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Evaluation of Robocup Maps

PerMIS 2009

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September 23, 2009



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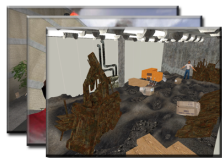
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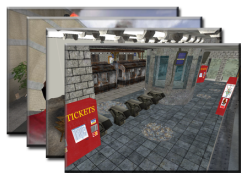
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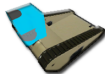
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1 Victims



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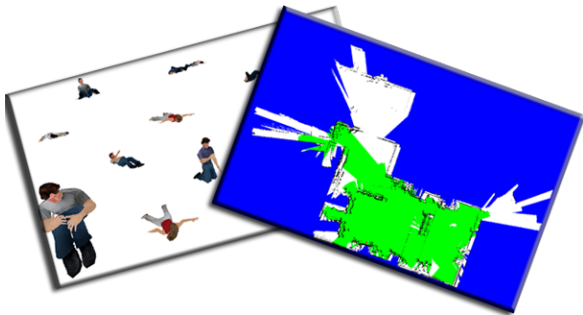
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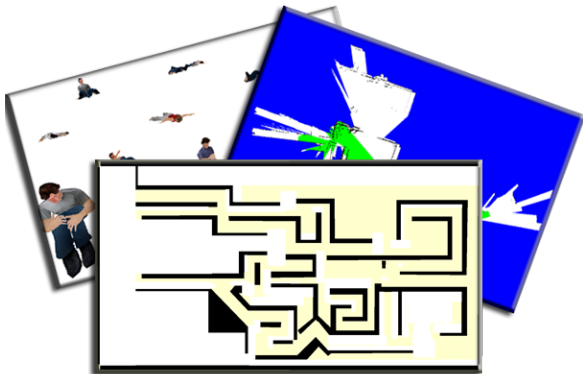
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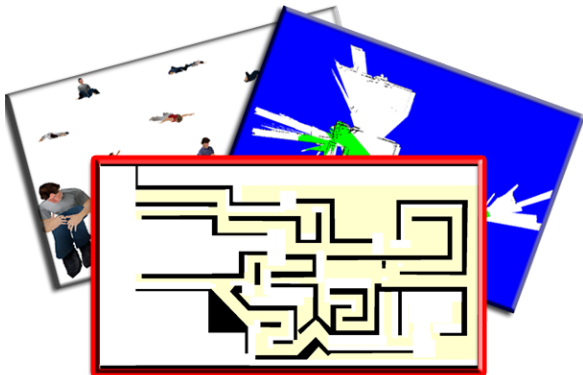
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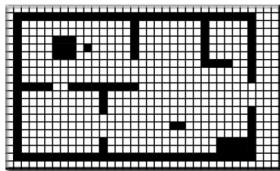
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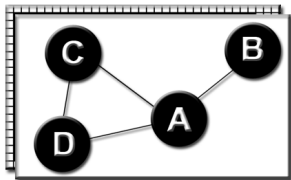
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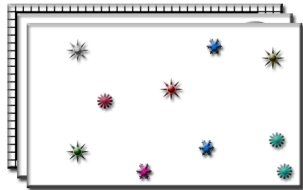
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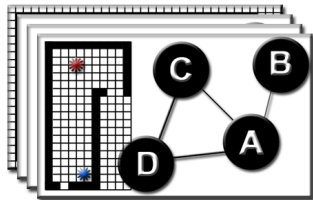
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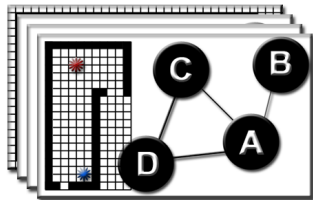
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- Map representation
- Algorithmic differences



