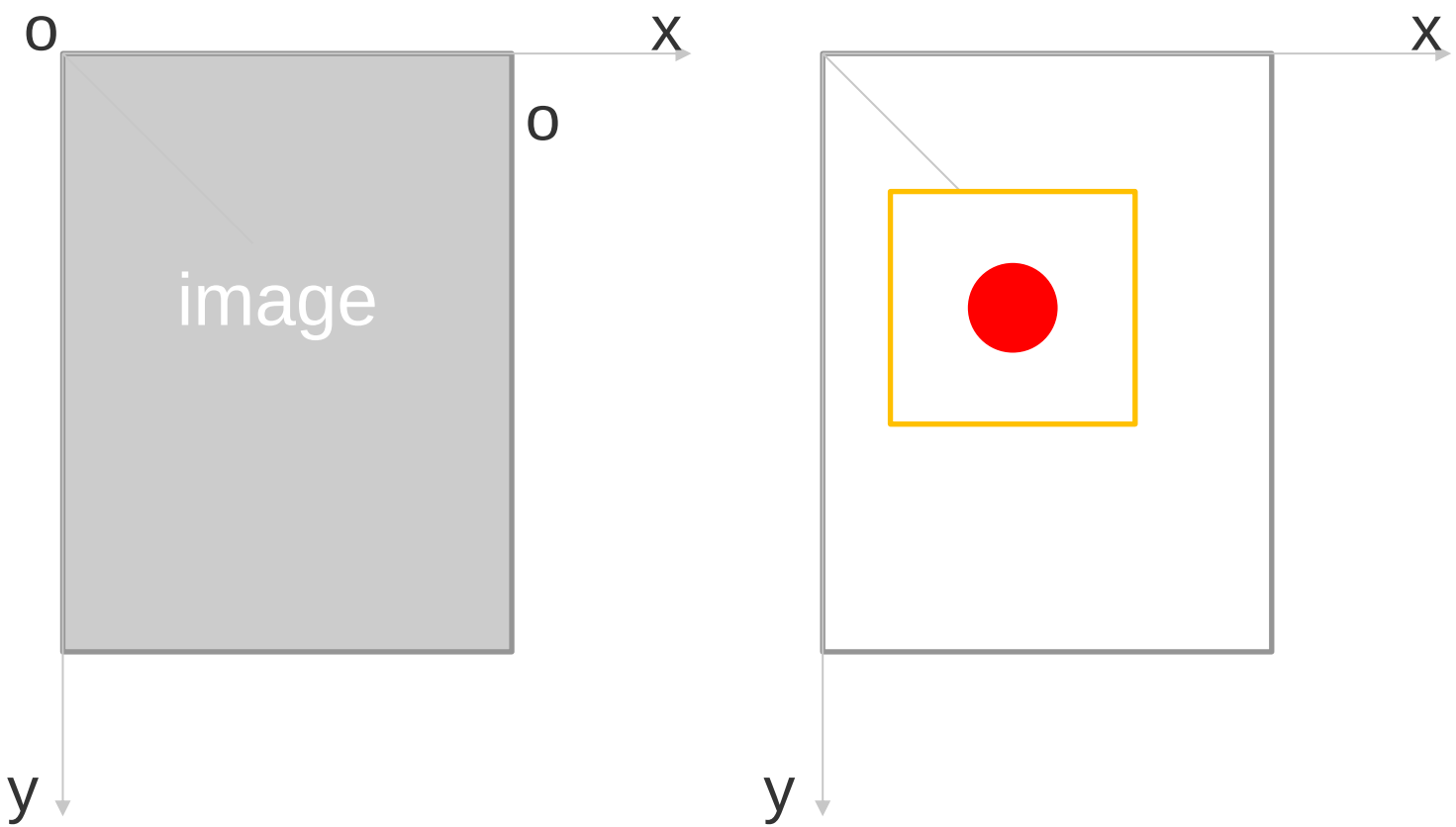
Navigation arrow

Direction arrow

Staircase go up/down

Staircase forbidden

Symbol Placement



Automatic Route Visualization

START(I)

