SPACE IDENTIFICATION AND SPACE SUBDIVISION: A POWERFUL CONCEPT FOR INDOOR NAVIGATION AND NAVIGATION

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CONTENT

- Spaces
- Sims3D
  - BIM as input model
  - Point clouds as input model
- Accessibility
- Space assisted localization

MOTIVATION

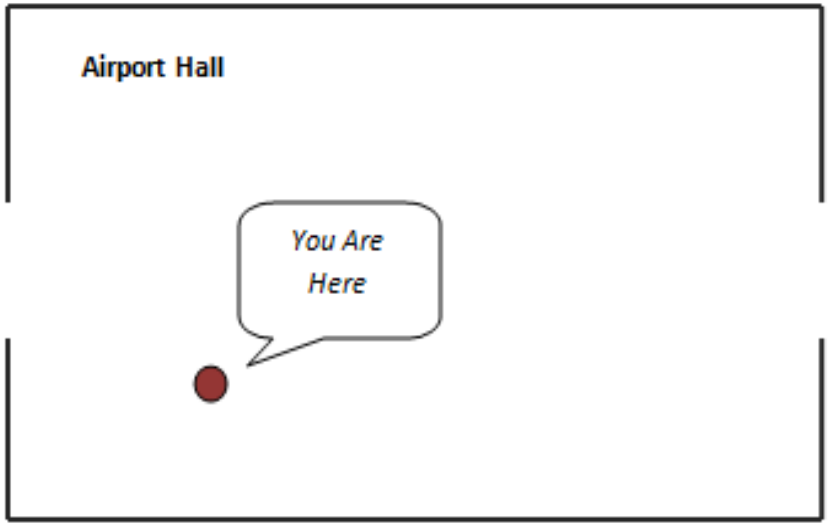
Rooms are represented as single indivisible spaces or subdivided according to a geometric criteria

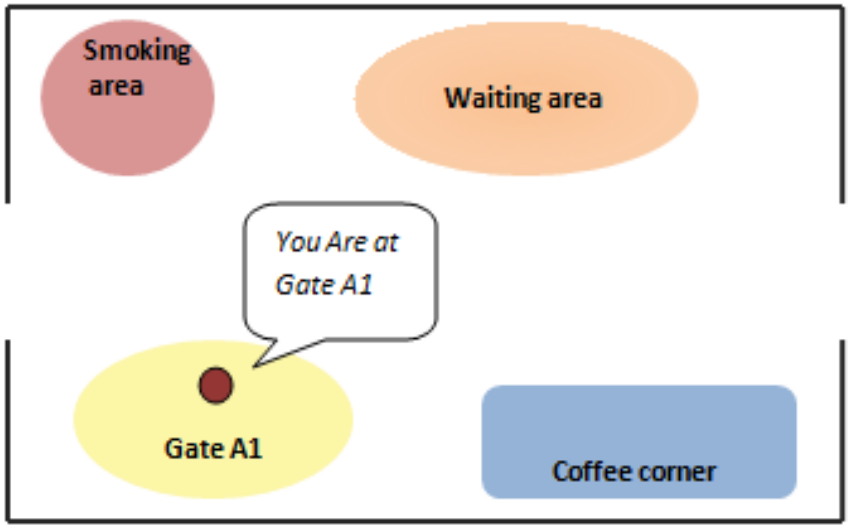
- No information on free of obstacle areas

- No descriptive localisation
- No possibilities to navigate to those areas

=> no clear network pattern

Subdivision!
Semantic identification!



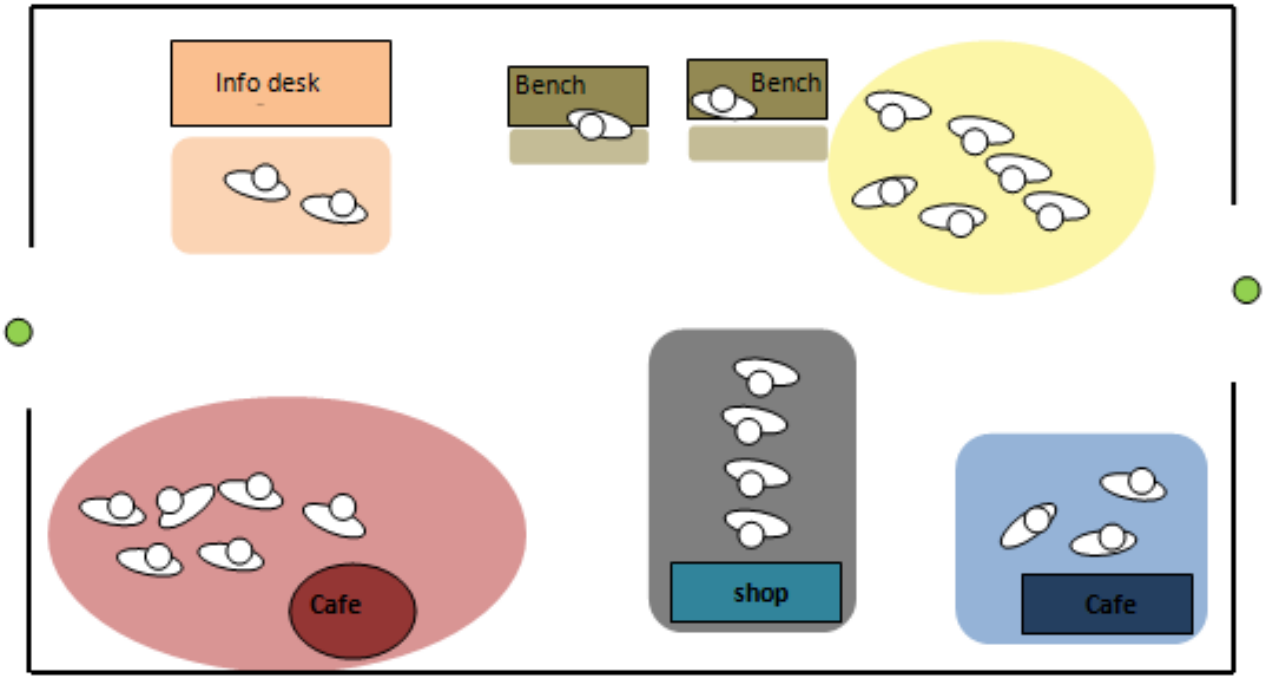


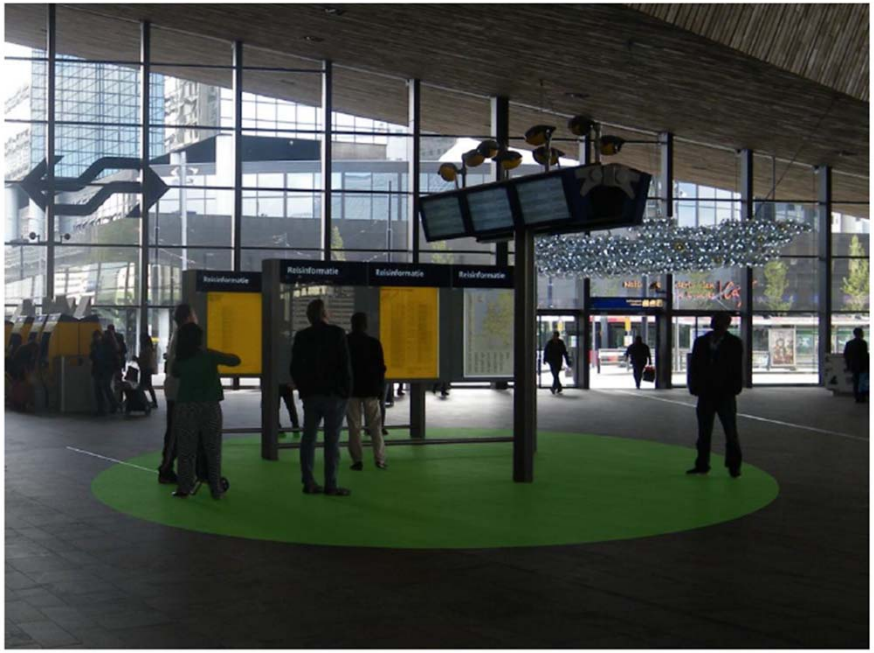
WHAT DOES INFLUENCE SUBDIVISION?

People: presence and their behaviour

Objects in indoor environment

=> navigable and non-navigable areas

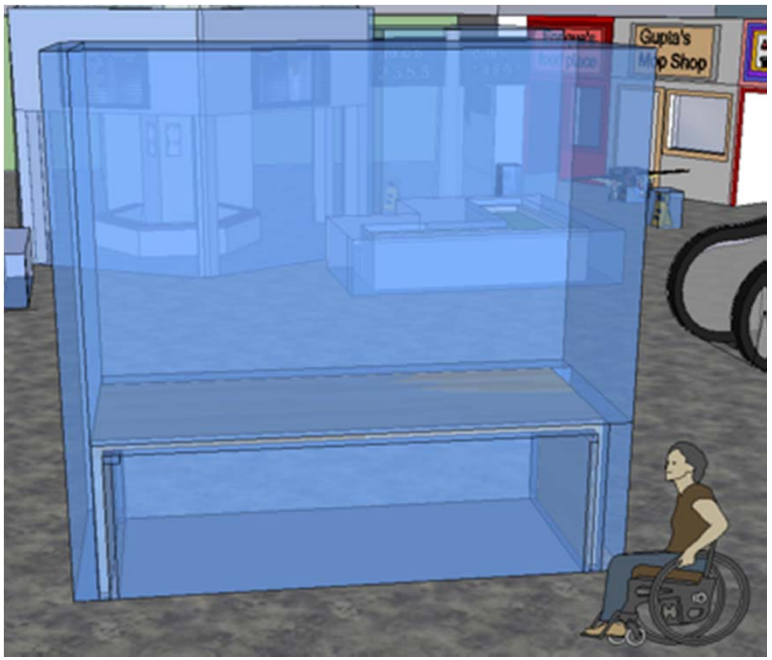




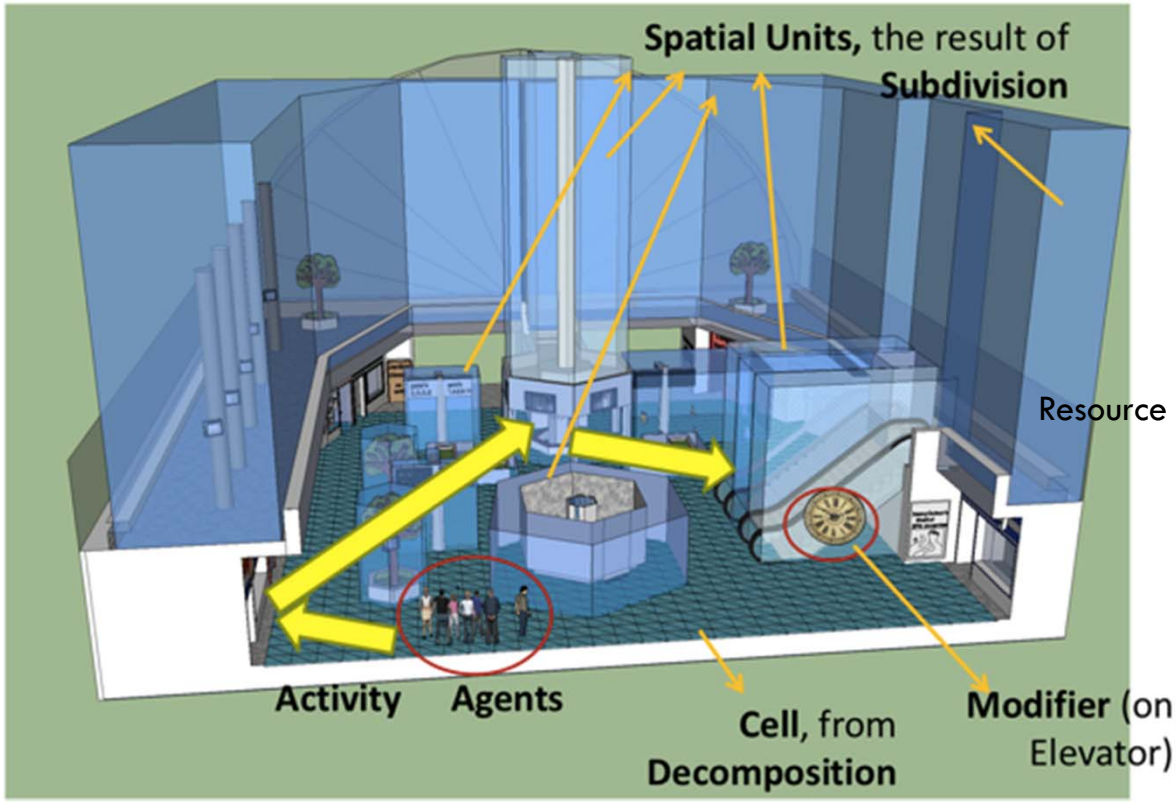
Indoor Space Subdivision for Indoor Navigation, 2014, Kruminaite, M. and S. Zlatanova, ISA'14, Proceedings of the Six ACM SIGSPATIAL International Workshop on Indoor Spatial Awareness, pp. 25–31

3D SUBDIVISION

Navigable / Non-navigable



HOW TO IDENTIFY NAVIGABLE SPACE?



A Conceptual Framework of Space Subdivision for Indoor Navigation, 2013, S. Zlatanova, S., L. Liu, and G. Sithole, ISA '13 Proceedings of the Fifth ACM SIGSPATIAL International Workshop on Indoor Spatial Awareness, ACM New York, NY, USA. pp. 44-48.

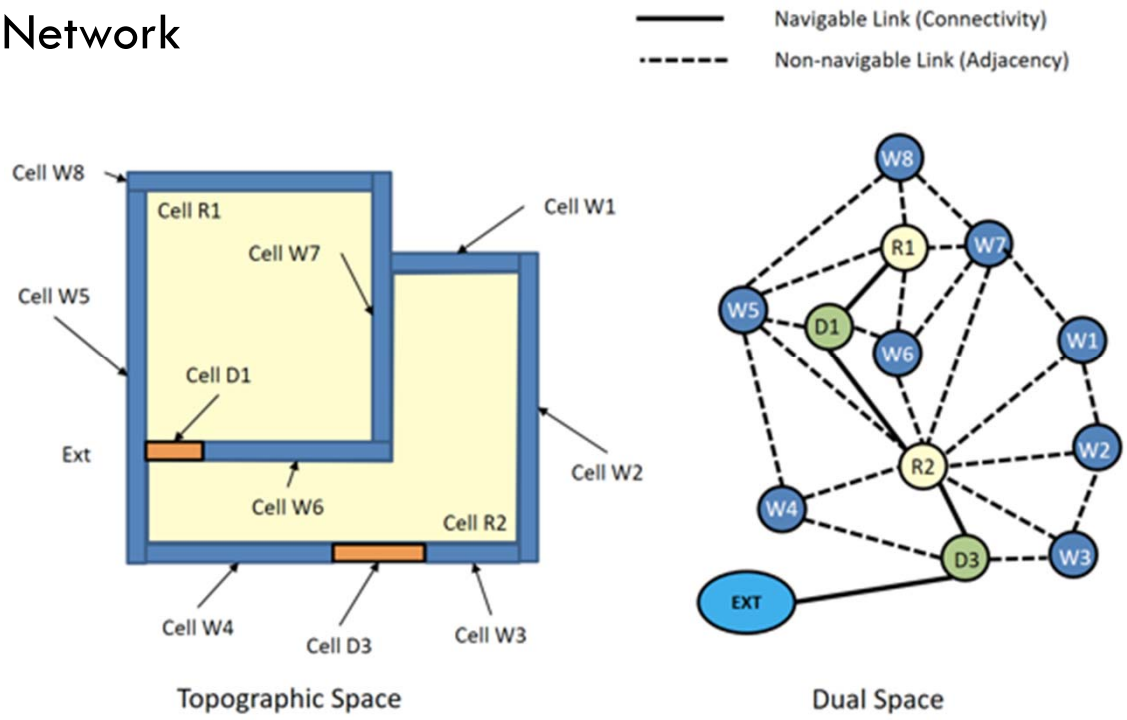
SPACES: INDOORGML (2008)

How to provide guidance?