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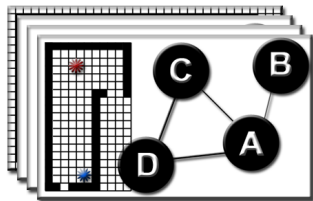
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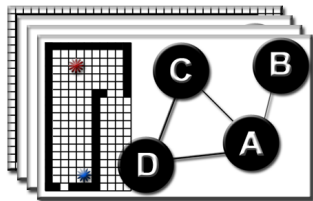
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- Embeds geo-reference information
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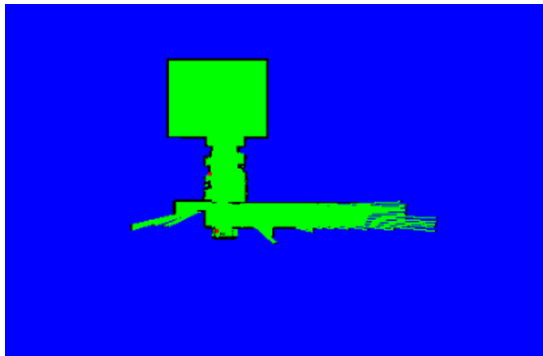
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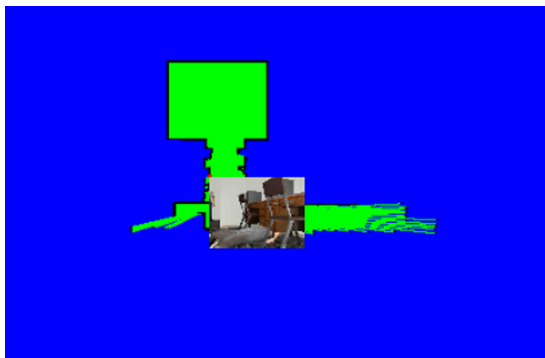
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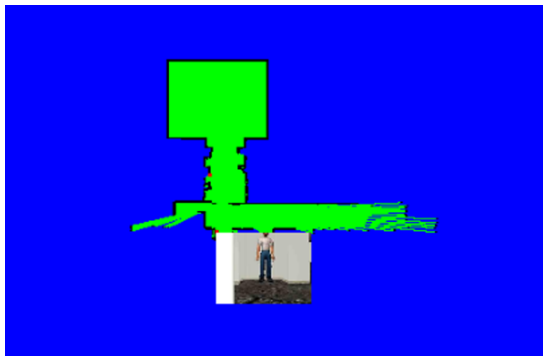
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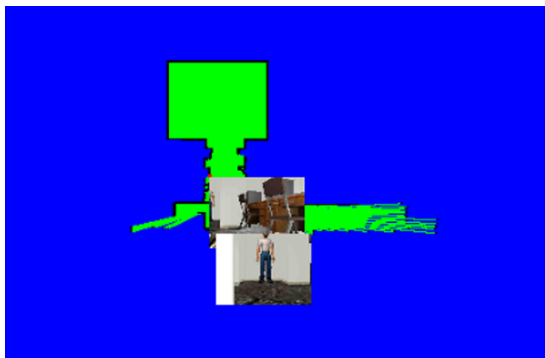
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- Accounts for translations, rotations, and scale
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- Practical for ...



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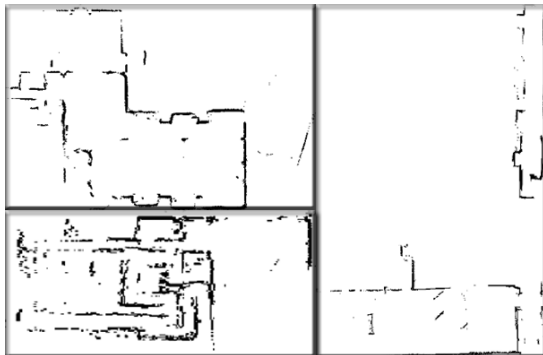
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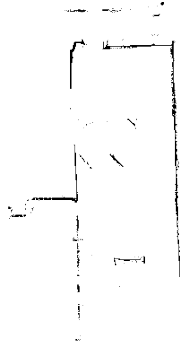
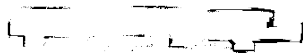
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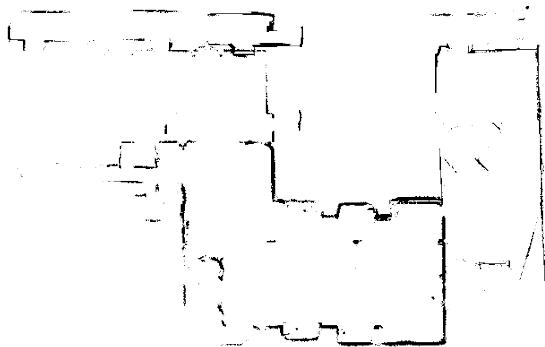
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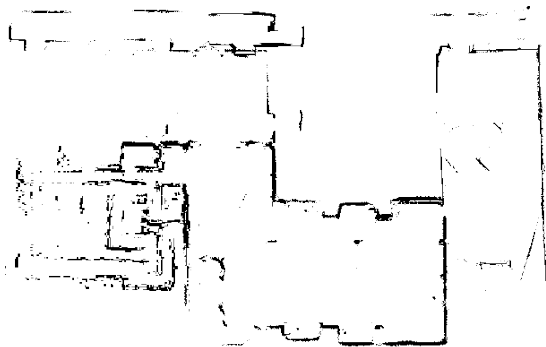
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MIF Vector Format