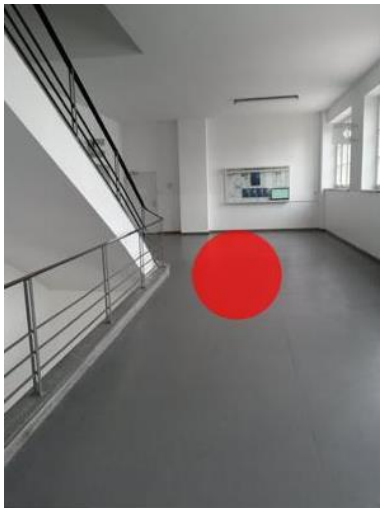
END(I)

PATH_ALONG(I, object)

PATH_THROUGH(I, object)

UP(I, object) /DOWN(I, object)

DO_NOT(I)



ON_SURFACE(I, object)

Manual Modification

1-1

2-6

3-24

Figure 8 Visualization result after manual modification (1-1, 2-6 and 3-24)

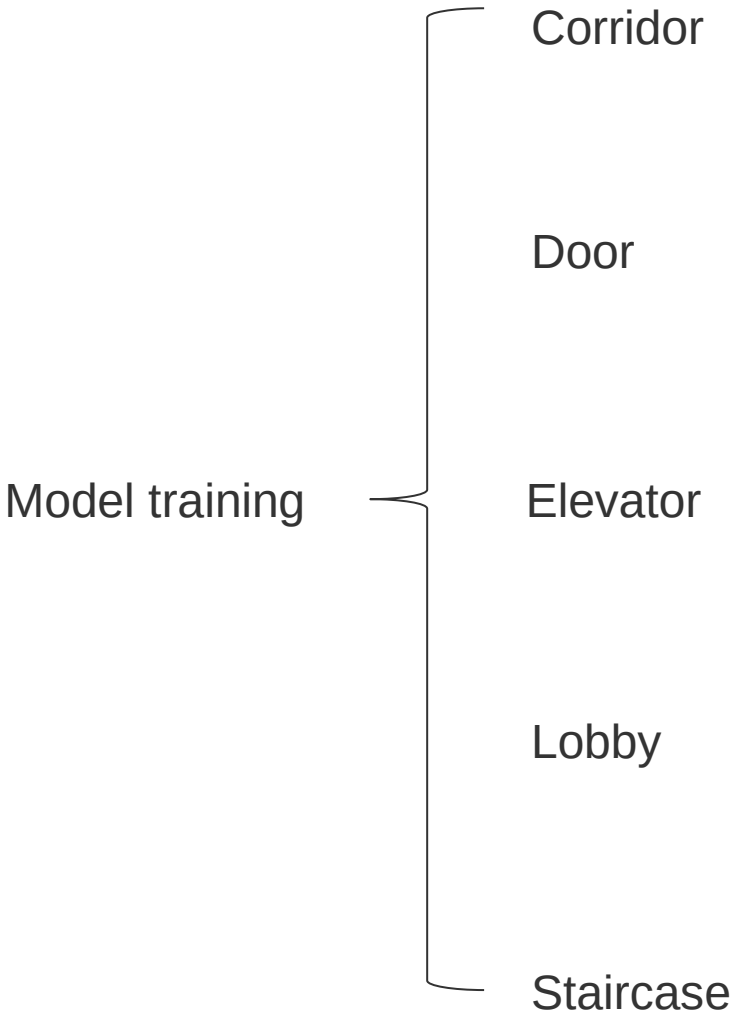
- direction arrow is added
- unnecessary symbols are deleted
- For instance, a turn-left arrow is added to 1-1; original filled red circle is replaced by a walk-forward arrow in 2-6; original filled red circle is replaced by a turn-left arrow in 3-24.

