LYU1702

Augmented Reality Game with Tango

Features:

- Color
- Shape
- Distance(Depth)

Types: Floor, Wall, Obstacle

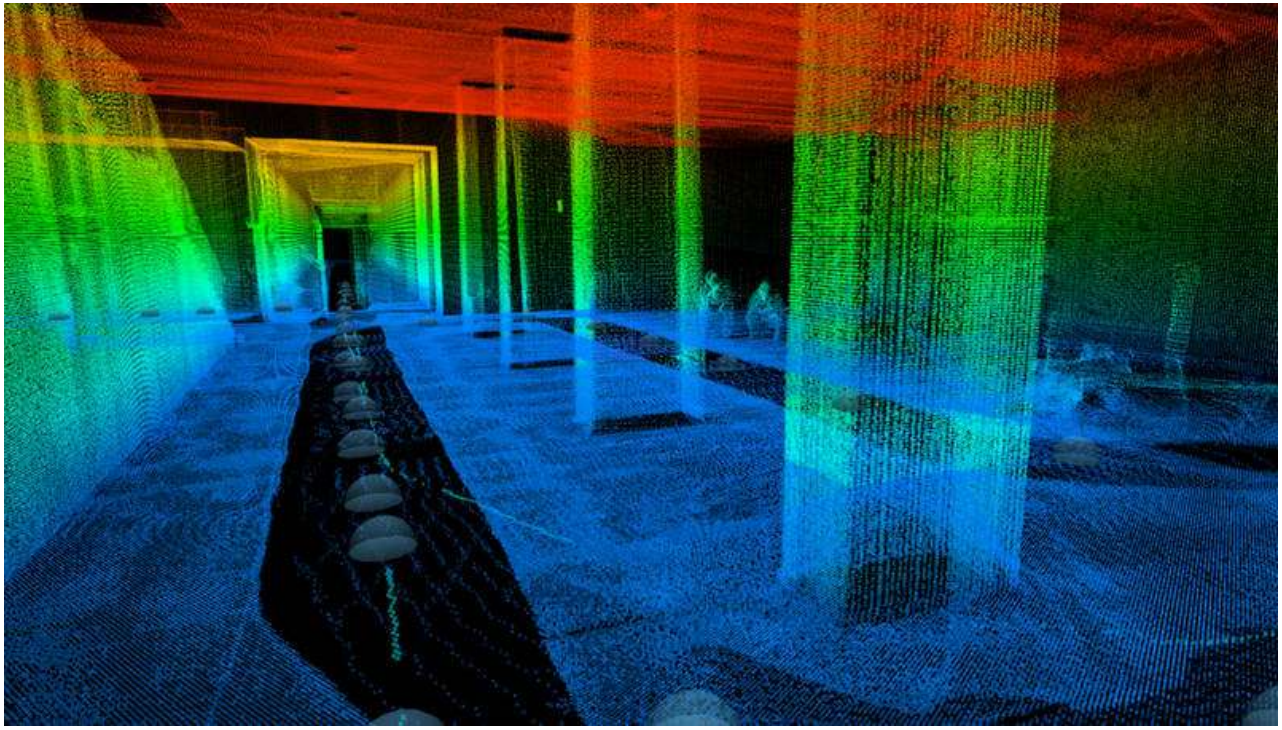
- Segmentation and Classification

How does human understand environment

Image Information

Fishing on Lake

Depth Information



Some Previous Work

- AR Implementation
  - Plane Finding
  - Area Description Saving and Recognizing
  - Motion Tracking with Area Learning
- Tower Defense Game
  - Map Generator
  - Dynamic Enemy Navigation (D* Lite)
  - Other Game Elements (A Complete Game Scene)