- Geo-reference / Open standard / Layer-friendly
- Many geometric primitives
- Supports labels and attributes

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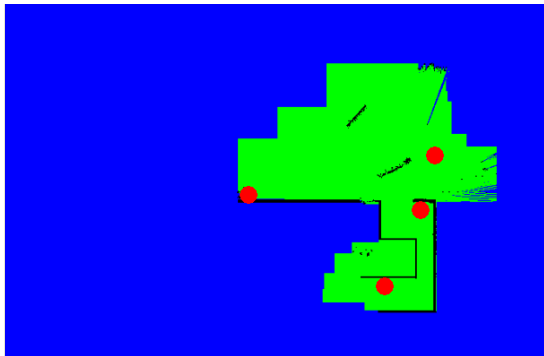
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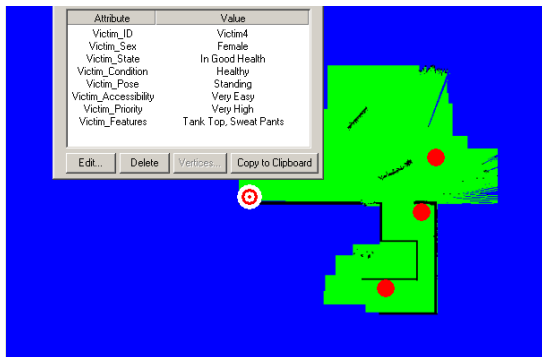
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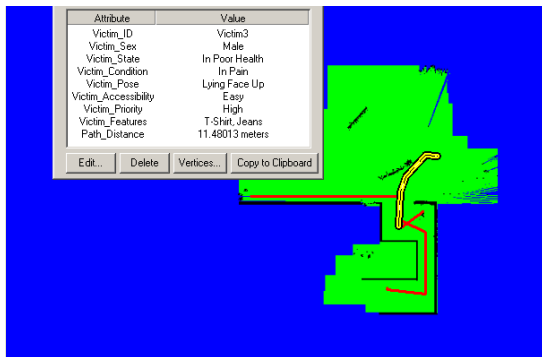
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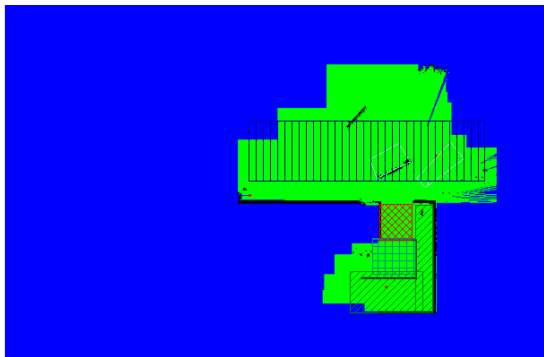
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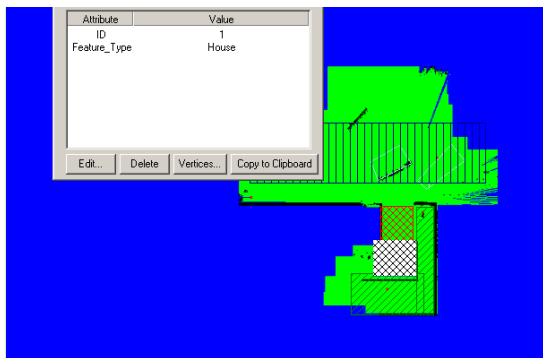
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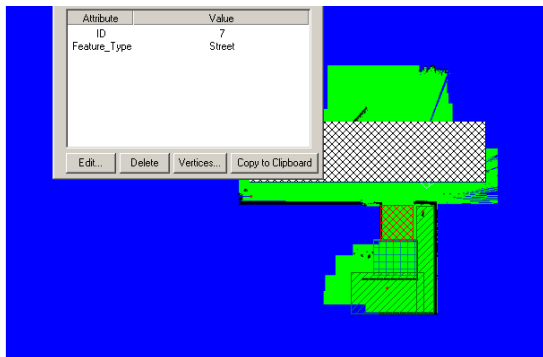
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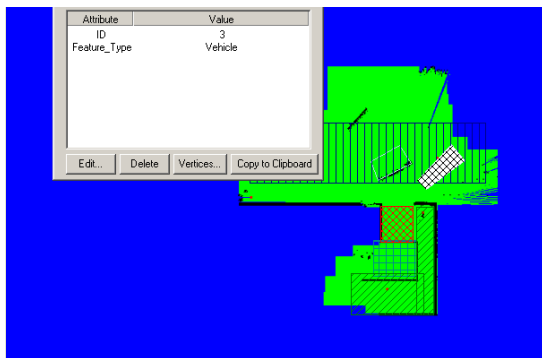
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- 1 Occupancy grid maps
- 2 Binary representation
- 3 Ground Truth data available