- **Route 1** (23 images)
  - path from room 1779 to room 3704
  - simple and typical, mainly consists of corridors and staircases

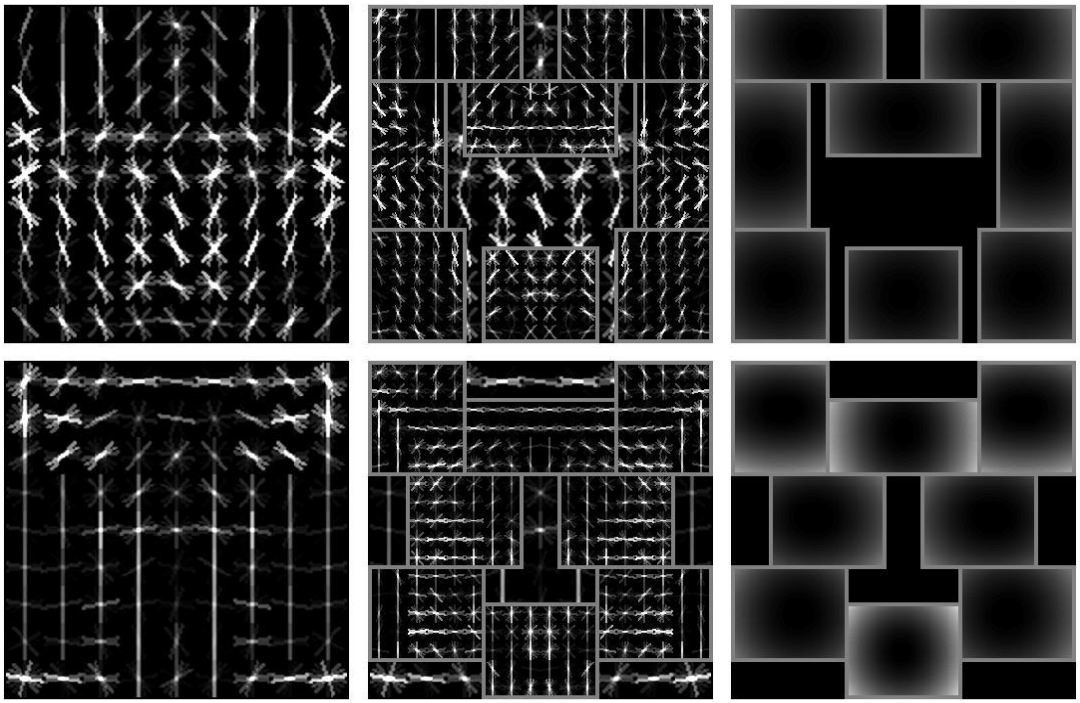
- **Route 2** (20 images)
  - path from lobby in direction of Carl von LinDE-HÖRSAAL to room 3238
  - contains some ambiguous structures and especially one door-closed scene

- **Route 3** (40 images)
  - path from the lobby which on the 2nd floor in direction of physical building to the door on the ground floor which is the closest exit to signal light on Theresienstr
  - most complicated as it contains all five structures. Elevator and staircases appear in the same scene