How to process point cloud

1

Empty Space

2

Norma Estimation
and Plane Detection

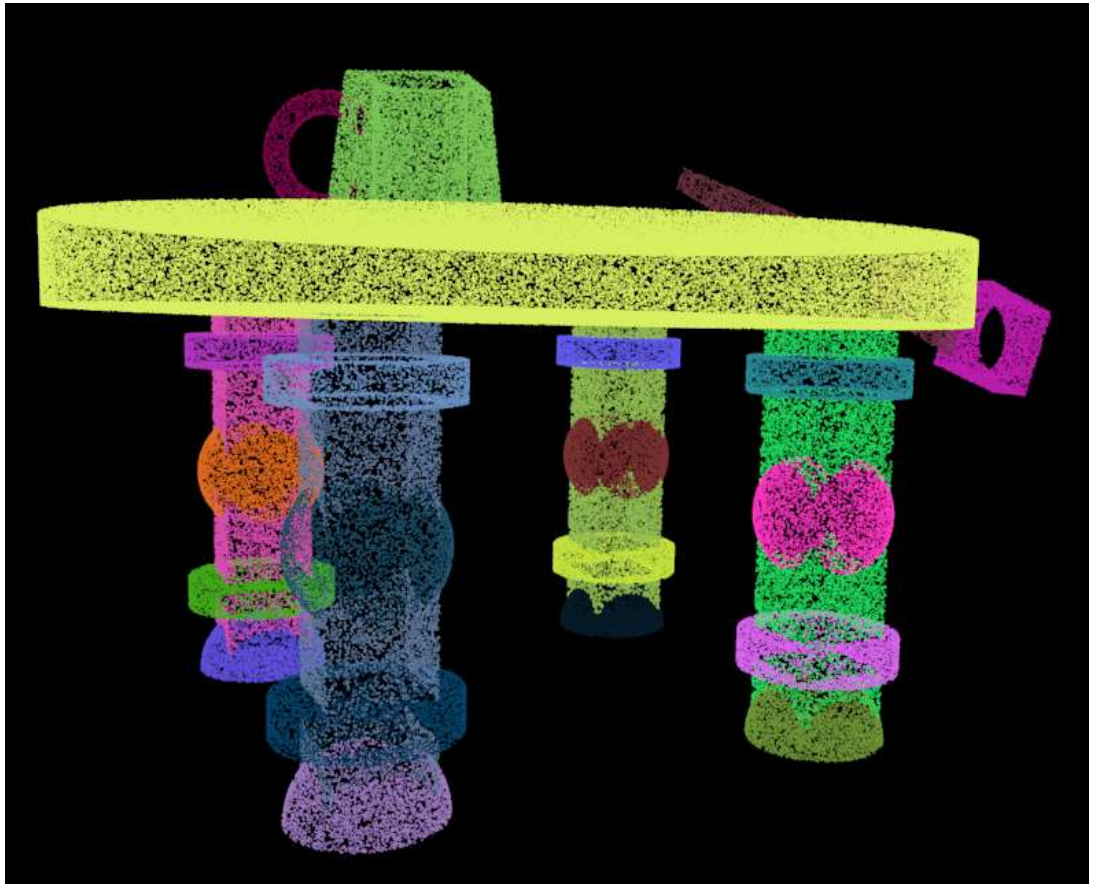
3

Segmentation