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- Map Score (Martin et al. 1996)

$$\forall_i, S = \begin{cases} S + 1 & \text{if } GT_i = M_i \\ S & \text{otherwise} \end{cases}$$

- Overall Error (Carlson et al. 2005)

$$\forall_i, S = \begin{cases} S + 1 & \text{if } GT_i \neq M_i \\ S & \text{otherwise} \end{cases}$$



Pixel-to-Pixel Metric: Map Score and Overall Error

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539,524

0

489,363

50,161

491,321

48,203

496,818

42,706

496,758

42,766



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510,952

0



470,275

40,677



469,373

41,579



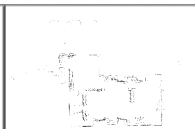
471,312

39,640



470,619

40,333



471,864

39,088



472,174

38,778



Pixel-to-Pixel Metric: Picture-Distance-Function

- Picture-Distance-Function (Birk 1996)

$$\forall_i : GT_i = 1,$$

$$S = S + \min(\text{ManDist}(i, j)) : M_j = 1$$

$$\forall_i : M_i = 1,$$

$$S = S + \min(\text{ManDist}(i, j)) : GT_j = 1$$

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Pixel-to-Pixel Metric Examples: Picture-Distance-Function

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0



48.9046



44.3993



38.4483



36.0430



61.9765



58.2449



Image-Based Metrics: Baron's and Pearson's Correlation

- Baron's Correlation (O'Sullivan 2003)
- Pearson's Correlation (Guyon et al. 2006)
- Highly dependent on number of occupied pixels

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What have we learned from previous works?

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- No "catch-all" solution
- Application-dependent (USAR)
- Categorized solution
 - Metric Quality
 - Skeleton Quality
 - Annotation
 - Grouping
 - Utility
- Creativity



Metric Quality

- Rewards map accuracy compared to ground truth
- Similar localization errors can have different impacts
 - Global Quality
 - Local Quality
- **Scoring:** normalized based on best map

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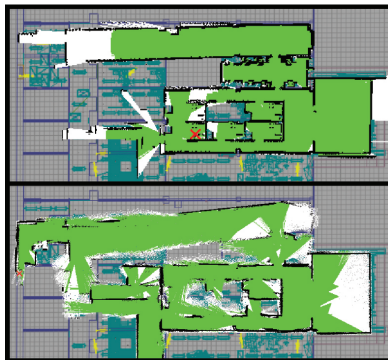
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- Rewards map accuracy compared to ground truth
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Skeleton Quality

- Reduces a map into a set of connected locations
- Accuracy determined by following the skeleton
 - False positives
 - False negatives
- Scoring: point deductions for each inconsistency