Geometry + Semantic = Model

+ Connectivity = Network

+ Accessibility = Context Network

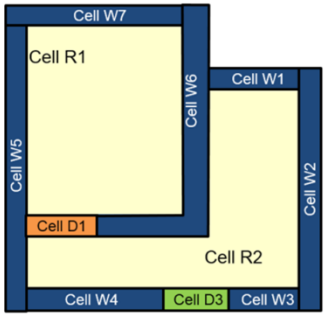


http://www.opengeospatial.org/standards/indoorgml
(since 2014)

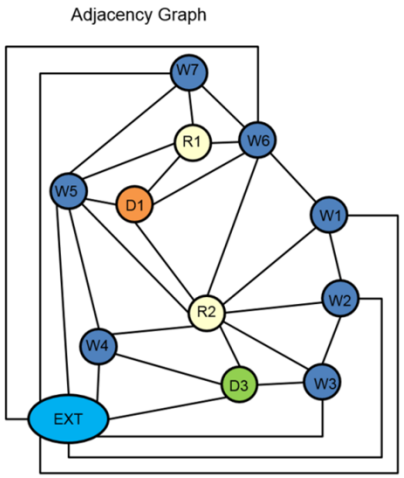
INDOORGML SPACES

Non-overlapping space subdivision

Space identification



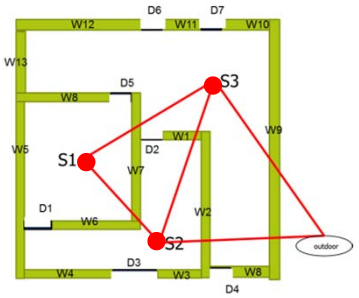
Primal Space



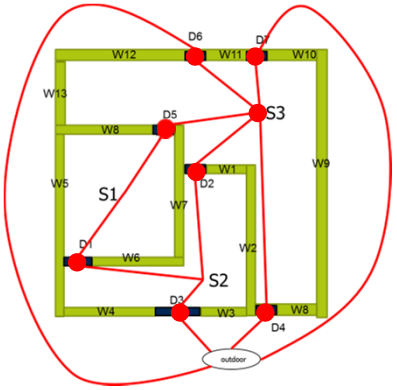
Dual Space

Green/White: primal space

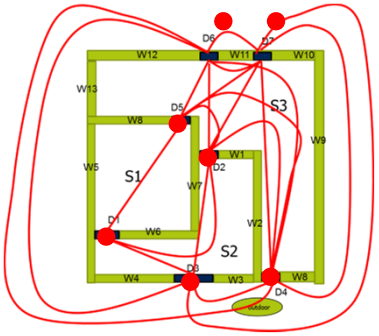
Red: dual space



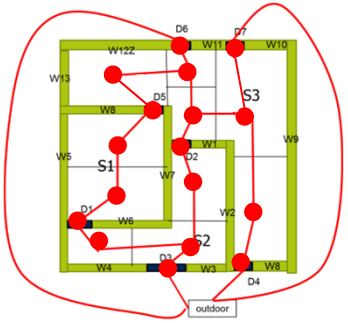
'Thin' door



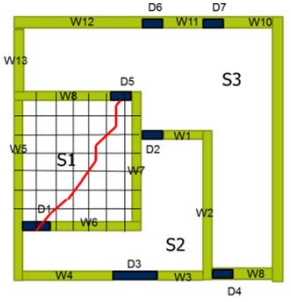
'Thick' door



'Thin' room (visibility graph)



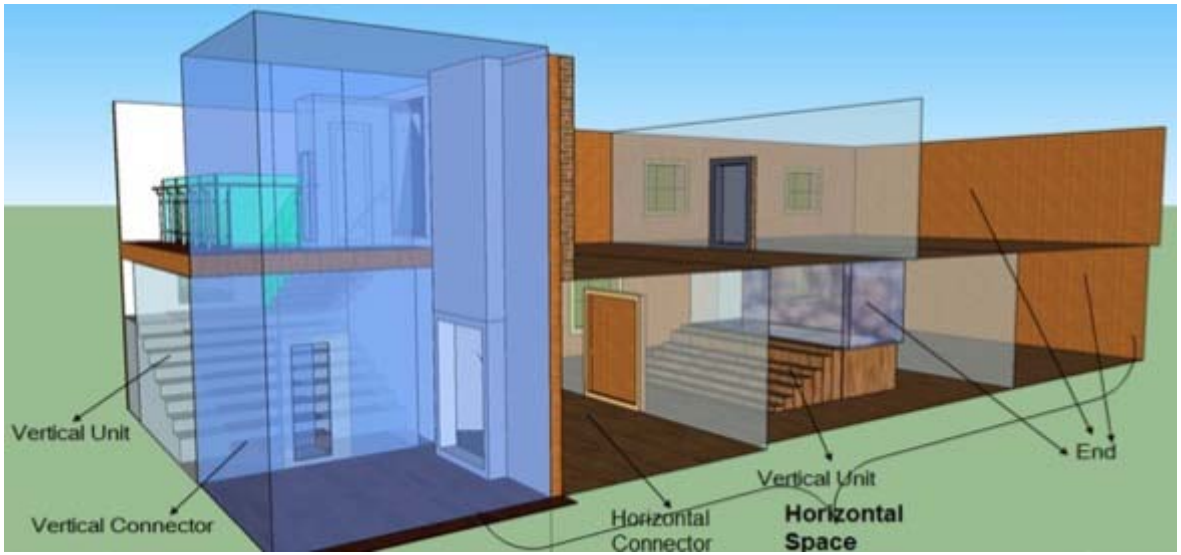
Space subdivisions

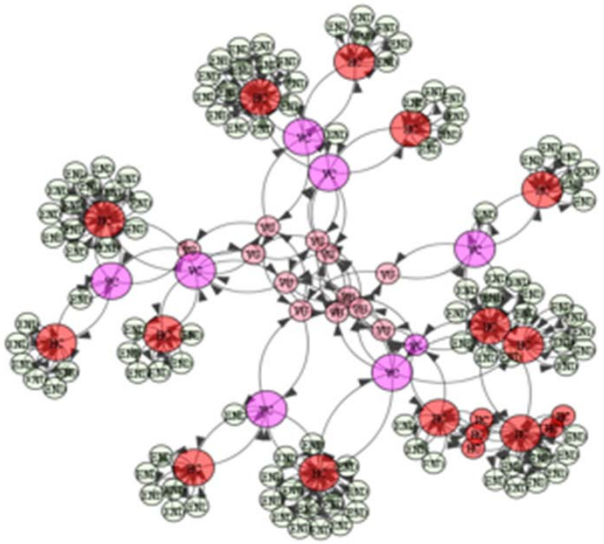


SEMANTICS

More information = More possibilities

PhD thesis completed 2017: Indoor Semantic Modelling for Routing





Liu, L, 2017, Indoor Semantic modelling for Routing, PhD Thesis

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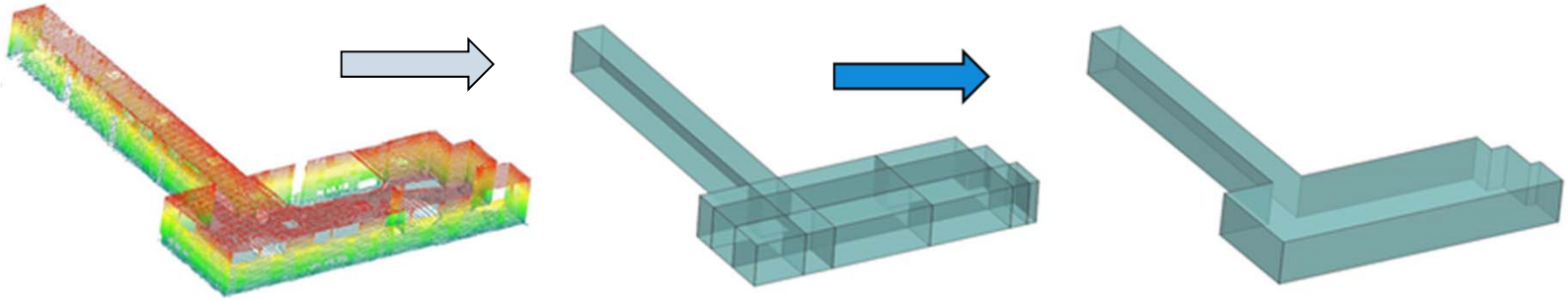
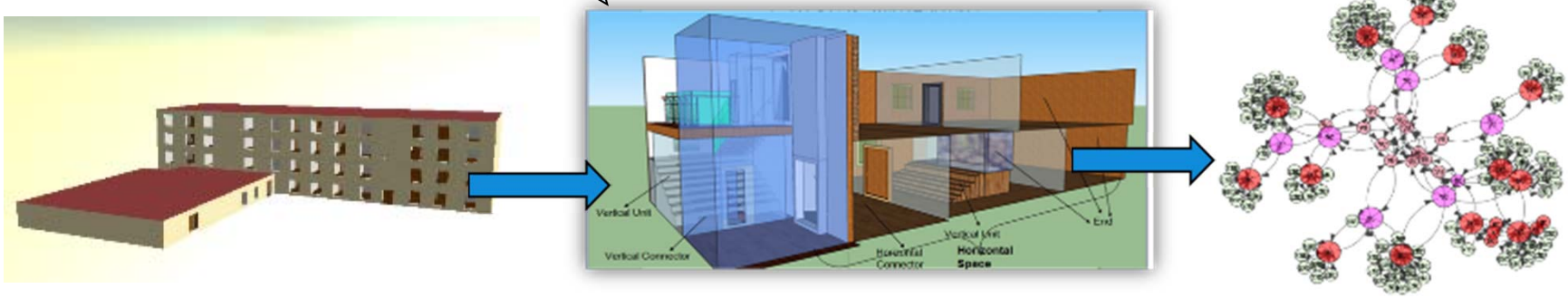
  - BIM as input model
  - Point clouds as input model
- Accessibility
- Space assisted localization

3D RECONSTRUCT & 3D SUBDIVIDE



point cloud cuboid shapes final model



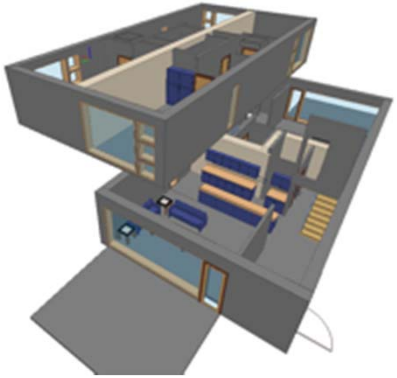
- 3D model space subdivision network

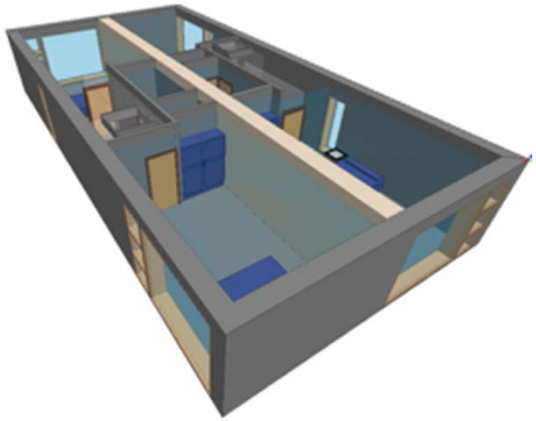
www.sims3D.net

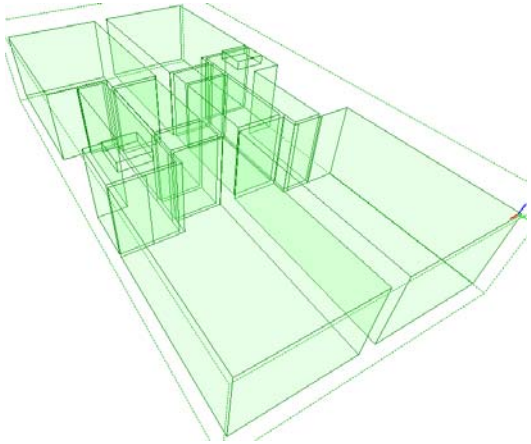
BIM AS IMPUT MODEL

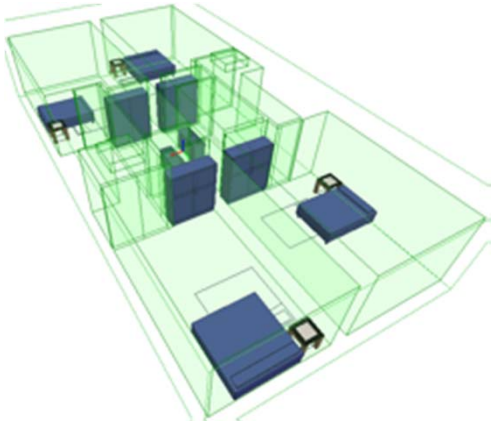
- 3D indoor semantic models can provide good description.

- IFC :
- The indoor spaces (IfcSpace)
- The furniture elements (IfcFurnishingElement)
- The openings (windows and doors)
- Spatial links between the objects









SPACE SUBDIVISION: HOW?

Flexible Space Subdivision (FSS) framework.

Mobility of objects:

Static (S-objects) e.g. wall

Semi-mobile (SM-objects) e.g. furniture, crowd

Mobile (M-object) e.g. human

Subspaces:

Object spaces (O-Spaces) -> SM-objects

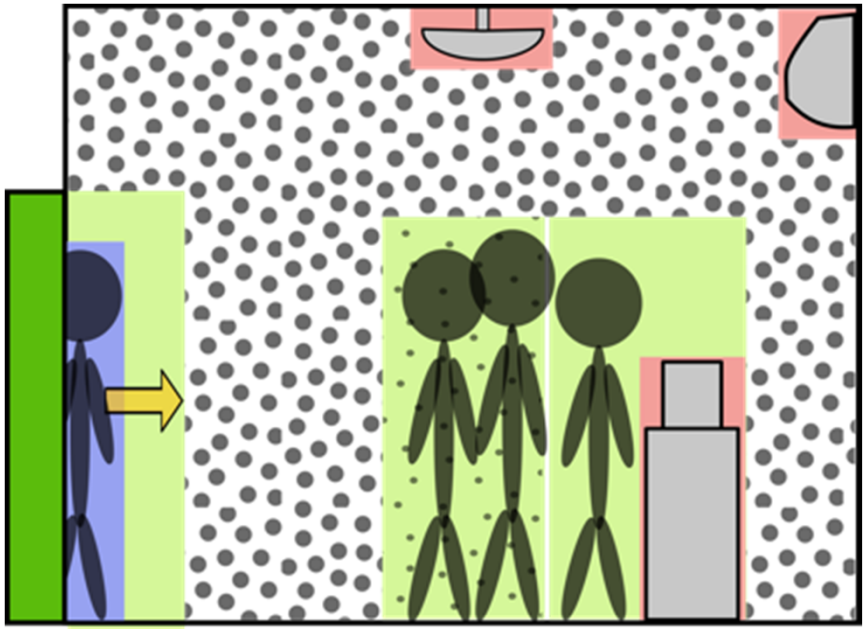
Functional spaces (F-Spaces) -> SM and M-objects