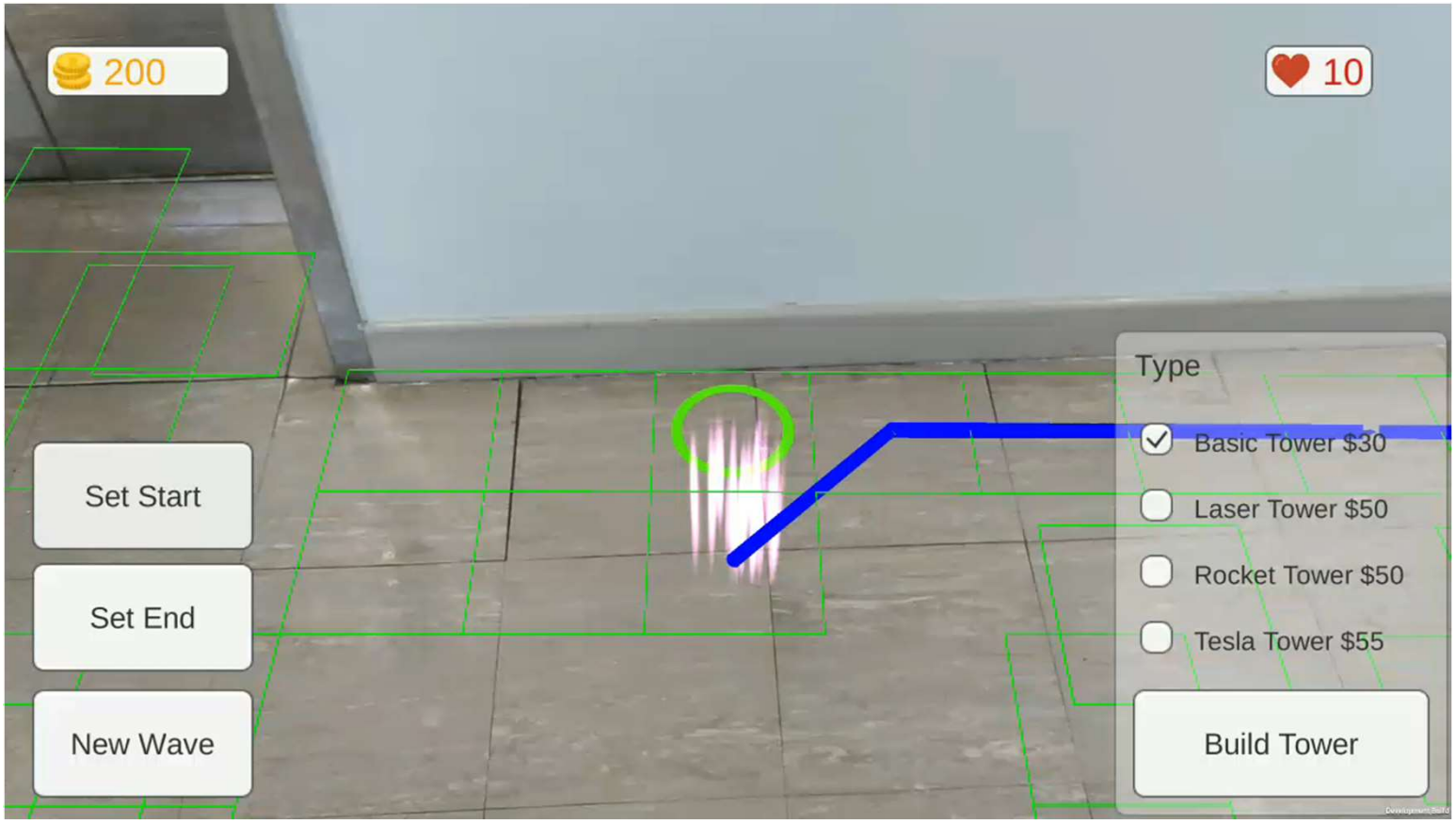
Normal Estimation

Segmentation

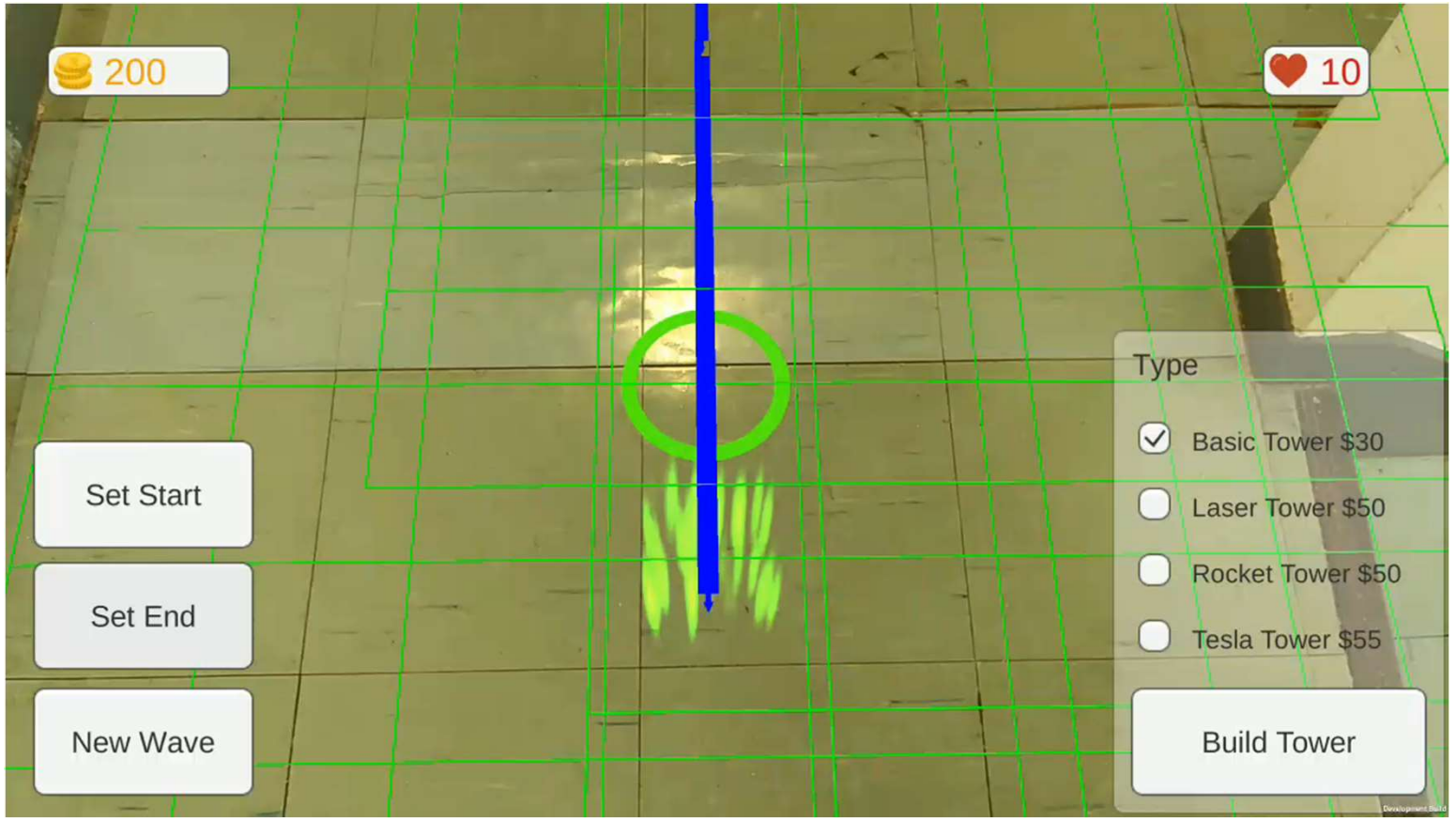
- Edge-Based
- Region Growing
- Model Fitting