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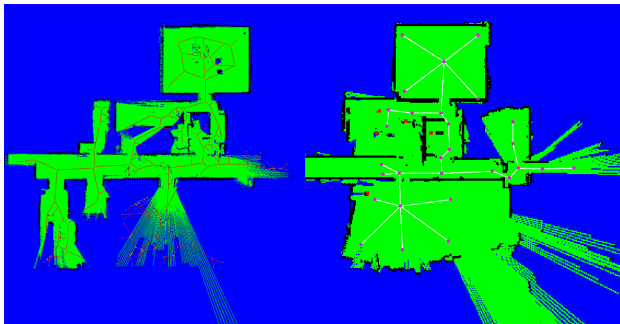
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- Labeled information located on the map
- Describes important features or landmarks
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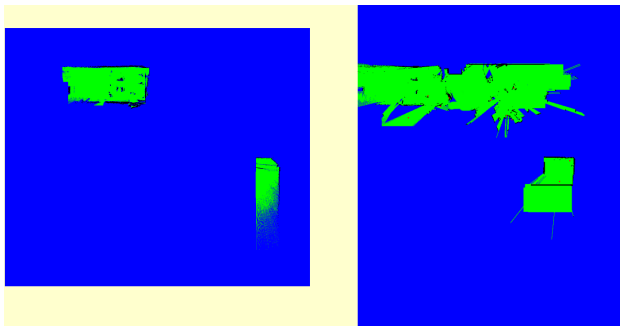
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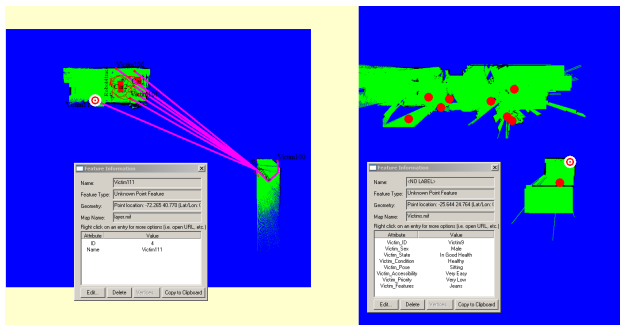
- Labeled information located on the map
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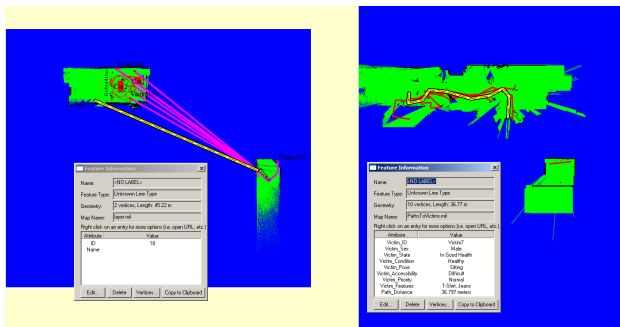
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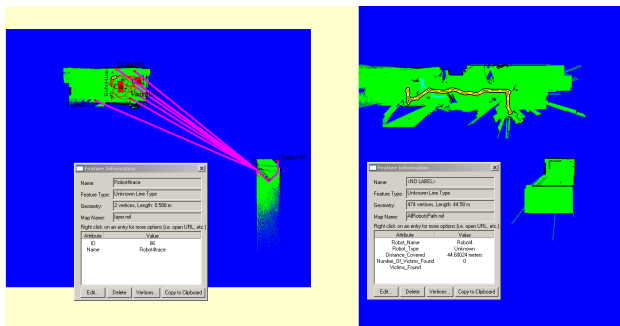
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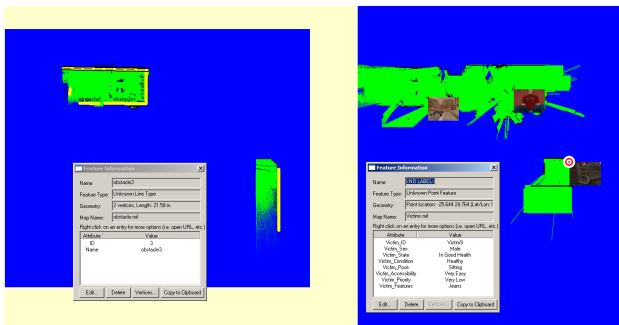
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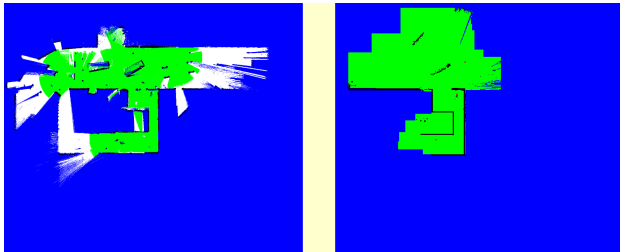
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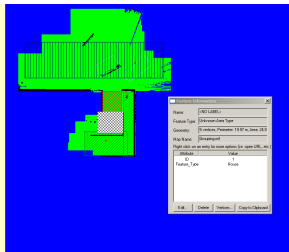
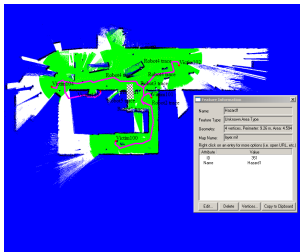