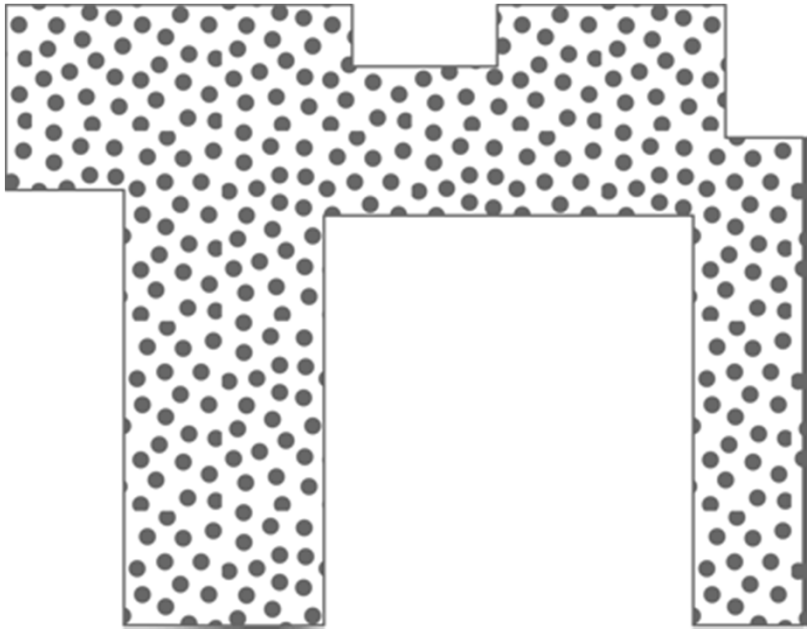
Remaining free spaces (R-Spaces) -> M-objects

Spatial subdivision of complex indoor environments for 3D indoor navigation. 2018 A. Diakité and S. Zlatanova. International Journal of Geographical Information Science (IJGIS), Vol.32, Issue 2, pp. 213-235

SPACE SUBDIVISION: FFS

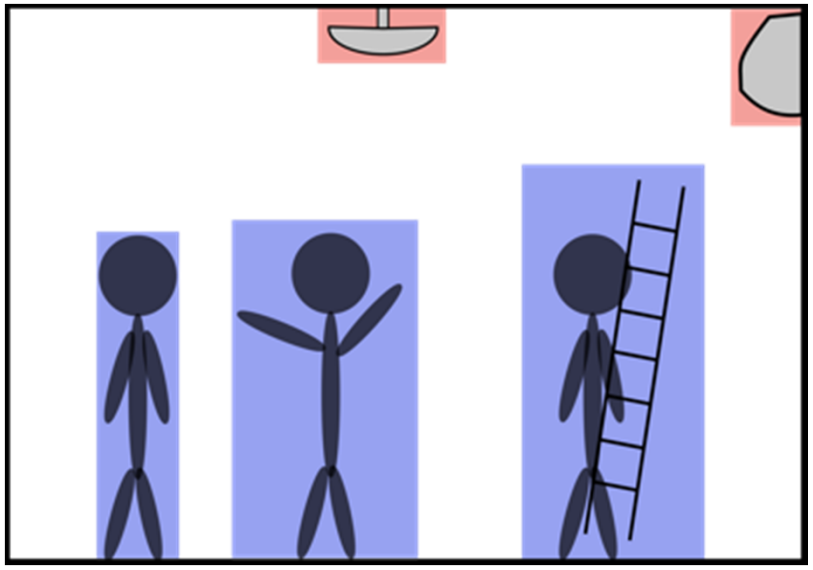
Remaining free space

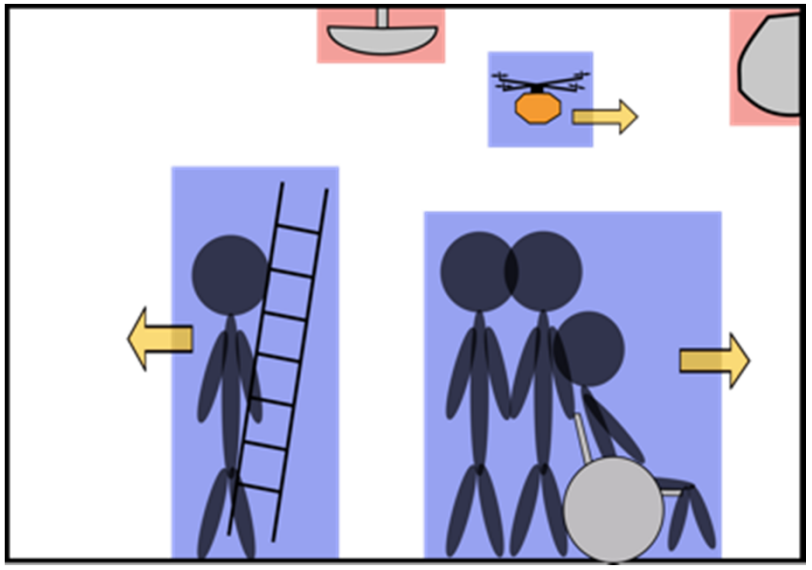




AGENT SPACES (A-SPACES)

The space needed for navigation => spatial constraints of the moving agents and the resources they may carry.



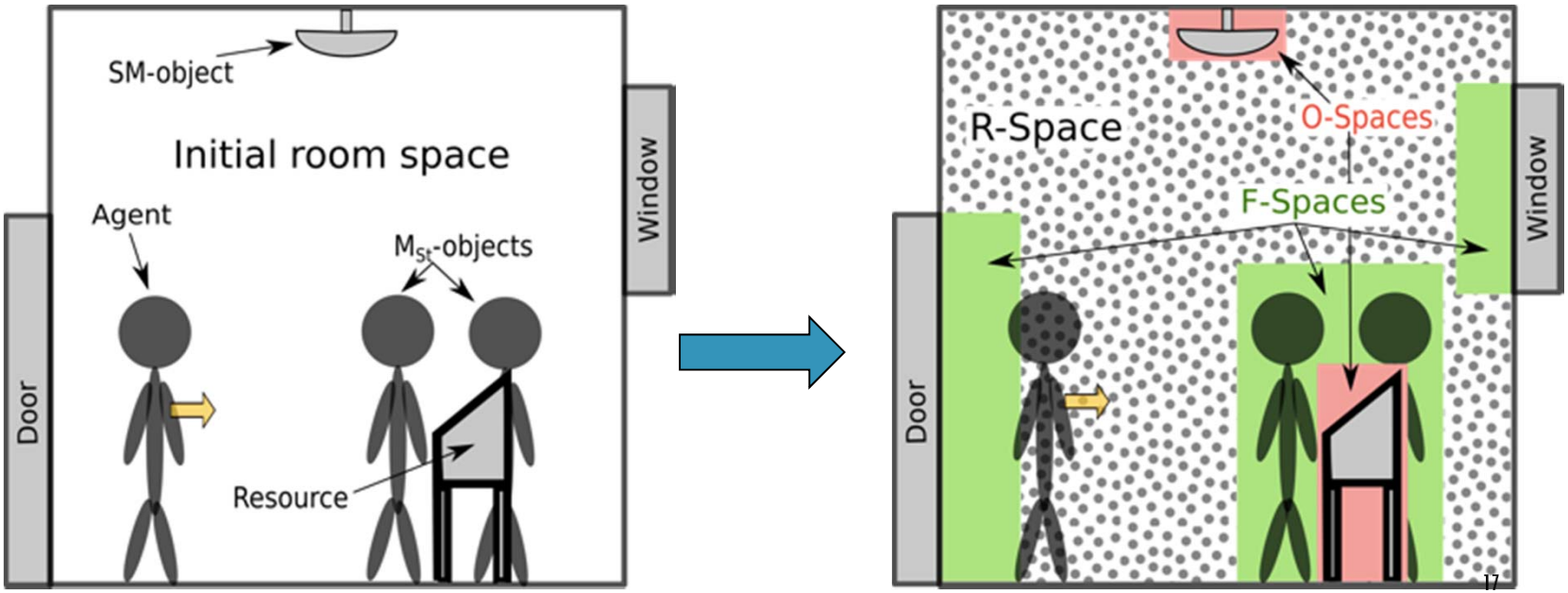


SPACE SUBDIVISION: FFS

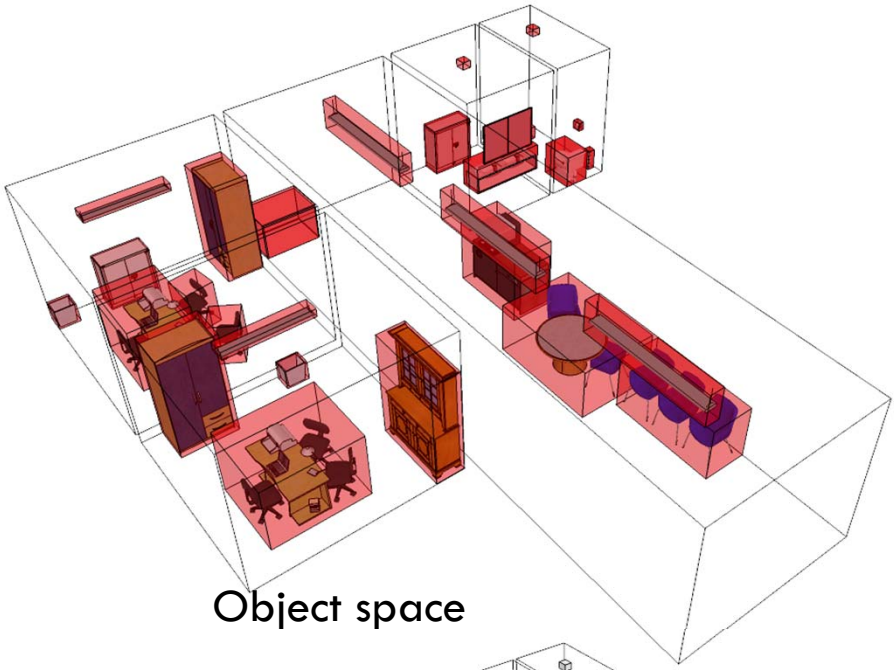
No conflict between subspaces: priority rules

Spatial relationships maintained.

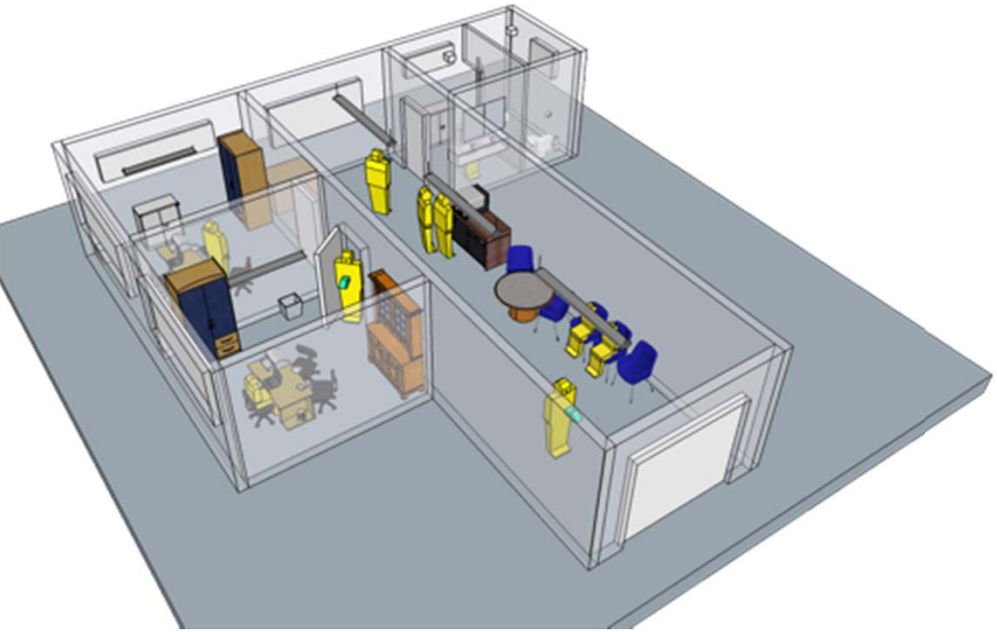
Special interaction with the A-Spaces.



