

# Appendix D

## Grid Size Calculation

The grid size calculation is done by hand. The following approach has been used in our work.

For *Sensor Field* there is *effective sensor boundary* given as set:

$$Boundary(Sensor \in SensorField) = \{points \in polarCoordinates\} \quad (D.1)$$

The *Boundary* for sensor fields is then given as *union of all single sensor boundaries*:

$$Boundary(SensorField) = \bigcap_{\forall Sensors} Boundary(Sensor \in SensorField) \quad (D.2)$$

Depending on boundary properties it can be projected into maximal avoidance grid boundary values:

$$Boundary(SensorField) \rightarrow AvoidanceGrid : \begin{matrix} \max(distanceRange) \\ \max(horizontalRange) \\ \max(verticalRange) \end{matrix} \quad (D.3)$$

Our approach taken worst LiDAR performance into account [1] and following parameters for avoidance grid were calculated:

1. distance range  $[0m, 10m]$ ,
2. horizontal range  $[-180^\circ, 180^\circ]$ ,
3. vertical range  $[-30^\circ, 30^\circ]$ .

The *count of layers* is derived from *average distance traveled by one movement application*:

$$layerCount = \frac{|distanceRange|}{avg. \ length(movement \in MovementSet)} \quad (D.4)$$

The *layer length* is based on *our movement set* (tab. ??, ??) the average movement length is 1 m, therefore the *layer count* is 10.

The *efficient boundary* is given by *Reach Set*. Estimate reach set coverage space using *ellipsoidal toolbox* [2] up to given *sensor field* maximal distance:

$$Boundary(ReachSet) = Ellipsoid(UASSystem, distance) \quad (D.5)$$

The values for *Reach Set Boundary* with distance 10 m was following:

1. distance range  $[0m, 10m]$ ,
2. horizontal range  $[-45^\circ, 45^\circ]$ ,
3. vertical range  $[-45^\circ, 45^\circ]$ ,

The *Avoidance Grid* boundary is given as *intersection* of all boundaries:

$$Boundary(AvoidanceGrid) = Boundary(ReachSet) \cap Boundary(SensorField) \quad (D.6)$$

The values for *Avoidance Grid Boundary* for our UAS system (sec. ??) following:

1. distance range  $[0m, 10m]$ ,
2. horizontal range  $[-45^\circ, 45^\circ]$ ,
3. vertical range  $[-45^\circ, 45^\circ]$ ,
4. layer count 10, layer distance 1m.

The *horizontal cell count* and *vertical cell count* was estimated by *rule of thumb* to have value 7 and 5.

# Bibliography

- [1] Roberto Sabatini, Alessandro Gardi, and Mark A Richardson. Lidar obstacle warning and avoidance system for unmanned aircraft. *International Journal of Mechanical, Aerospace, Industrial and Mechatronics Engineering*, 8(4):702–713, 2014.
- [2] Alex A Kurzhanskiy and Pravin Varaiya. Ellipsoidal toolbox (et). In *Decision and Control, 2006 45th IEEE Conference on*, pages 1498–1503. IEEE, 2006.