Application-Navigation in Large Area



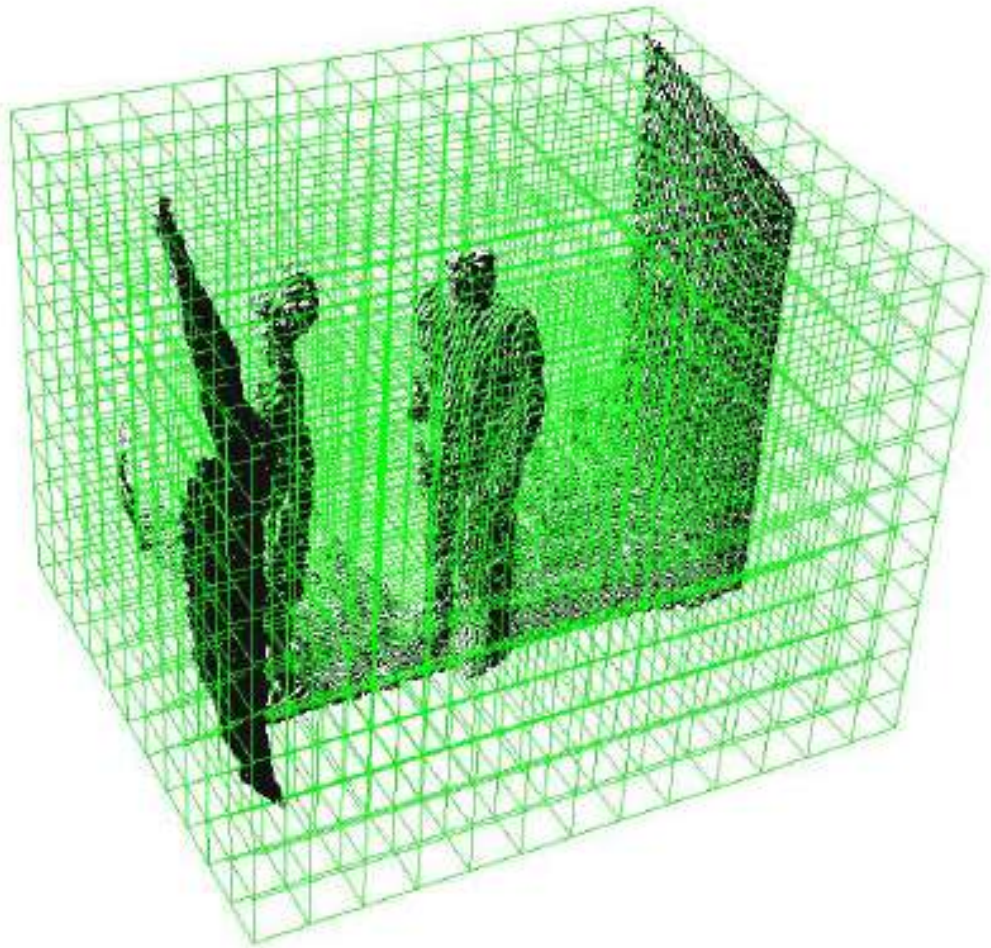
Application-Navigation in Multi-Floor

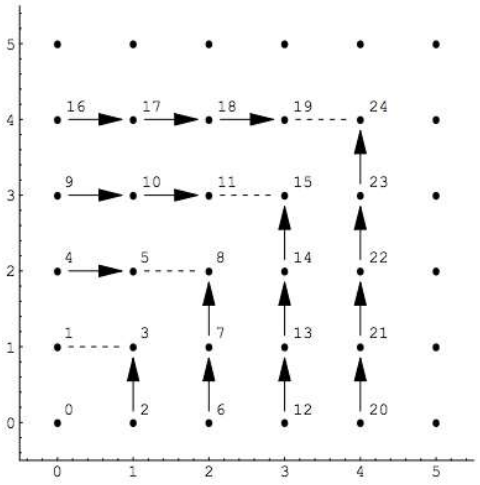


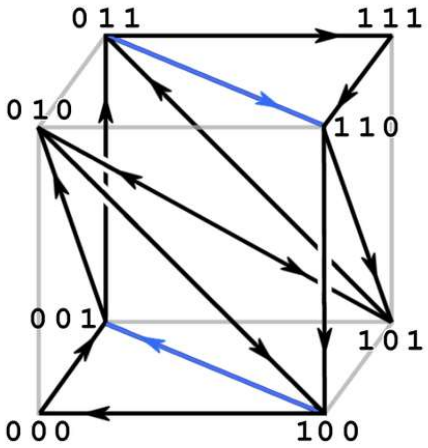
Algorithm

- Voxelize
- Build Hash Index for Voxels
- Calculate Normal Vector for each Non-Empty Voxel
- Find Walkable Surface
- Navigation