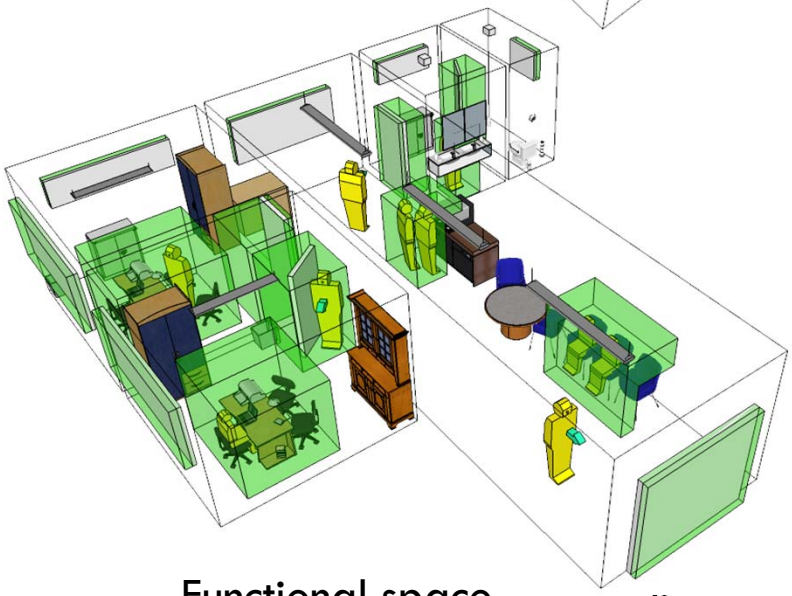
CASE STUDY



Object space

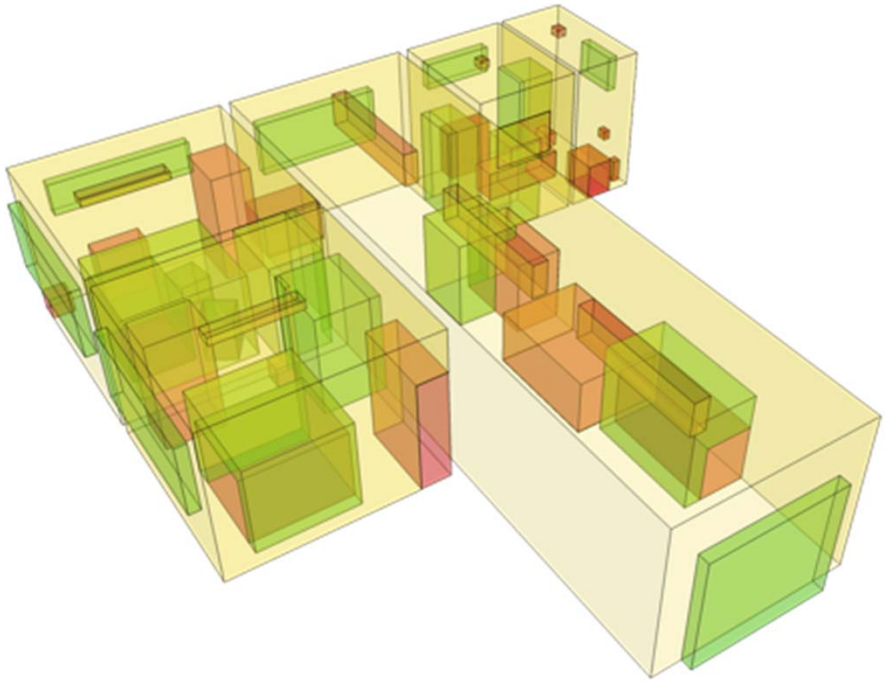


Original BIM model

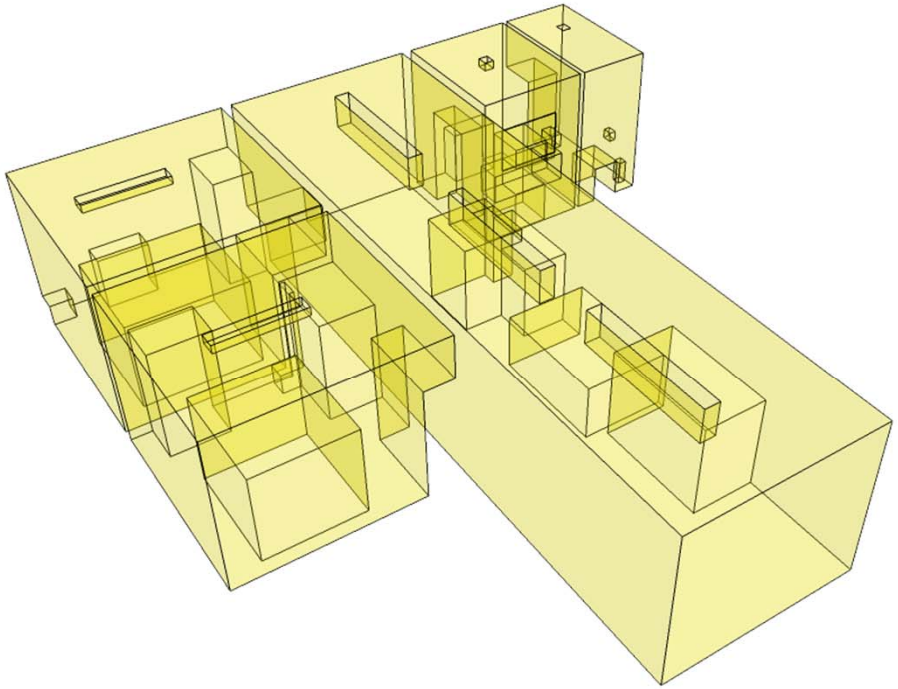


Functional space

CASE STUDY

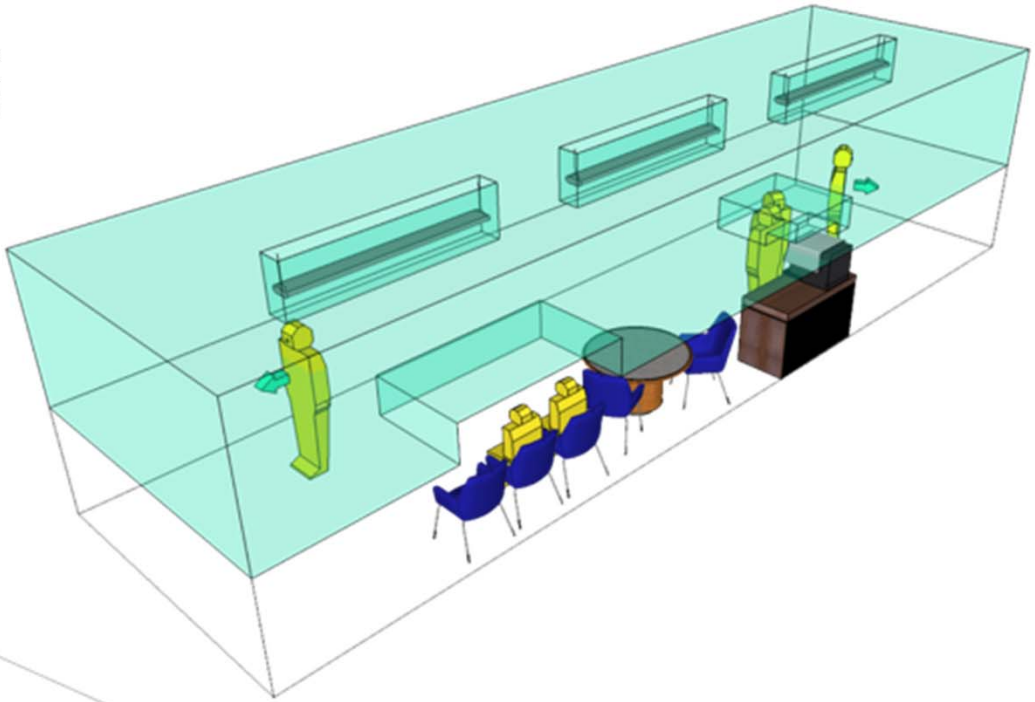


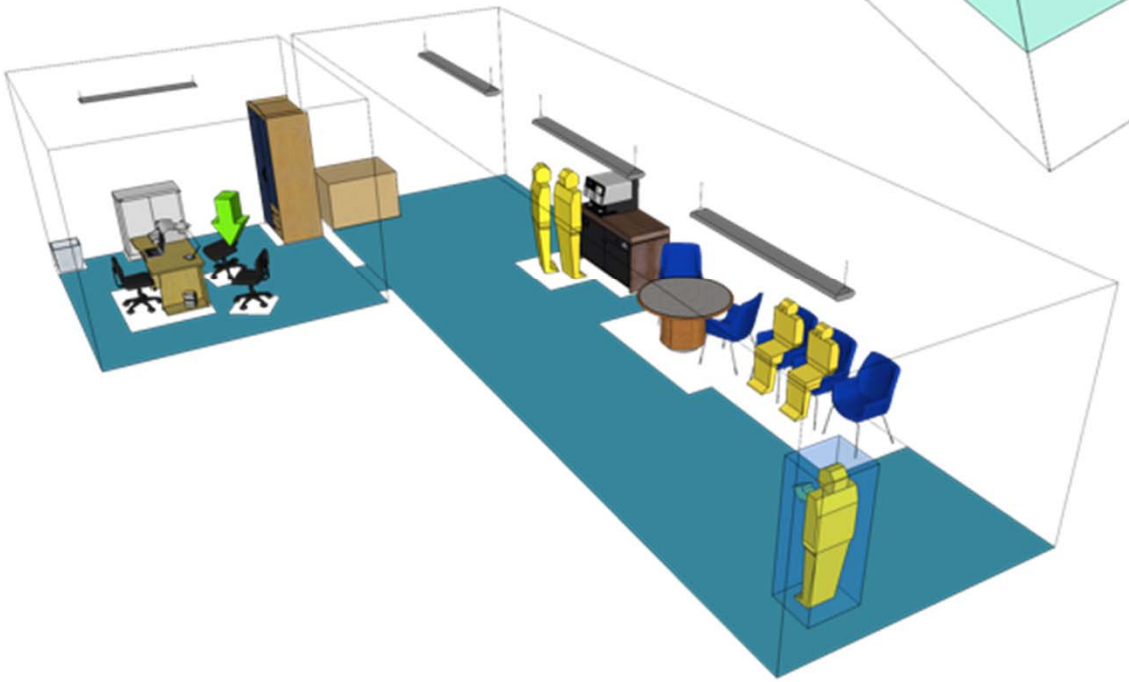
FFS subdivision



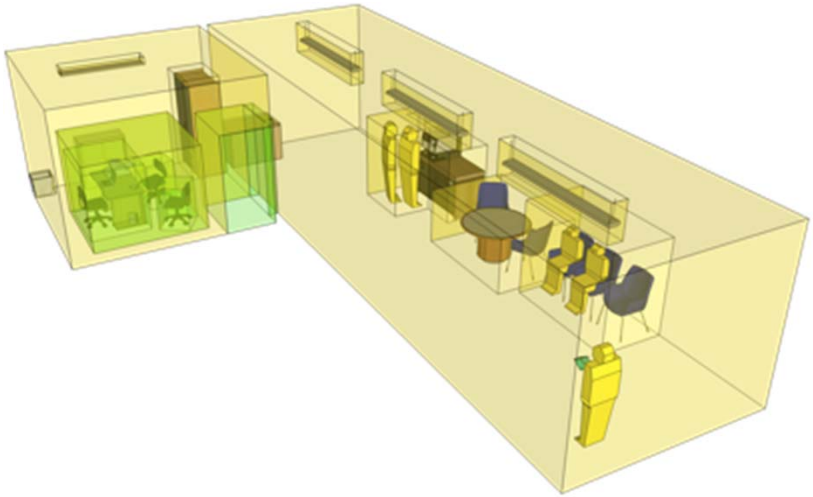
Remaining
(Navigable) Space

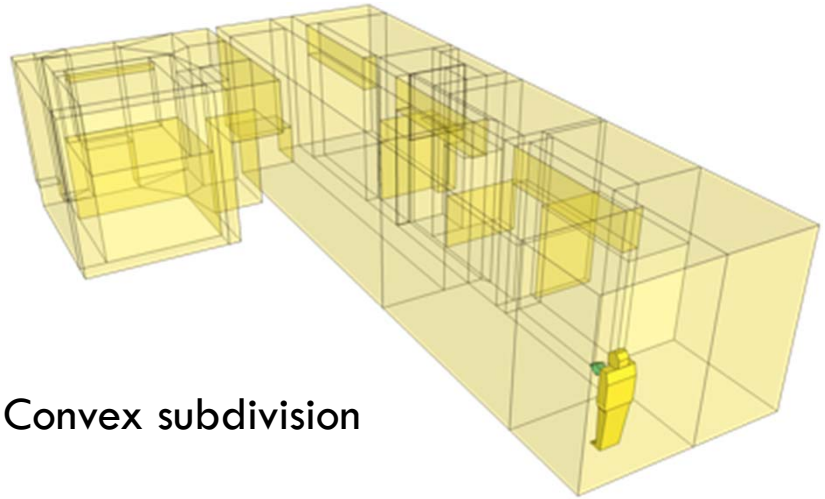
WALKING, FLYING



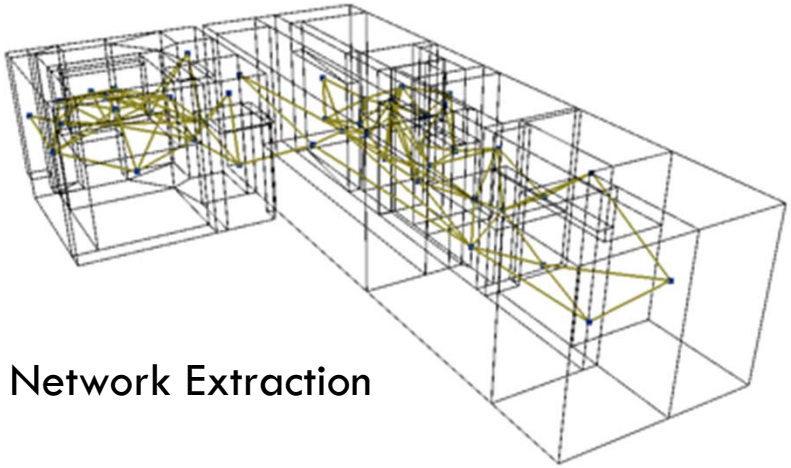


NETWORK FOR PATH COMPUTATION

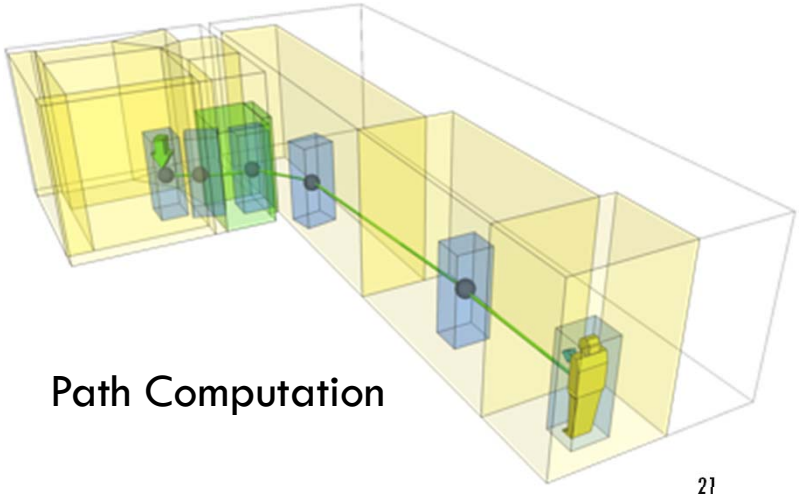




Convex subdivision

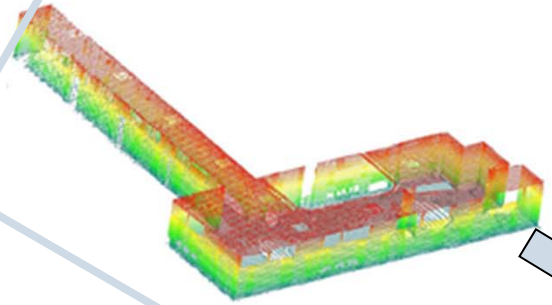


Network Extraction

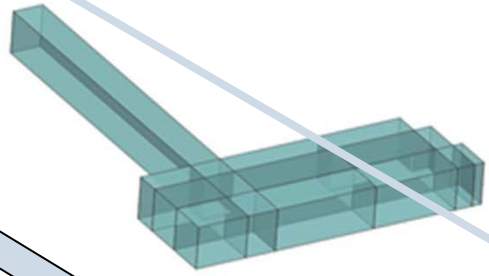


Path Computation

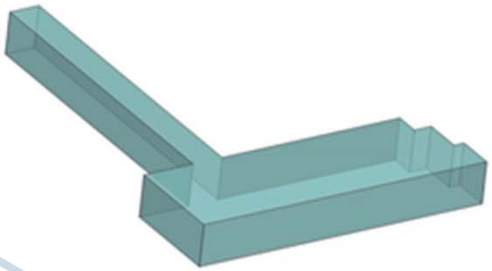
3D RECONSTRUCT & 3D SUBDIVIDE



point cloud

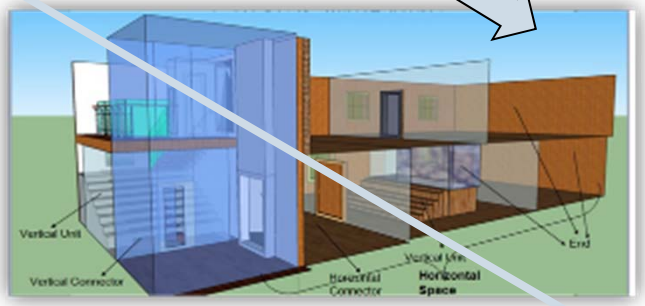


cuboid shapes

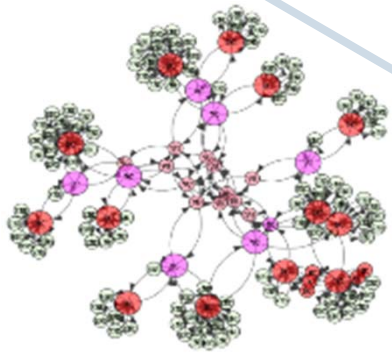


final model

- 3D model

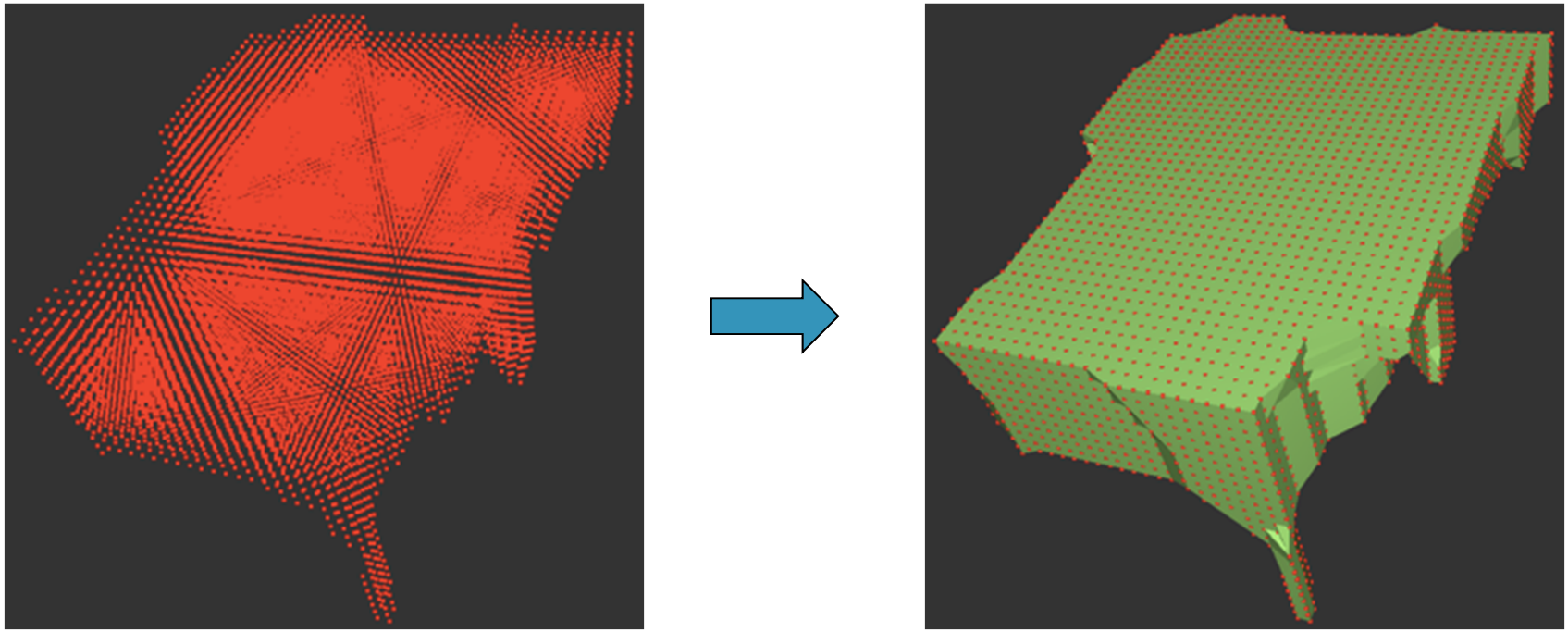


space subdivision



network

ONGOING

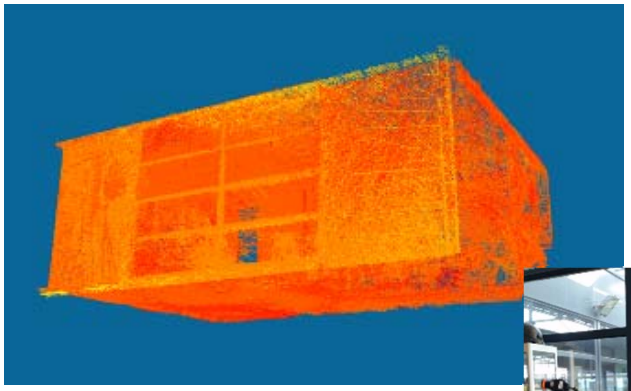


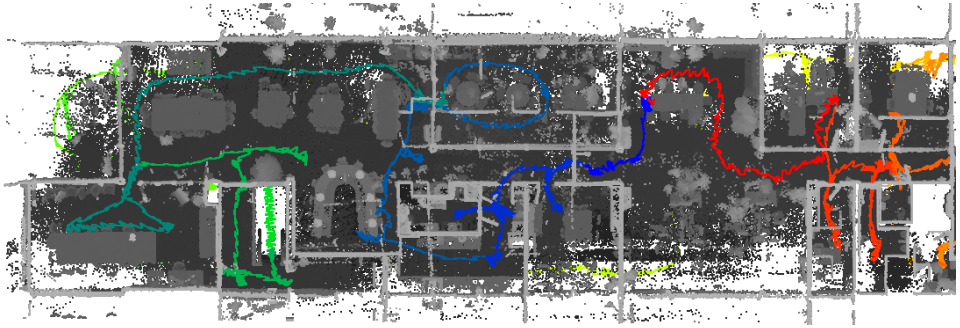
3D RECONSTRUCTION

Permanent structure reconstruction, wall detection

Room classification

Opening detection from cluttered data: door, window