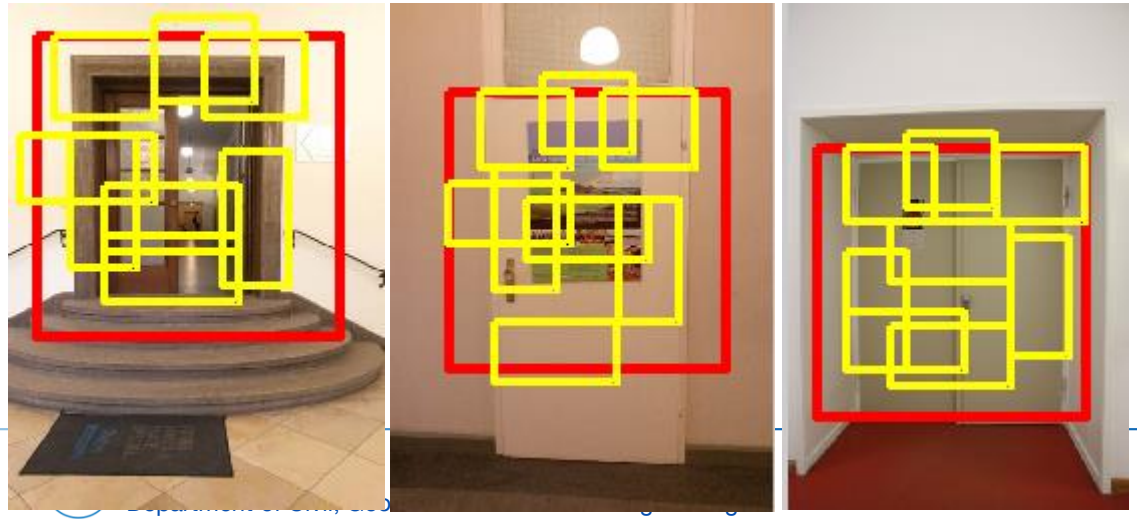
Indoor Scene Recognition



Indoor Scene Recognition

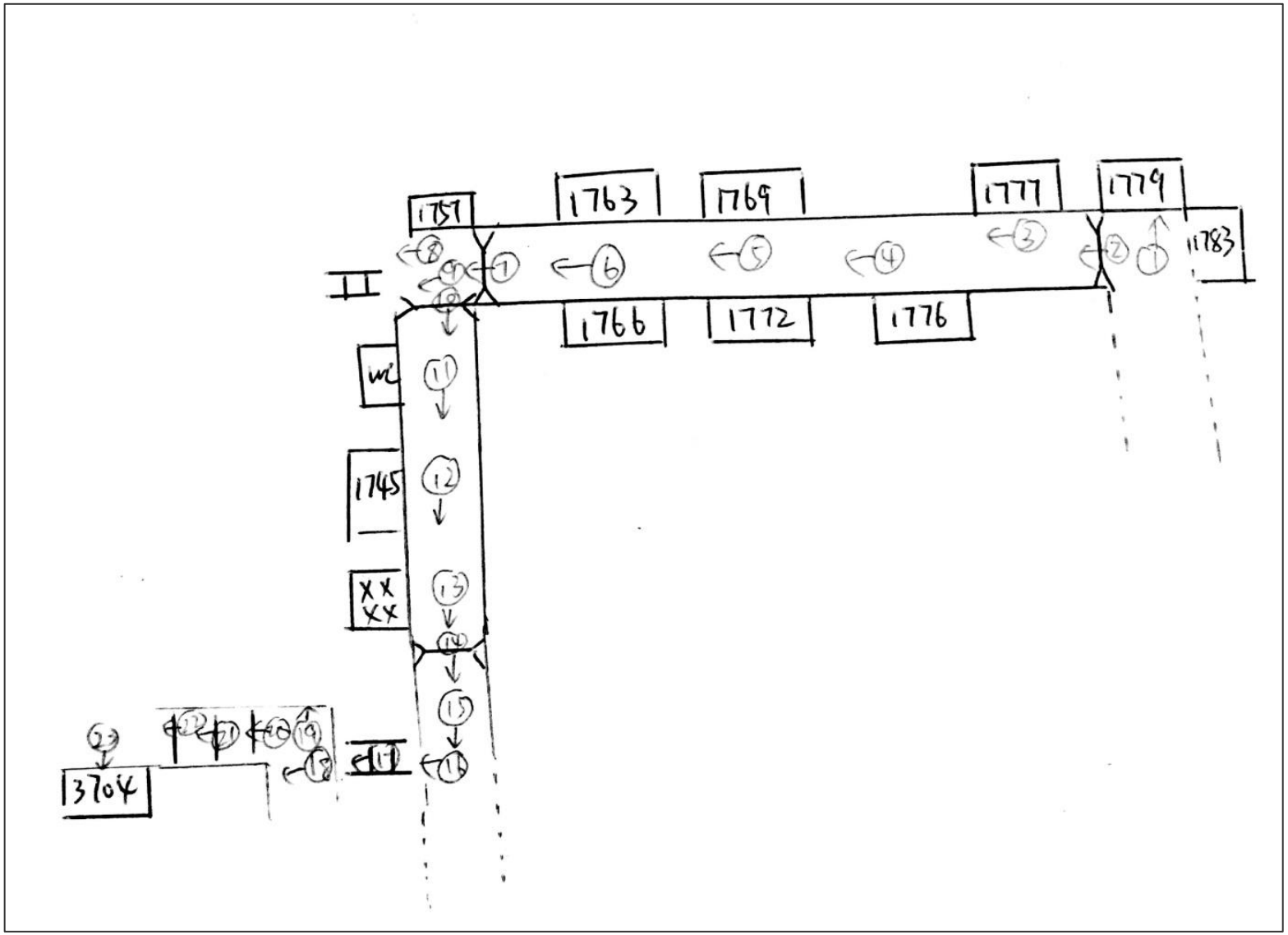


Door model



Correctly recognized door scenes with bounding boxes

Route 1 Floor Plan Draft

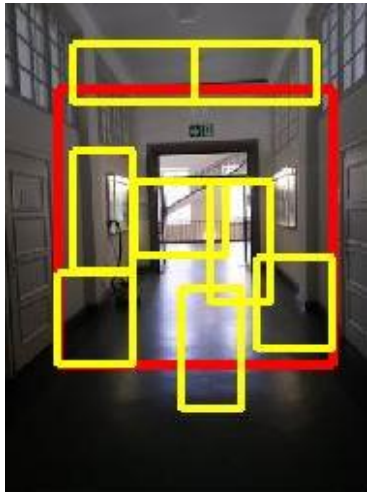


Indoor Scene Recognition Result

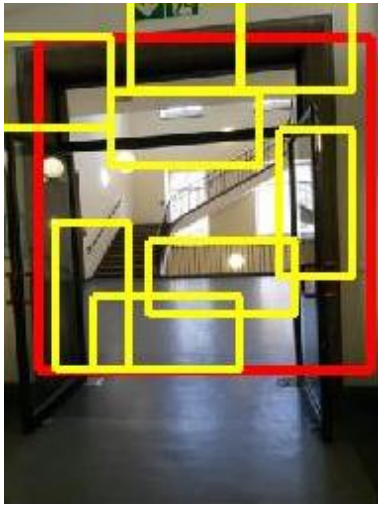
path1 = 'lobby' 'door' 'corridor' 'corridor' 'corridor' 'corridor' 'elevator' 'staircase' 'door' 'door' 'corridor' 'corridor' 'corridor' 'corridor' 'staircase' 'staircase' 'lobby' 'elevator' 'lobby' 'staircase' 'staircase' 'elevator' 'door'

Indoor Scene Recognition Result Analysis

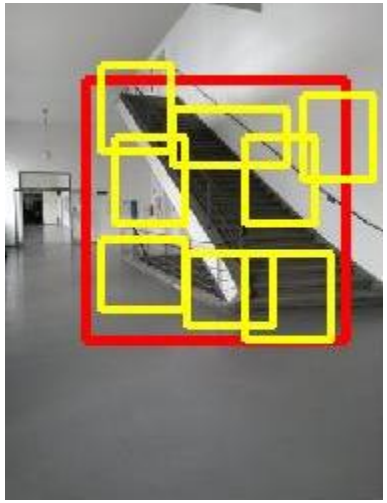
Scene 6.3-2
'door'



Scene 6.3-6
'corridor'



Scene 6.3-7
'elevator'