Voxelize







Build Hash Index

- If we want to be able to use negative coordinates, we can simply add this to the top of our function:
- x = if x >= 0 then 2 * x else -2 * x - 1
- y = if y >= 0 then 2 * y else -2 * y - 1
- z = if z >= 0 then 2 * z else -2 * z – 1

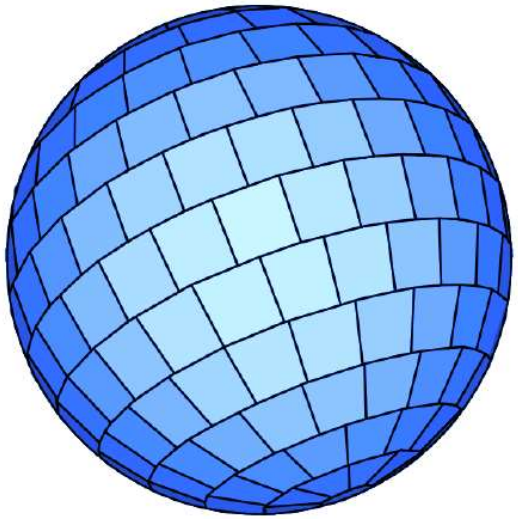
Calculate Normal Vector

- Based on Hough Transformation
  - Classification by Sampling and Voting
  - The voting procedure is carried out in a parameter space, from which object candidates are obtained as local maxima in a so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform.

- Basic Idea:
  - For each voxel, pick fixed number of 3 random points (triple)
  - For each triple, calculate normal vector of the their plane (3 points can define a plane)
  - Vote for all the triples
  - Get the best bin (normal vector range) with most votes
  - Calculate the average normal vector in this bin as the final normal vector

Calculate Normal Vector

- Accumulator



n_ϕ	M
5	23
10	82
15	171
20	290
25	441

Calculate Normal Vector

- Discretization Issues
  - If the main peak of the distribution of normals lies near a bin boundary, votes will be almost equally distributed between two (or more) adjacent bins.
  - Although the above accumulator guarantees the nearly equal area for bins, their shape is different
- How to solve
  - Rotate the points and run algorithm several times

Complexity

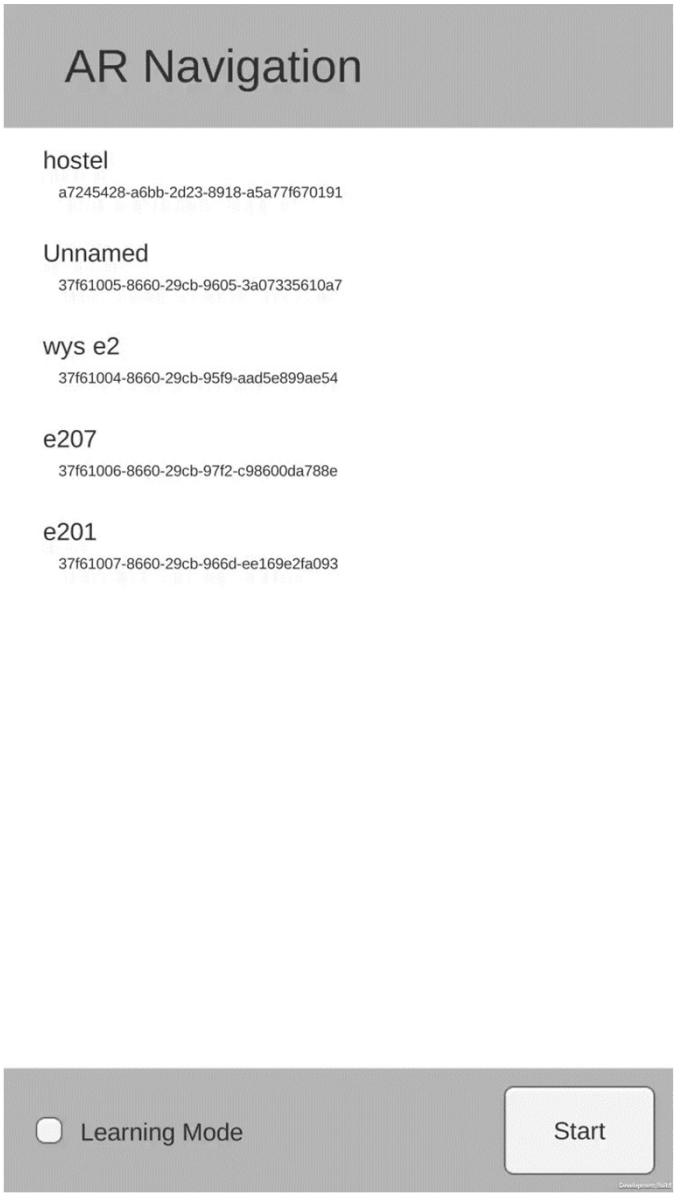
- O(k) for each voxel, where k is the sampling size and k << n, n is the number of points in each voxel. So it's very fast and can be run in real time.
- Compared to RANSAC for same purpose: its complexity is O(kn)