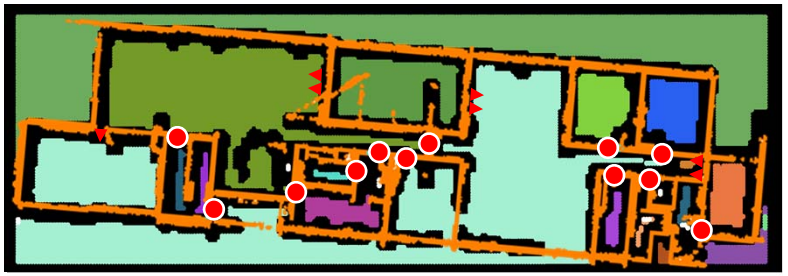




ITC

SPACE PARTITIONING AND NAVIGABLE SPACE

Space partitions

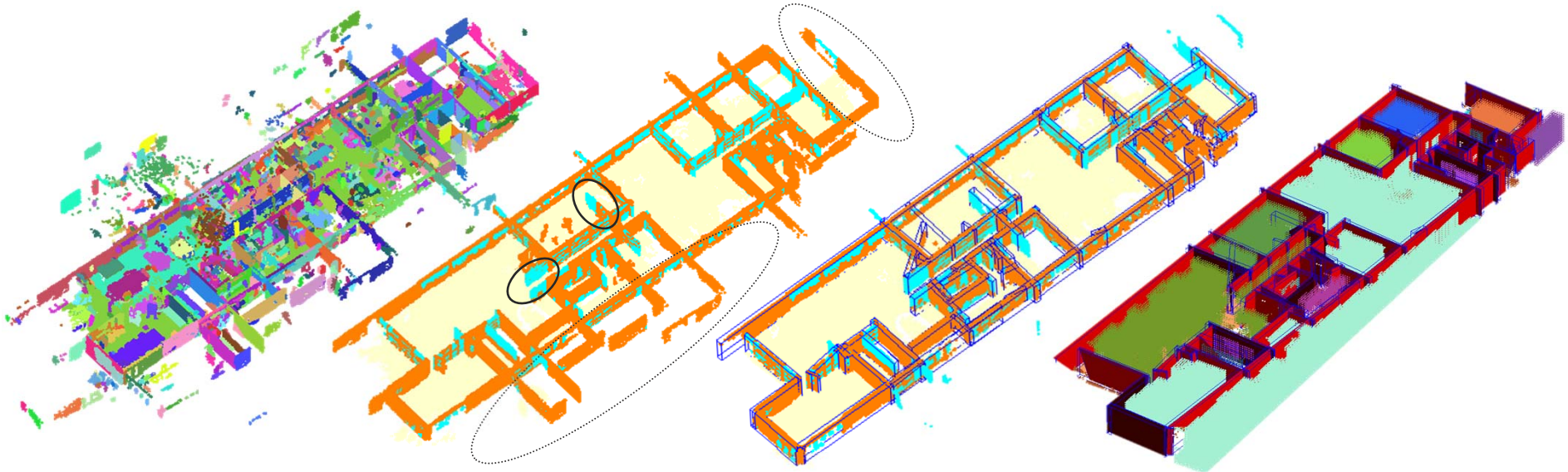


Space partitions, walls and doors

Space partitions and ground truth walls

Space partitions and navigable space

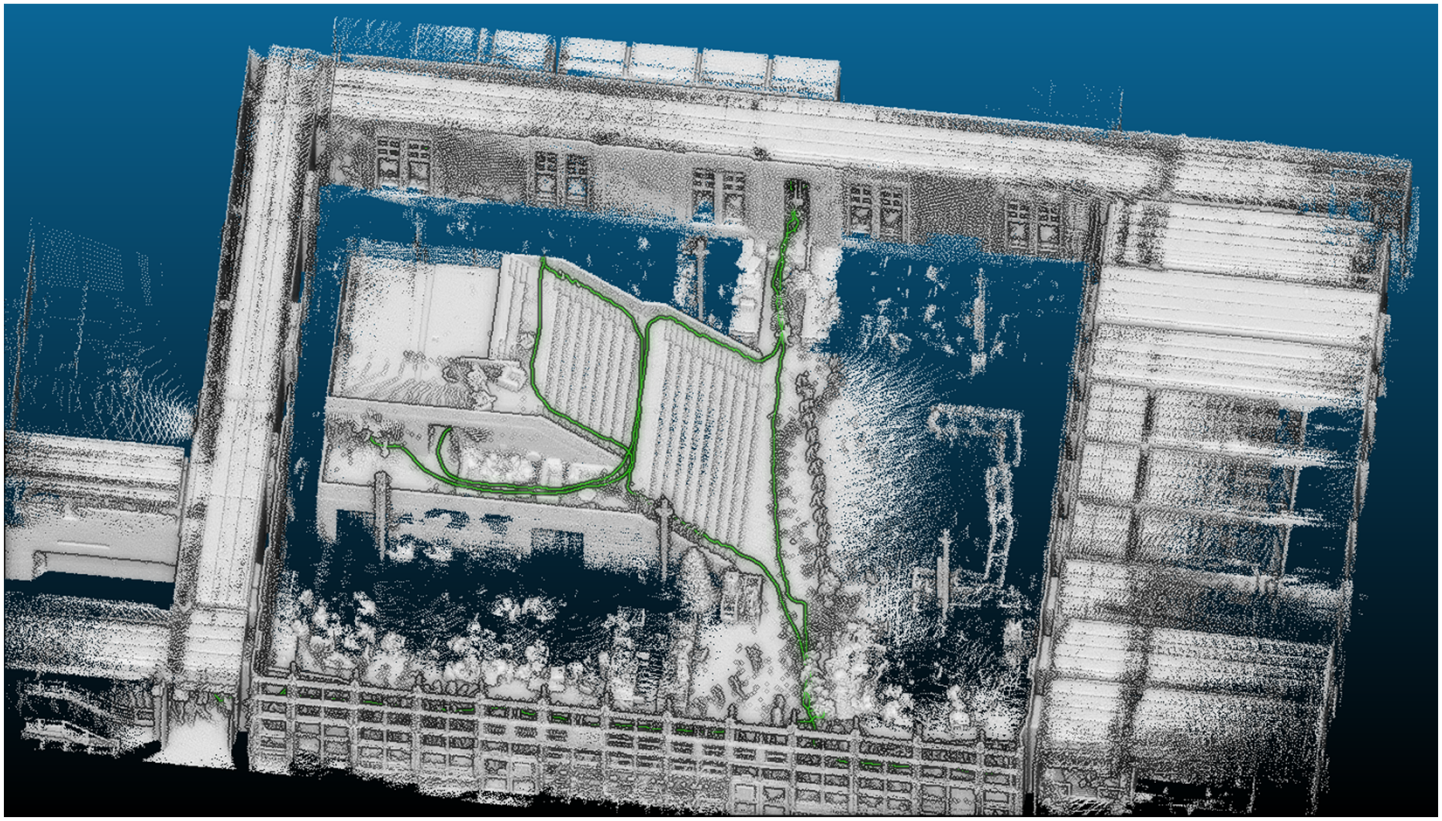
ANOTHER VIEW



Point clouds Openings Wall Faces Space Partitions

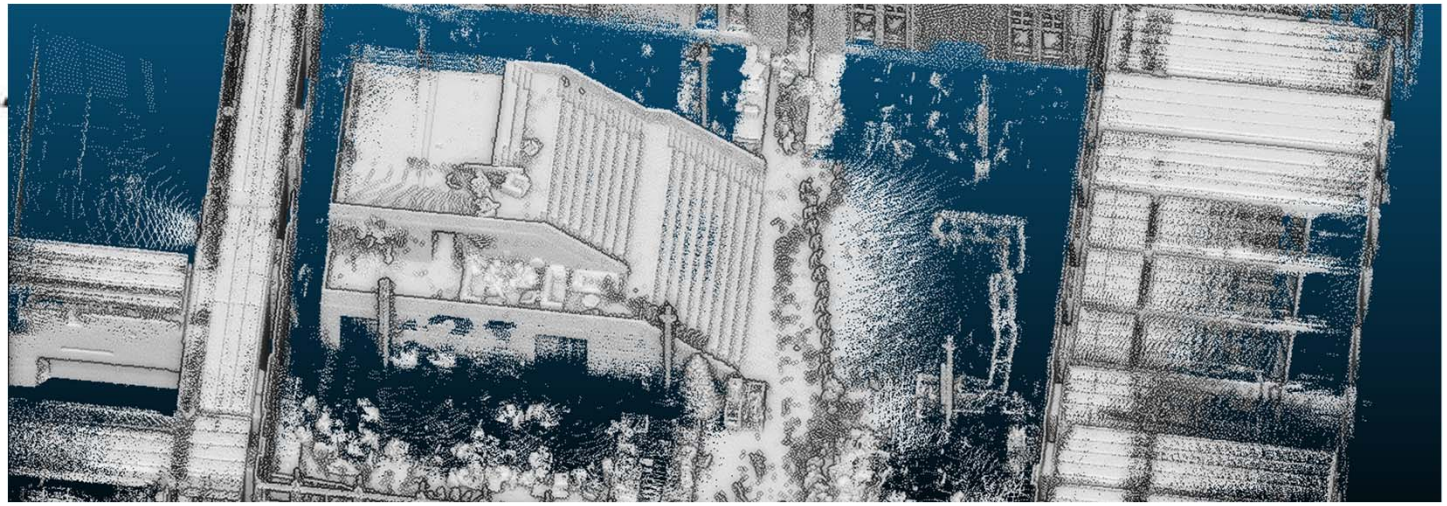
Exploiting Indoor Mobile Laser Scanner Trajectories for Semantic Iterpretation of Point Clouds. 2017, S. Nikoohemat, M. Peter, S. Oude Elberink, and G. Vosselman, ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences, IV-2-W4, 355-362, 2017. (best paper young author)

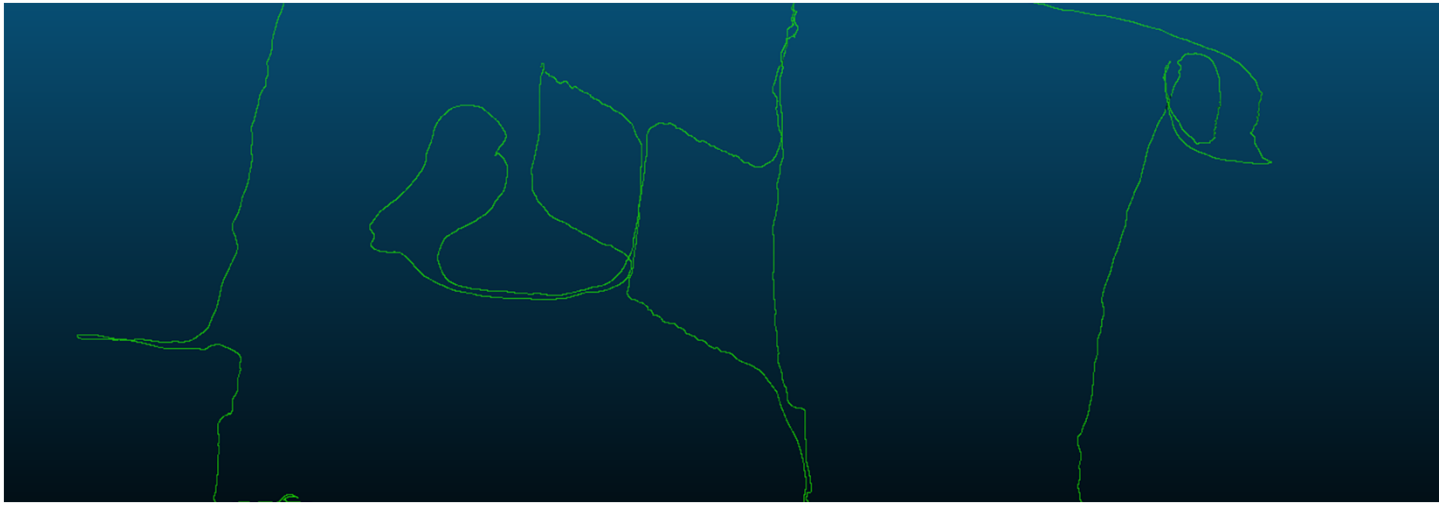
SPACE SUBDIVISION WITH RESPECT TO WALKABLE SURFACES



CGI

TU Delft



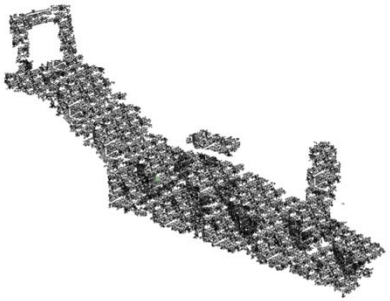


CGI

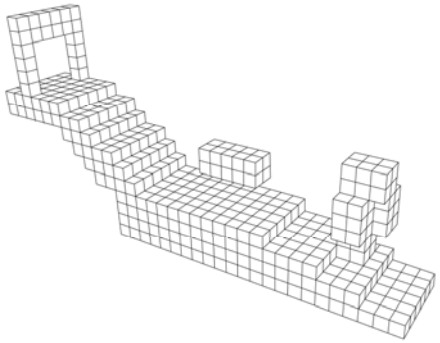
TUDelft

Automatic Generation of Indoor Navigable Space Using a Point Cloud and its Scanner Trajectory, 2017b Bart R. Staats, Abdoulaye A. Diakité, Robert L. Voûte, and Sisi Zlatanova. ISPRS Annals of Photogrammetry, Remote Sensing & Spatial Information Sciences, IV-2-W4, 393-400