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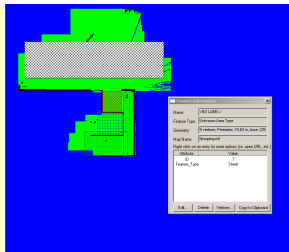
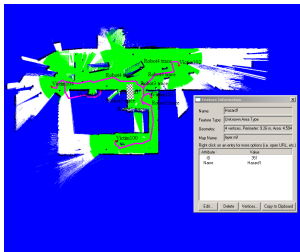
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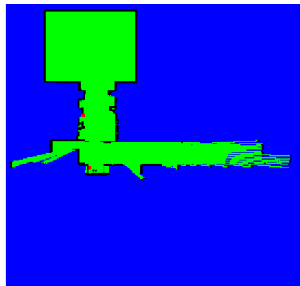
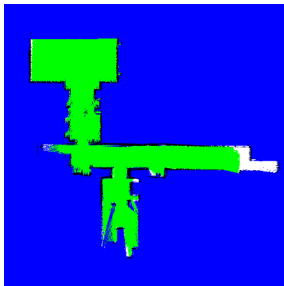
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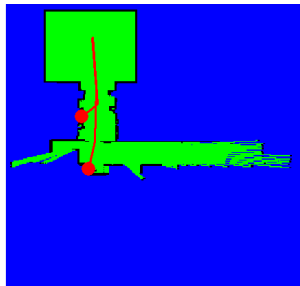
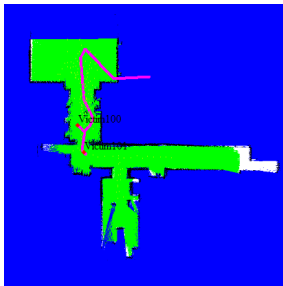
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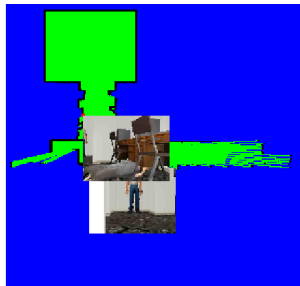
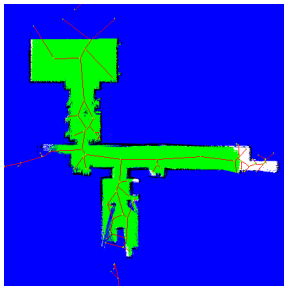
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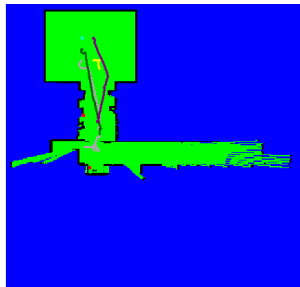
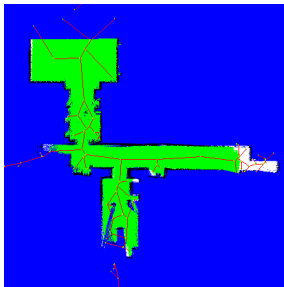
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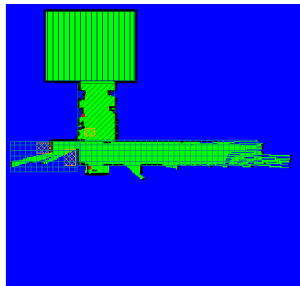
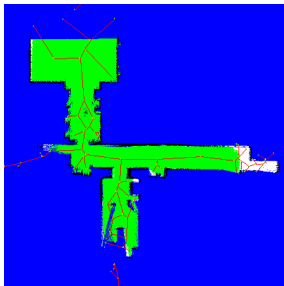
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- Reward teams for innovative information portrayal
- Scoring: additional bonus points