Calculate Normal Vector

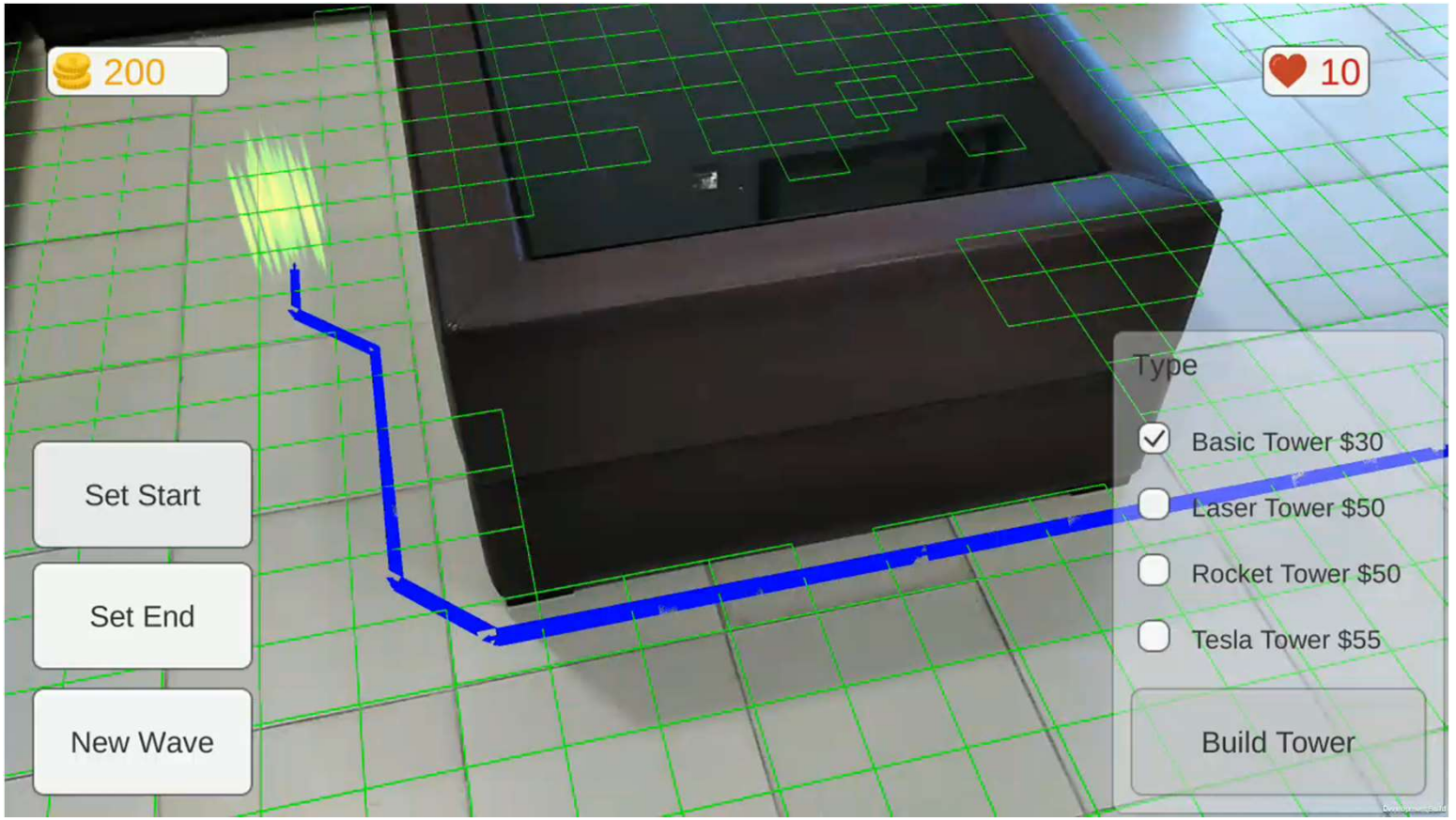
The speed can be increased by using multi-thread