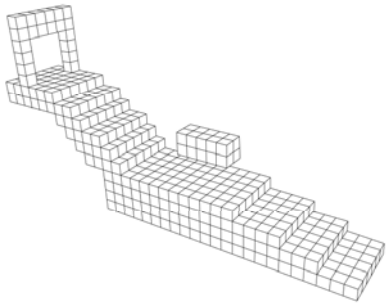
TRAJECTORY INFORMATION



Point cloud



Voxelisation
0.25cm

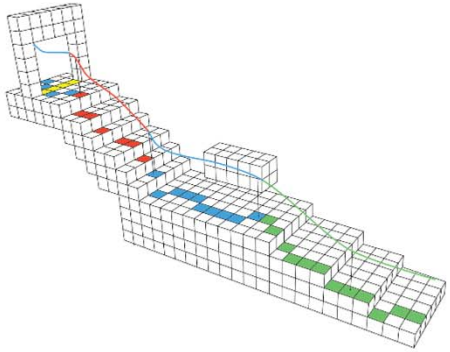


Removal
mobile objects

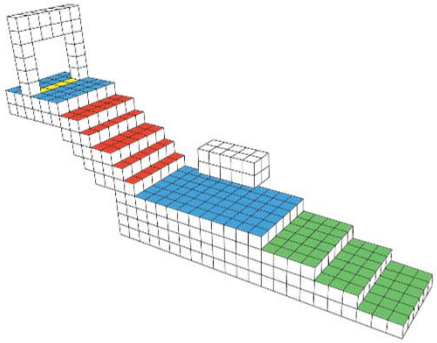
CGI

TUDelft

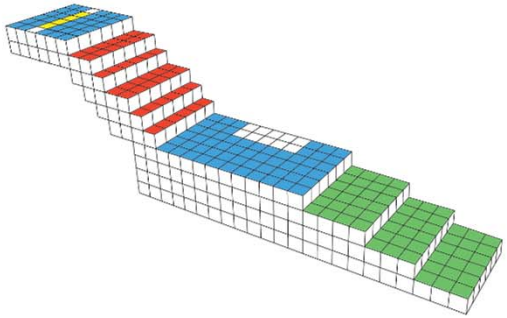
TRAJECTORY INFORMATION



Projecting trajectory on the ground surface



Region grouing

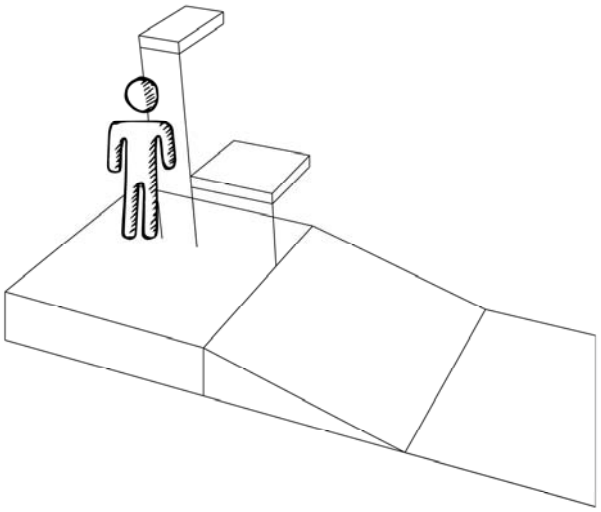


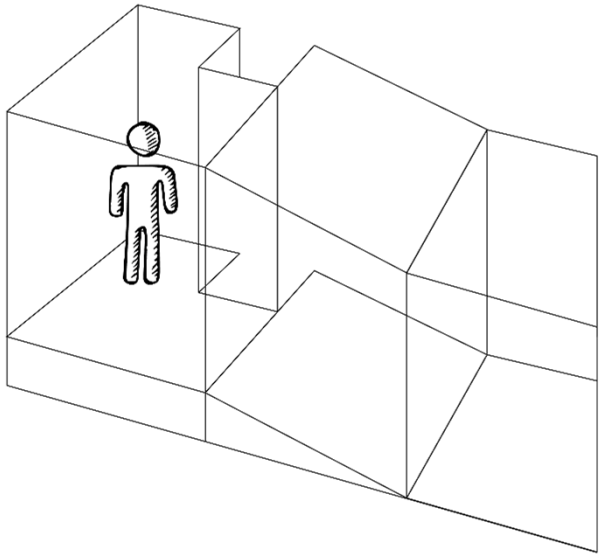
Static object removal

CGI

TUDelft

SPACE SUBDIVISION

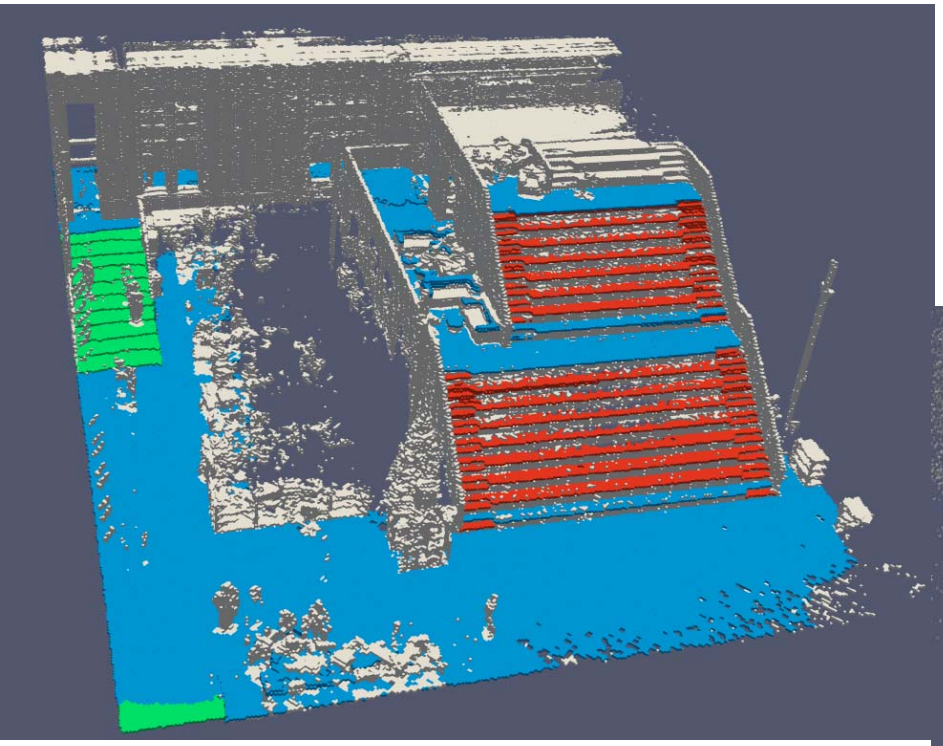


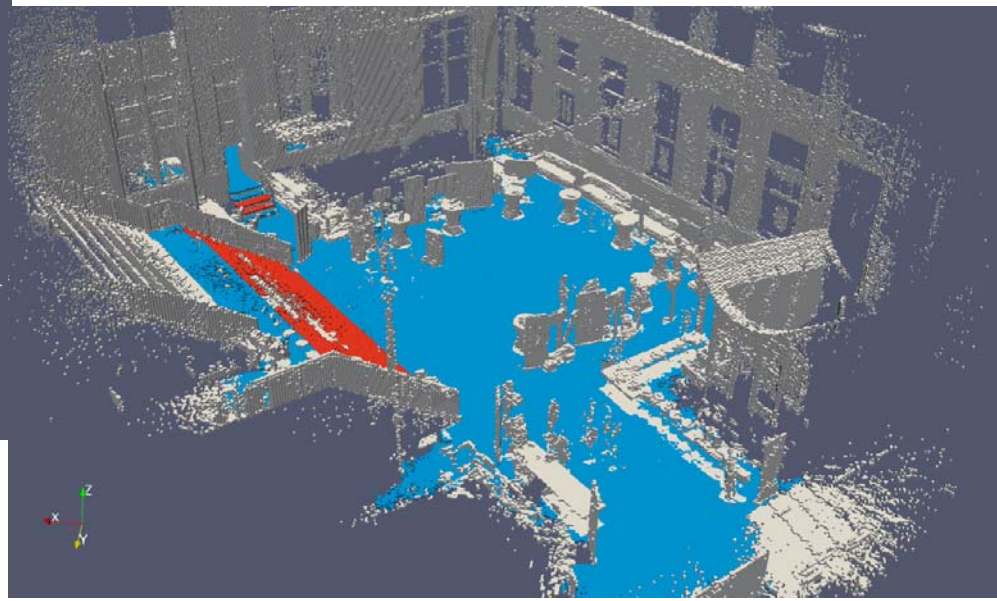


CGI

TUDelft

SPACE SUBDIVISION





Staats, 2017, Identification of walkable space in a voxel model, derived from a point cloud and its corresponding trajectory

CONTENT

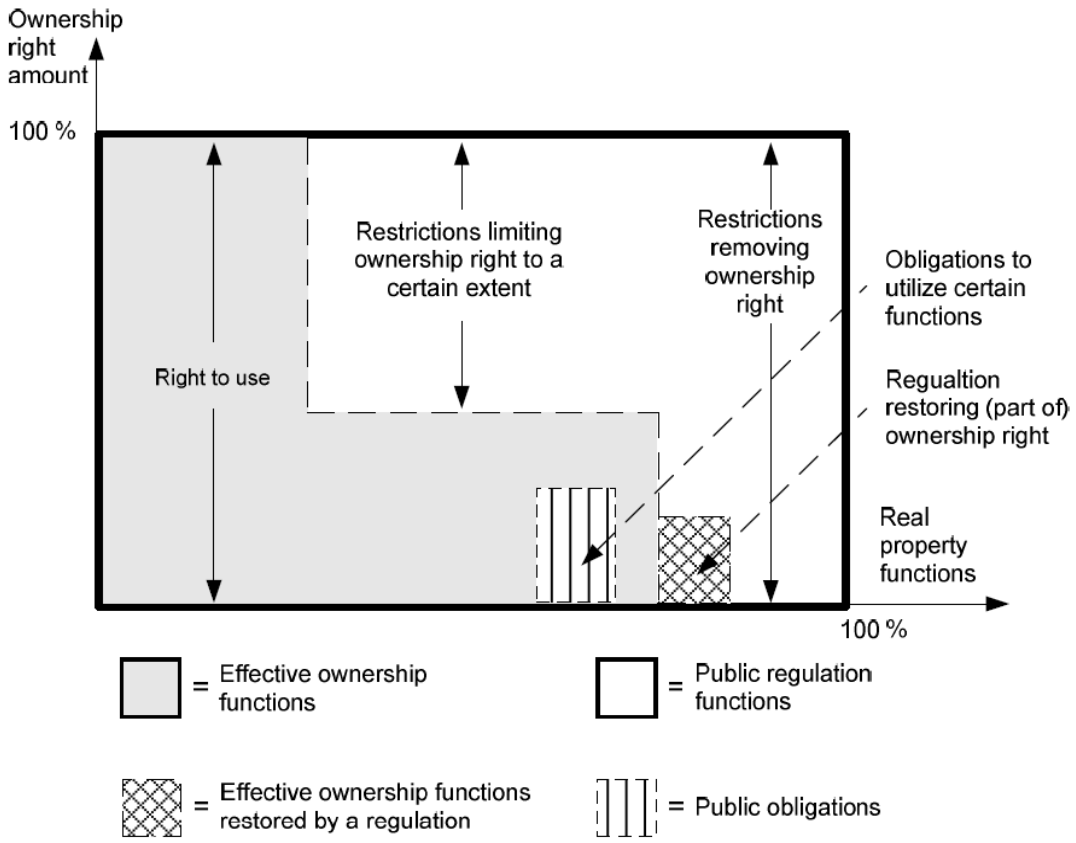
- Spaces
- Sims3D
  - BIM as input model
  - Point clouds as input model
- Accessibility
- Space assisted localization