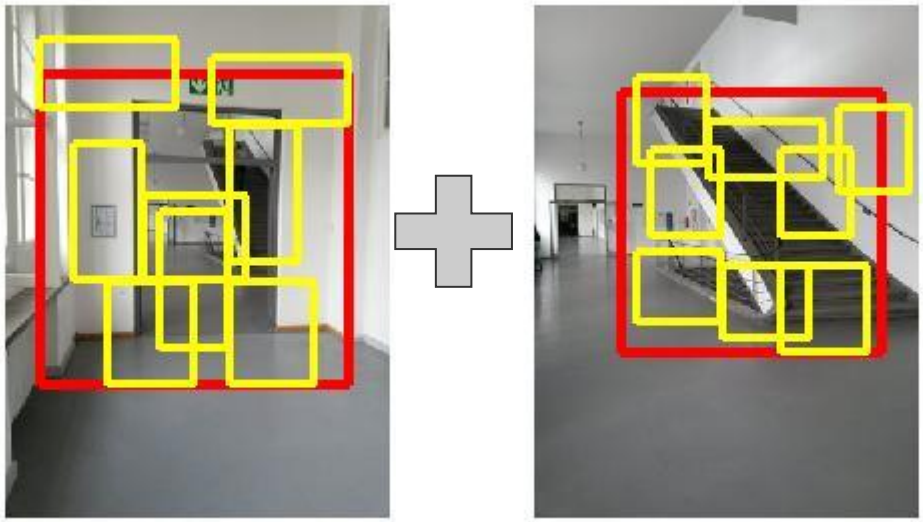
Scene 6.3-15
'staircase'

- Staircase, door and corridor can be recognized
- hierarchical recognition
- The recognition accuracy is 87%

- Three scenes are mistakenly recognized as elevator

Image Schema

Scene Label → Image Schema → Route Description



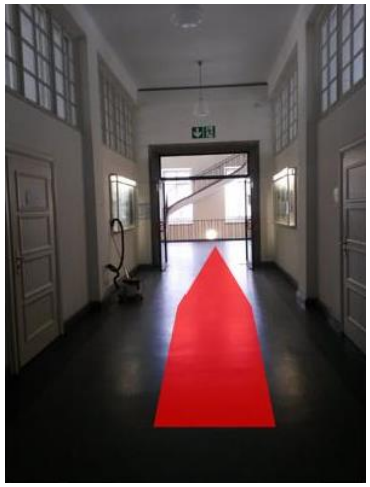
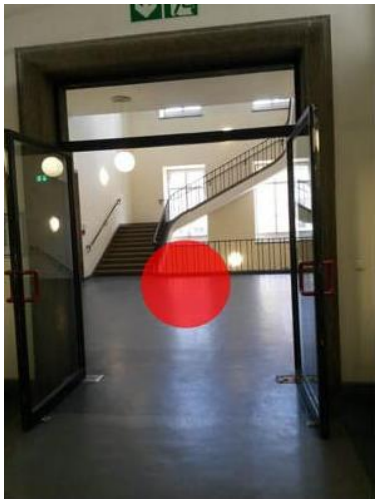
PATH_ALONG(I,corridor)
LINK(I,staircase)

I go along the corridor.
I see a staircase.