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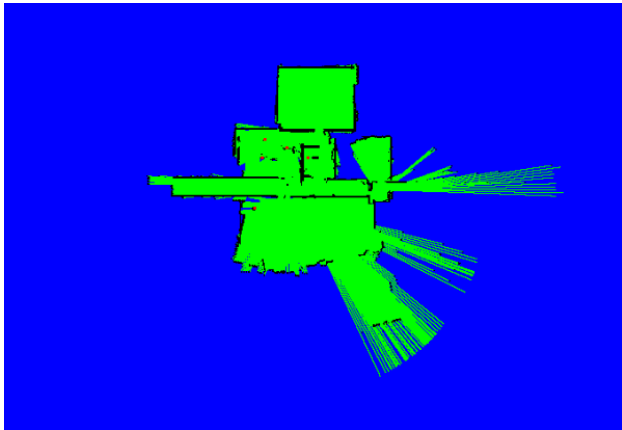
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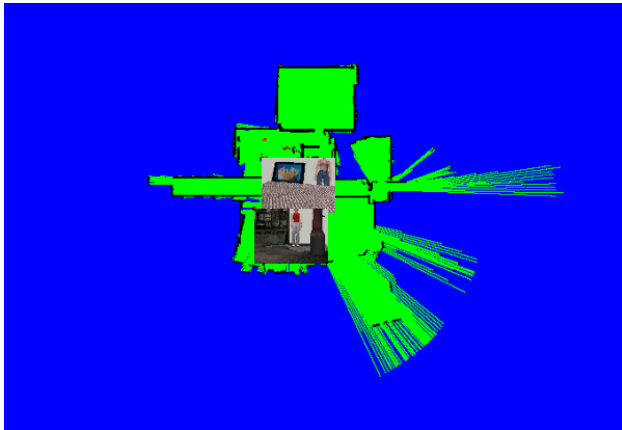
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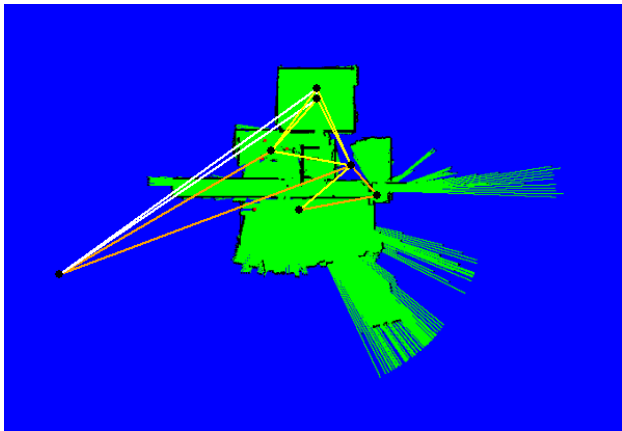
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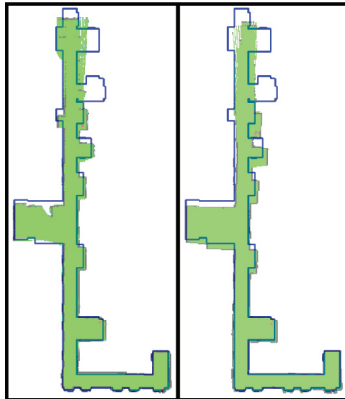
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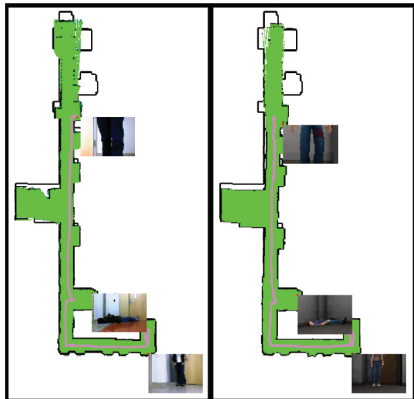
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- More function parameters
 - Time
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 - Human factors
- Automatic solutions
- Extrapolation to 3D maps



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- Lack of proper metric quality benchmarks
- Categorized map benchmarks for USAR
- Map representation standards
- Commitment to open-source and open standards
- Tested with simulated and real robots
- Benefit of simulations



Thanks!

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Questions?