The calculation of normal vector for voxels can be parallelized

Upgraded AR Game - Preparation

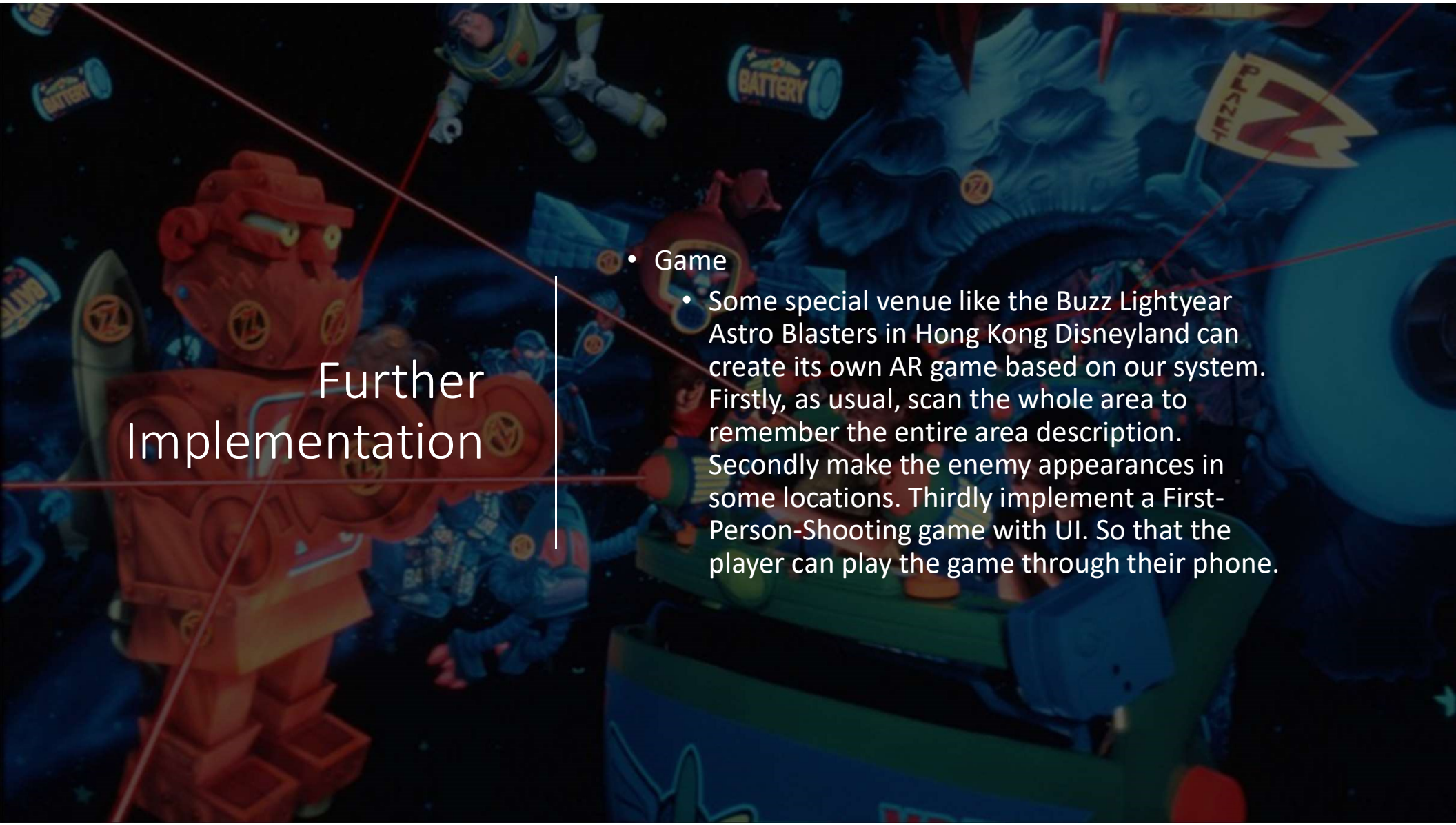


Upgraded AR Game - Demo



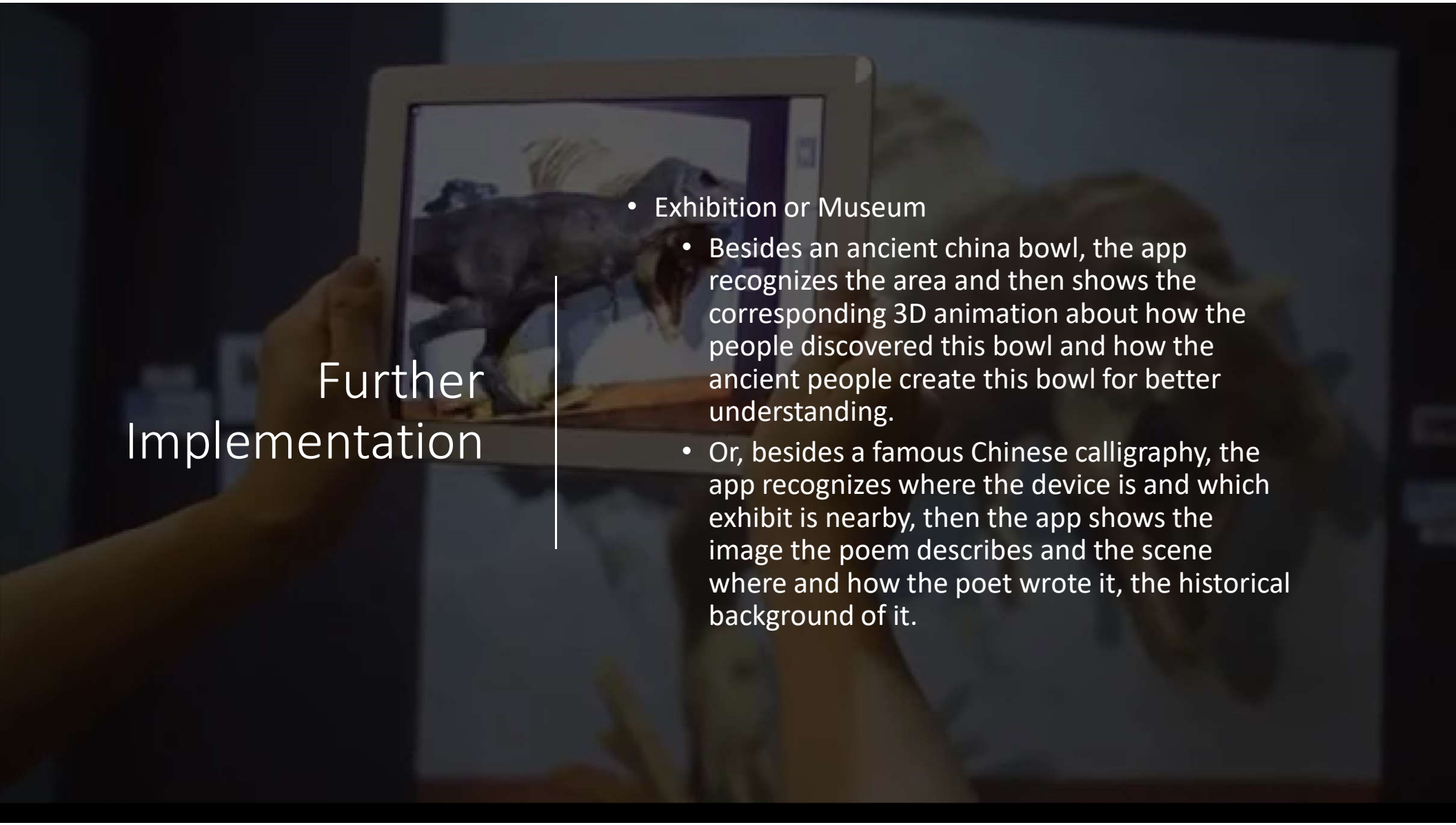
Further Implementation

- Indoor Navigation
  - For example, in a large mall or plaza, the owner can create his own navigation app based on our application. Firstly, walk through the whole mall to remember the entire area description, and Secondly mark the location of different shops and other facilities like the counters, the toilets and the exits. Then the app can firstly use the partial area description nearby to recognize where the device is, and secondly search the route to the desired destination for the user, and finally show the route to lead the user get to his destination.



Further Implementation

- Game
  - Some special venue like the Buzz Lightyear Astro Blasters in Hong Kong Disneyland can create its own AR game based on our system. Firstly, as usual, scan the whole area to remember the entire area description. Secondly make the enemy appearances in some locations. Thirdly implement a First-Person-Shooting game with UI. So that the player can play the game through their phone.



Further Implementation

- Exhibition or Museum
  - Besides an ancient china bowl, the app recognizes the area and then shows the corresponding 3D animation about how the people discovered this bowl and how the ancient people create this bowl for better understanding.
  - Or, besides a famous Chinese calligraphy, the app recognizes where the device is and which exhibit is nearby, then the app shows the image the poem describes and the scene where and how the poet wrote it, the historical background of it.

Reference

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- Borrmann D, Elseberg J, Lingemann K, et al. The 3d hough transform for plane detection in point clouds: A review and a new accumulator design[J]. 3D Research, 2011, 2(2): 3.

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- Grilli E, Menna F, Remondino F. A review of point clouds segmentation and classification algorithms[J]. Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci, 2017, 42(2): W3.