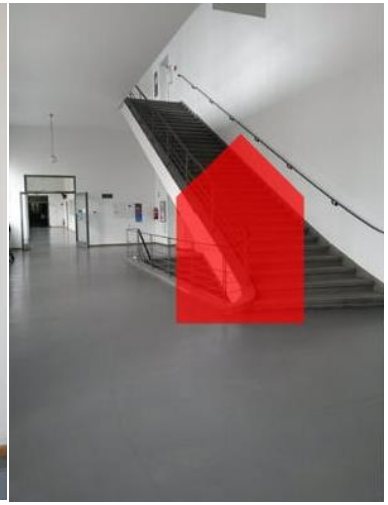
e.g. path from room 1779 to room 3704

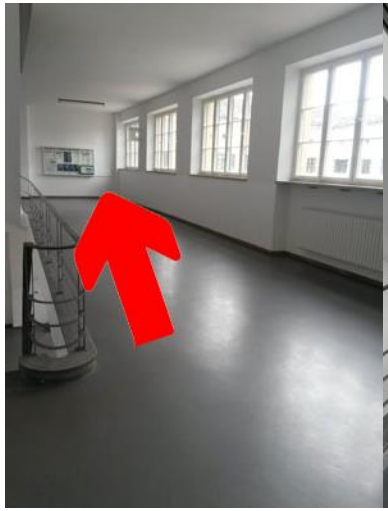
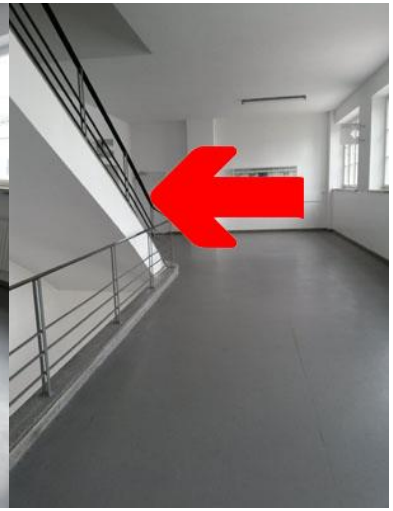
I start from here. I stand in the lobby. Turn left. I see a door. I stand in the corridor. I go along the corridor. I see a staircase. Turn left I see a door. I go through the door. I stand in the corridor. I go along the corridor. I see a staircase. I go up the staircase. I stand in the lobby. I stand in the lobby. I see a staircase. I go up the staircase. I see a door. I end here.

Route Visualization Result (1)

Route Visualization Result (2)



Route Visualization Result (3)

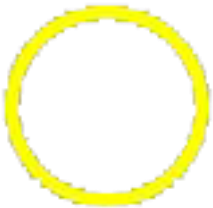
Background

- 8 students at an average age of 25
- Half of them come from electronic engineering department and the rest major in respectively industry design, geographic information system, communication engineering and physics
- Gender (5 males and 3 females)

Content of Experiment

- Symbol meaning guess
- Time record for each route
- Questionaire
  - Are you familiar with this route?
  - Do you think those images help you better find the way?
  - Comments (How do you feel about those visualization results? Do you think what can be improved? Do you think it's significant to do route visualization?)

Symbol Guess Result (1)



Most of them connect these two symbols with traffic signals and believe they have the same meaning with yellow traffic light and green traffic light. Only one of them guesses that they are related with destination.
After explaining, one of them suggests that green should be starting point because green represents continuing; another one suggests the destination can be marked with a flag instead.

More than 60% guess this symbol as “stop”, which is the exact meaning designed for. 25% of them think this symbol as some kind of warning or forbidden.

40% of them guess this symbol as going straight or walking on the road; 25% think it means going upward.

Symbol Guess Result (2)

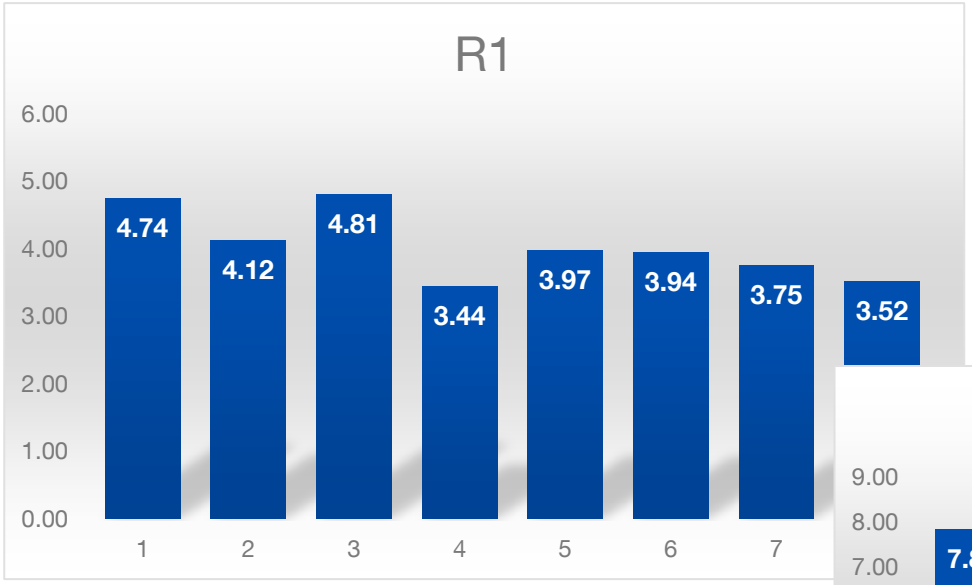
All of them understand this pair of symbol represents a contradiction, but none of them connect those symbols with staircase.