INDOORGML AND LADM

Rights

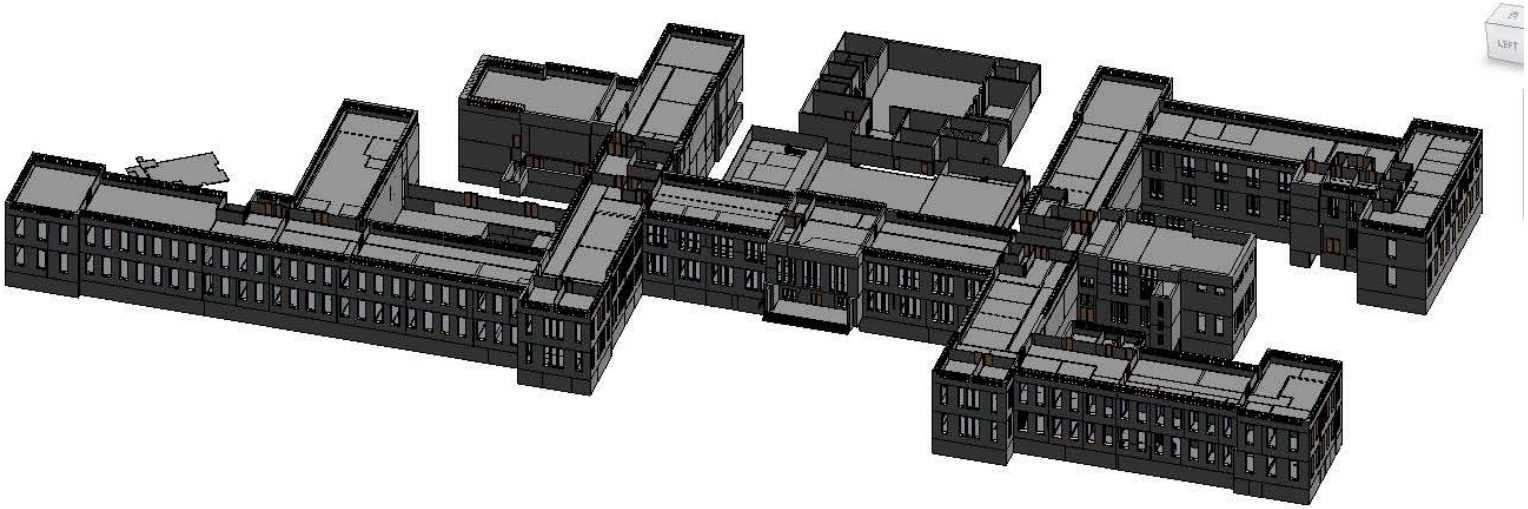
Responsibilities

Restrictions

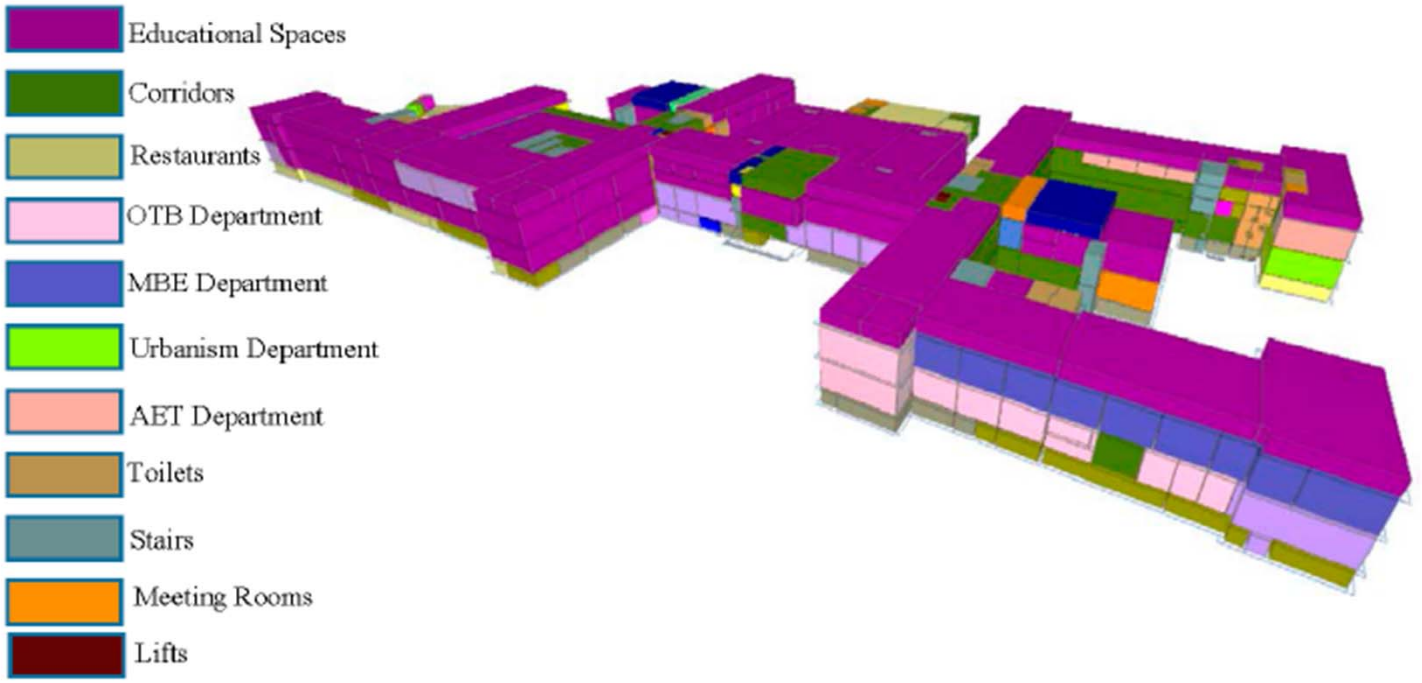


Supporting Indoor Navigation Using Access Rights to Spaces Based on Combined Use of IndoorGML and LADM Models
A. Alattas, S. Zlatanova, P. Van Oosterom, E. Chatzinikolaou, C. Lemmen and K.-J. Li, ISPRS Int. J. Geo-Inf. 2017, 6(12), 384

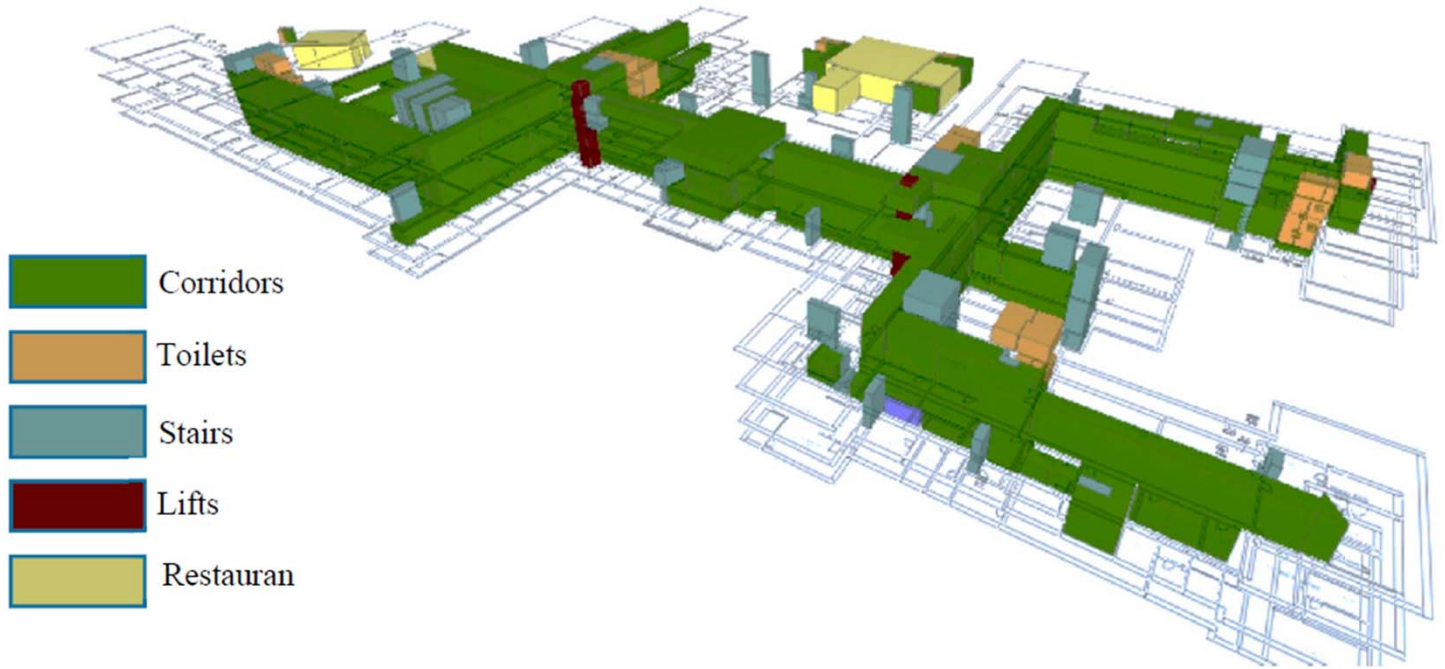
FACULTY OF ARCHITECTURE



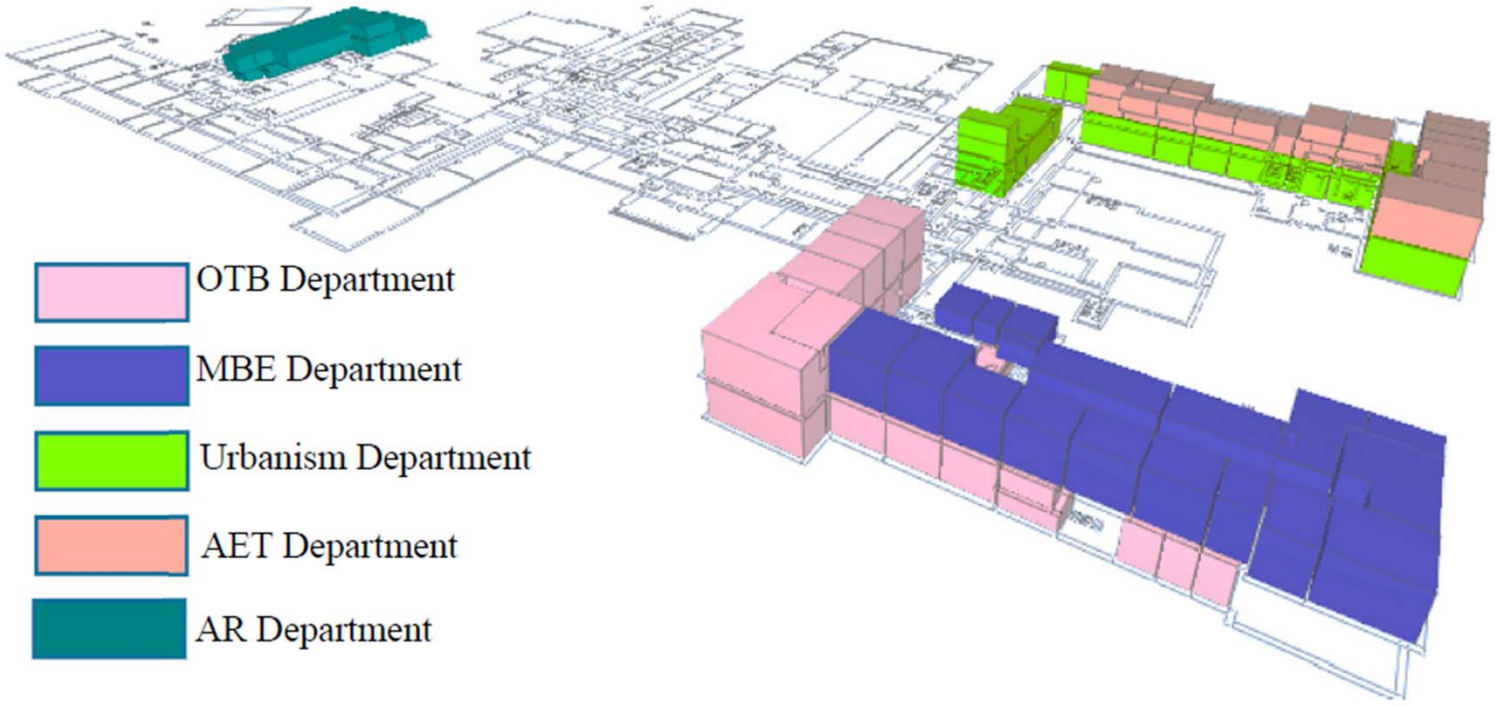
CONTROL THE SPACES: USE



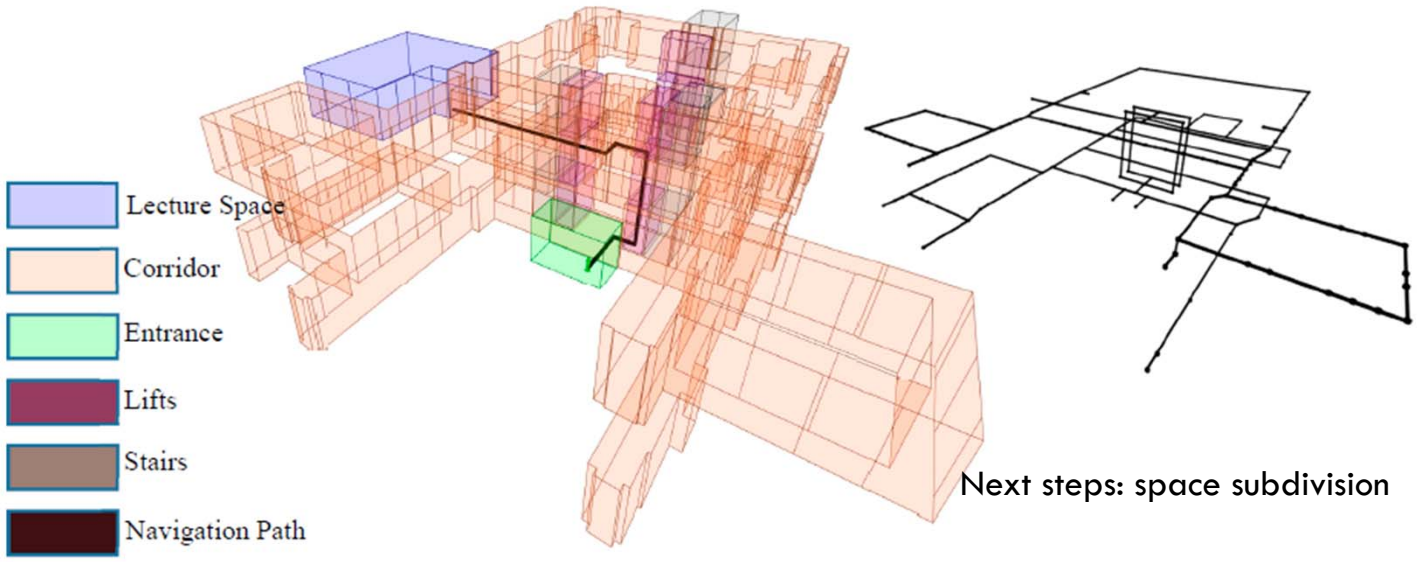
COMMON SPACES



OFFICES (NON-ACCESSIBLE FOR STUDENTS)



PATH TO A LECTURE ROOM (COMMON SPACE + LECTURE SPACE)



Next steps: space subdivision

The paper got appreciated by reviewers/editors: cover story for IJGI edition 12

SPACE ASSISTED LOCALISATION

Assumptions:

start location is known

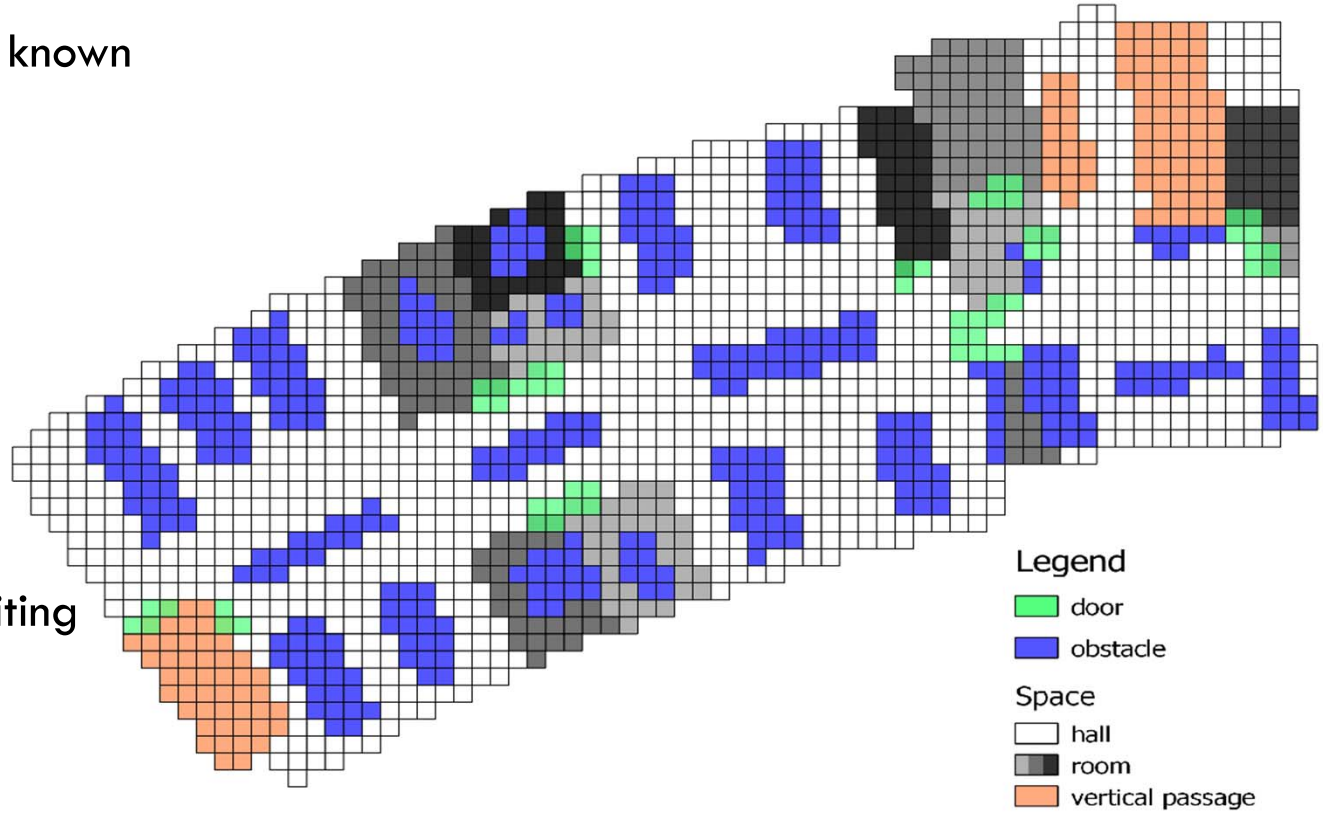
constant speed

no loops

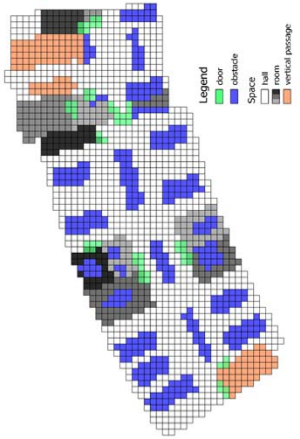
Cell phone:

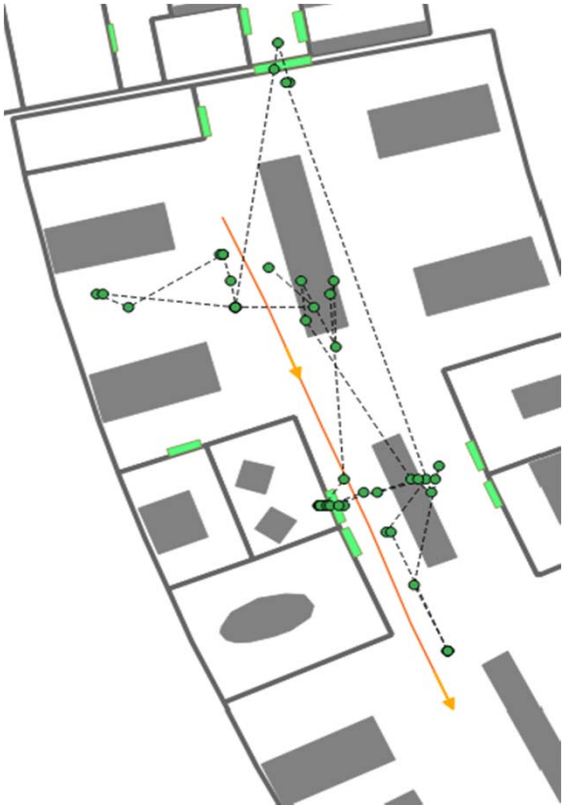
Wifi fingerpriniting

magnetometer

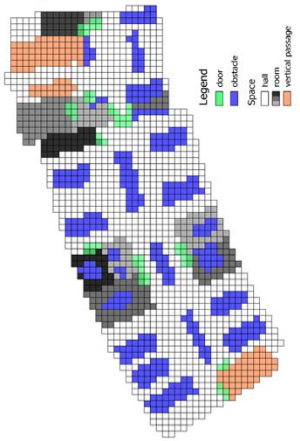


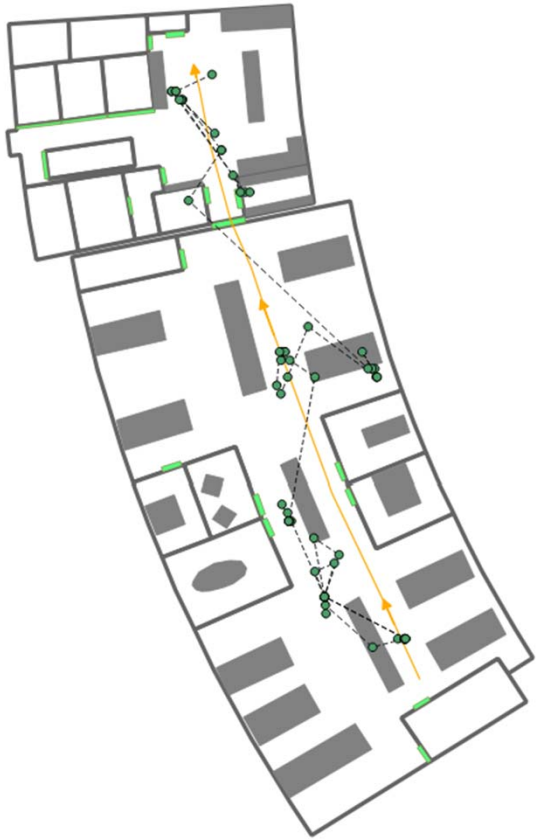
WALKING IN ONE SPACE

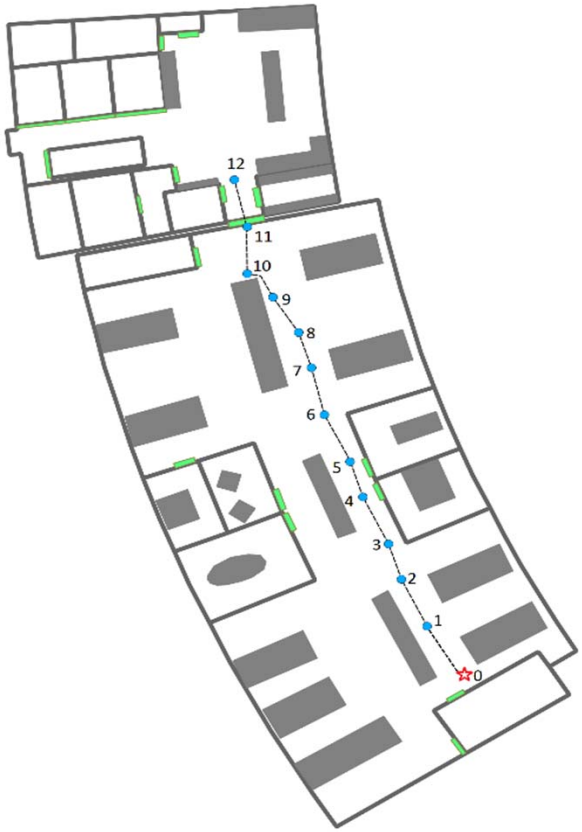




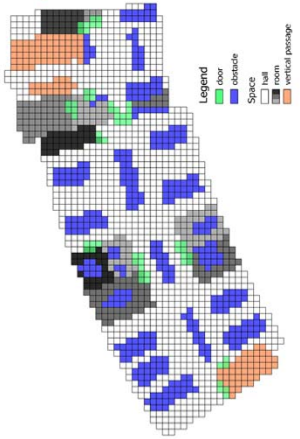
WALKING BETWEEN TWO SPACES

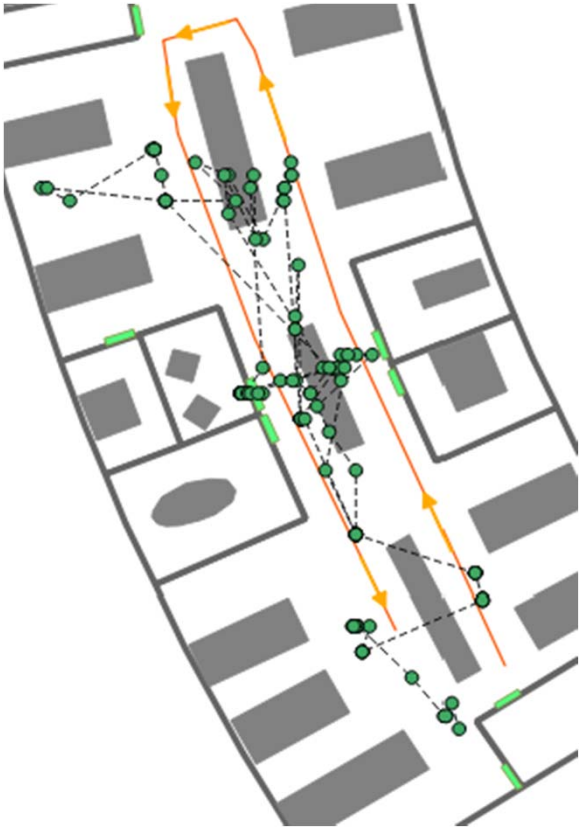


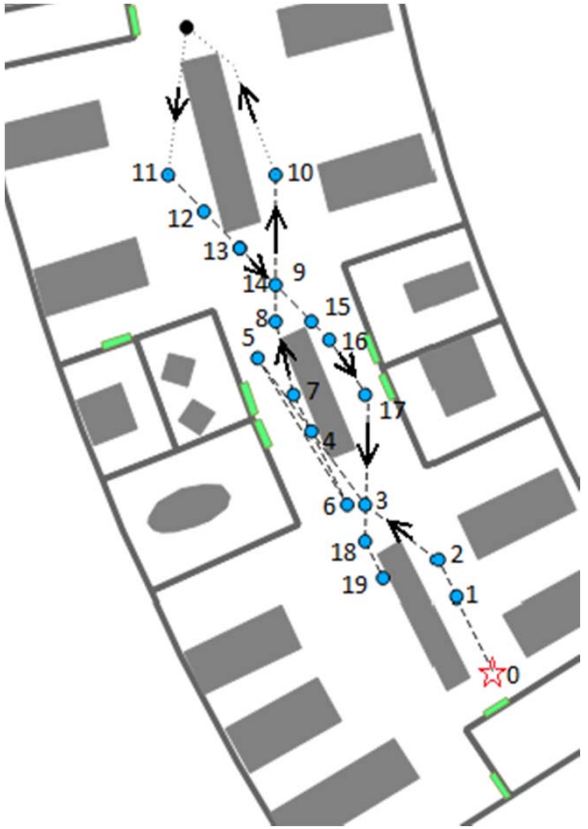




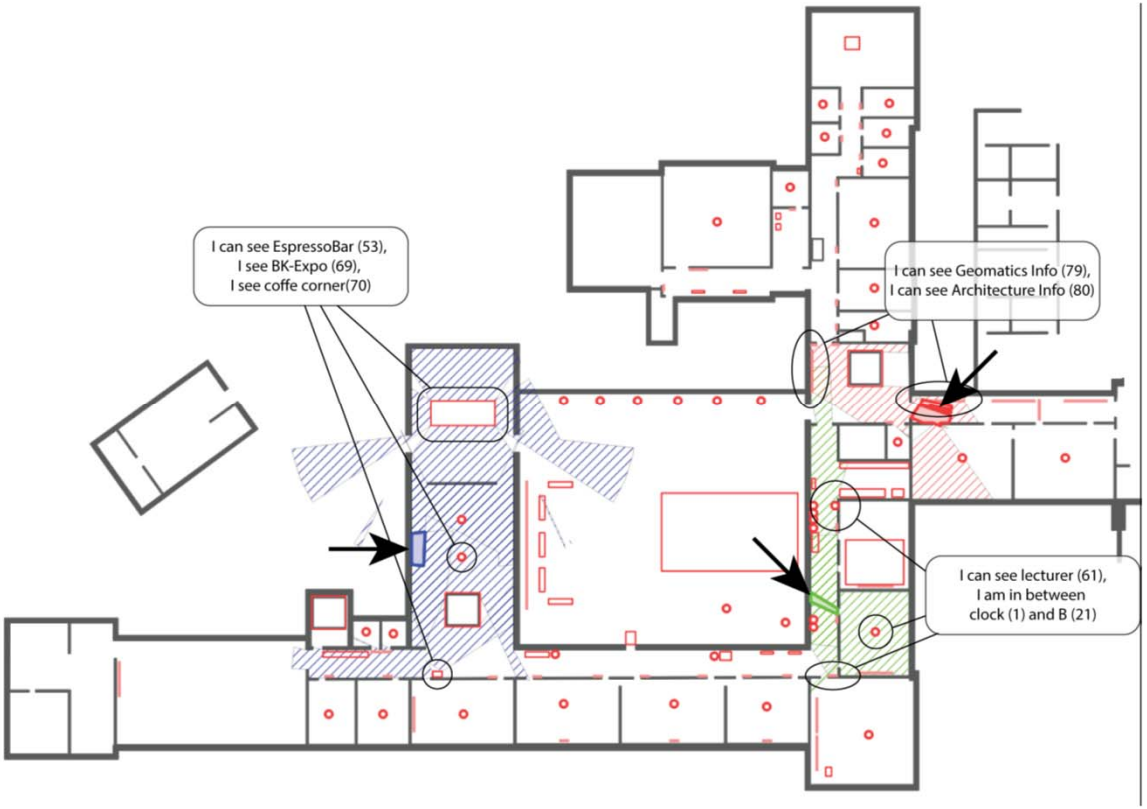
WALKING WITH A TURN







LANDMARK LOCALISATION



Willems, O., 2017, Exploring a pure landmark-based approach for indoor localisation

WHERE TO GO?

Navigation in public buildings (get to rooms)

Navigation to info desks/booths in exhibitions/airports (get to parts of rooms)

Navigation in construction sites (changing environments)

Orientation in libraries /shopping malls (finding books in shelves, finding favorite items)

Maintenance/repair operations inside buildings windows/walls (failure in utilities, cleaning windows, changing carpet)

Navigating to mobile facilities (finding trailers, people)

Navigation for emergency response (getting out to safe place, getting in to rescue)

Affects the geometric model and the space subdivision !!!!

UbiCOM

HOW TO GO?

Shortest path/Fasters path

Most visited route (museums)

Selected items (shopping)

Least turns (complex buildings)

Least accessed rooms

Least doors

Avoid obstacles: Static, Dynamic (wait, go around, goo trough)

Consider certain size (trailer, cleaning equipment)

Avoid certain areas, spaces (disable people, security)

Safest (avoid dark corridors)

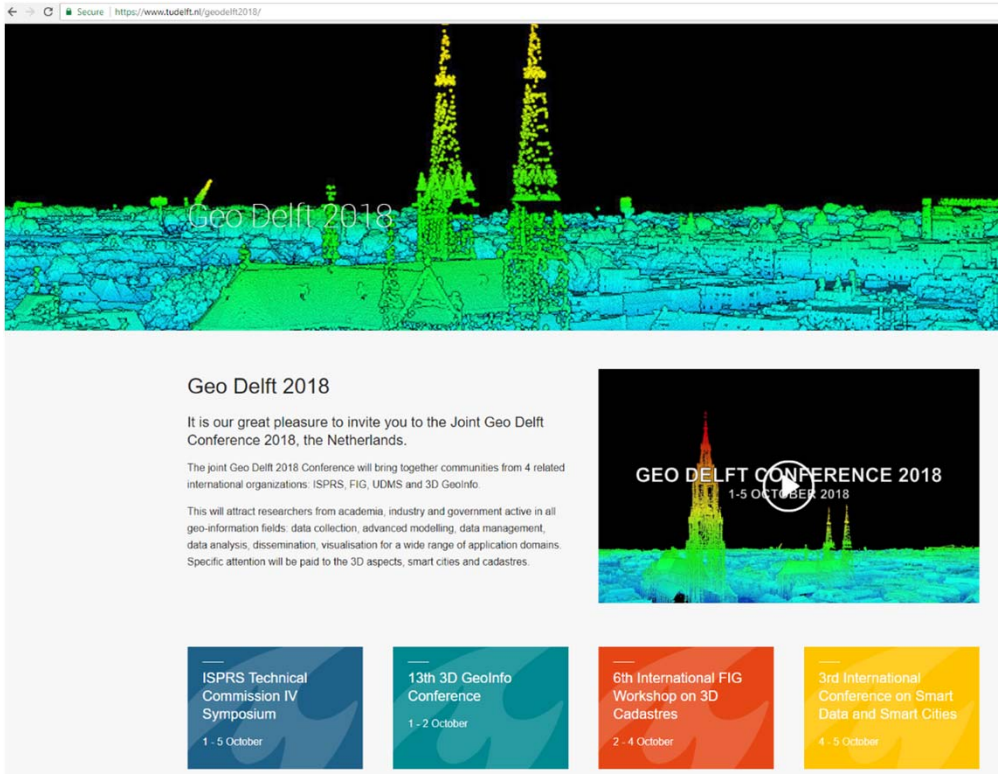
Never get lost/alert when not on path (combine with localisation)

Affects the geometric model and the algorithms !!!

Daisuke Takahata

GEO DELFT 2018, 1-5 OCTOBER

https://www.tudelft.nl/geodelft2018



1. ISPRS COM IV Spatial Information Science

2. 3D GeoInfo

3. FIG 3D cadastre

4. UDMS Smart Data Smart Cities

Deadlines 31st of March 2018

THANK YOU!
QUESTIONS?