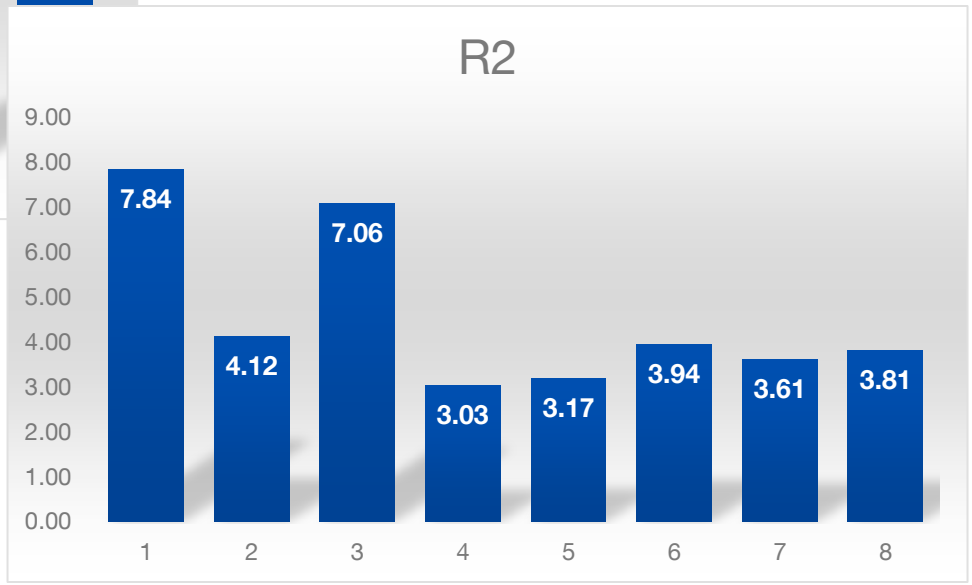
All of them understand it means turn left or to other directions.

According to their feedback about those symbols, 25% of them regard the navigation arrow and staircase symbol as the same; one out of eight suggests the direction symbol is better than navigation arrow and they both have similar meaning.

Result Analysis (1)

$$R_n = \frac{route(n)}{test\ time}$$





Result Analysis (2)

2-13

2-14

2-15

2-16

Improvement

2-15-1

3-33-1

3-36-1

Add sign "*Open the Door*" to 2-15 to remind people they should open the door in order to go to next step.

Increase illumination of those images relating to elevator so that elevator is easily distinguished. In 3-33-1, downward button is emphasized by magnifying; in 3-36-1, floor number button is also emphasized by adding an extra magnifying letter to original image.

Conclusion

- This paper focused on route visualization and proposed a systematic method, which is an innovative framework extended from image schema to process similar visualization workflow, to deal with overall process from dataset to visualization result.
- Firstly, the whole route was treated as a combination of consequent separate scene images, which are related to what people perceive when they walk on specific route and are selected depending on their importance that may affect decision that people might make.
- Secondly, previous scene recognition method was adapted and recognition accuracy was increased by reducing classes of final results. Accuracy of route 1 is 87%, route 2 is 85% and route 3 is 82.5%.
- Thirdly, visualization strategy was made and symbols were designed basically to highlight and point out where people should go next.
- Finally a user test was conducted and nearly all test objects performed better by applying visualization strategy in this thesis, thus effectiveness of this method was proved.

Potential Work

- understand the underlying mechanism of machine learning method so that training algorithms for dataset can be optimized and accuracy can be improved.

- landmark extraction and recognition is also a promising research direction as it can provide more additional information for people. In this paper, those critical structures (corridor, door, elevator, lobby and staircase) can also be treated as landmarks, but more objects such as food automat, WC sign and garbage box need to be extracted from images.

- automatic visualization of symbols, especially those turn-left/right arrow is challenging and need to be studied in the future in terms of placement and direction.

Q&A
Thank you!