Modeling the World

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Work by Matthew Brown and

Don Murray

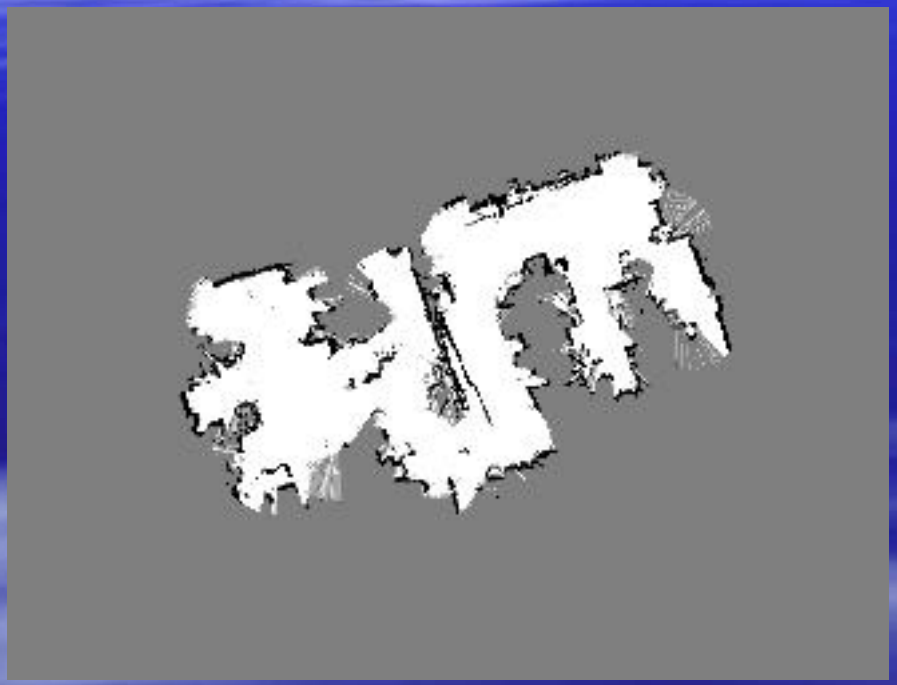
Motivation

- An agent needs a map to reason about actions
- Where am I? localization aids the agent to begin reasoning with its location in the map
- The map itself is an important artifact for use by others: stereo gives shape data, images

Navigation

- Vision based
- Build occupancy grid map of static features in the environment (using stereo)
- Path planning on grid
- Detect dynamic obstacles using stereo and bump sensors
- Update map and re-plan

Occupancy Grid Map Example



White : Empty space

Black: Obstacles

Grey: Unknown space

We refer to this map as the plan map

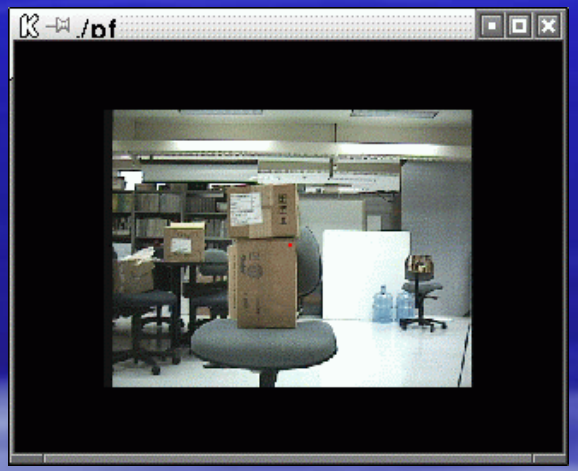
Avoiding Dynamic Obstacles

- Vision (while in translation)
  - if obstacle detected
    - Stop and signal supervisor
    - If obstacle persists over N number of seconds
      - Update plan map, re-plan and continue
- Bump
  - if obstacle detected
    - Stop and signal supervisor
    - Update plan map, re-plan and continue

Finding People

- Construct occupancy grid probability map of where people are standing
- Use the map to decide where to serve next
- Detect people using skin color segmentation
- Use stereo data to compute 3D position of people
- Project locations to floor plane
- Decrease the probabilities over time because people move around

Finding People (Cont.)
Example

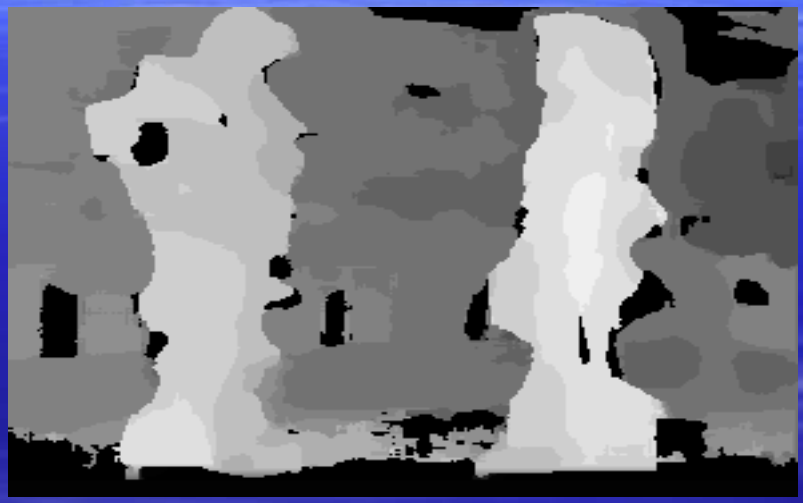


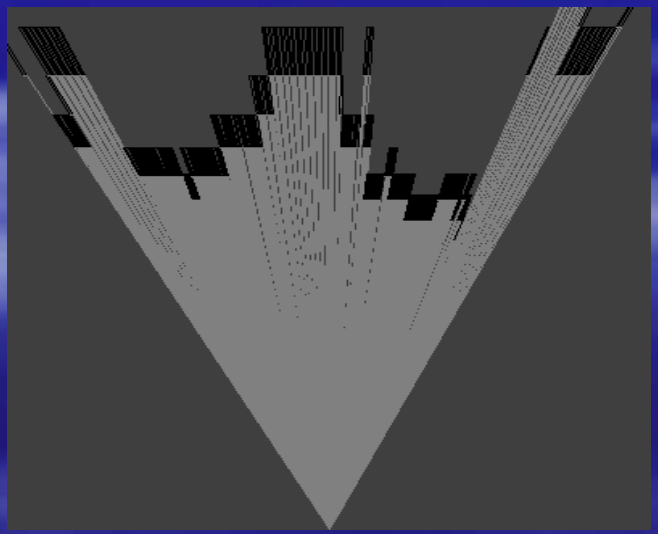
Color Image

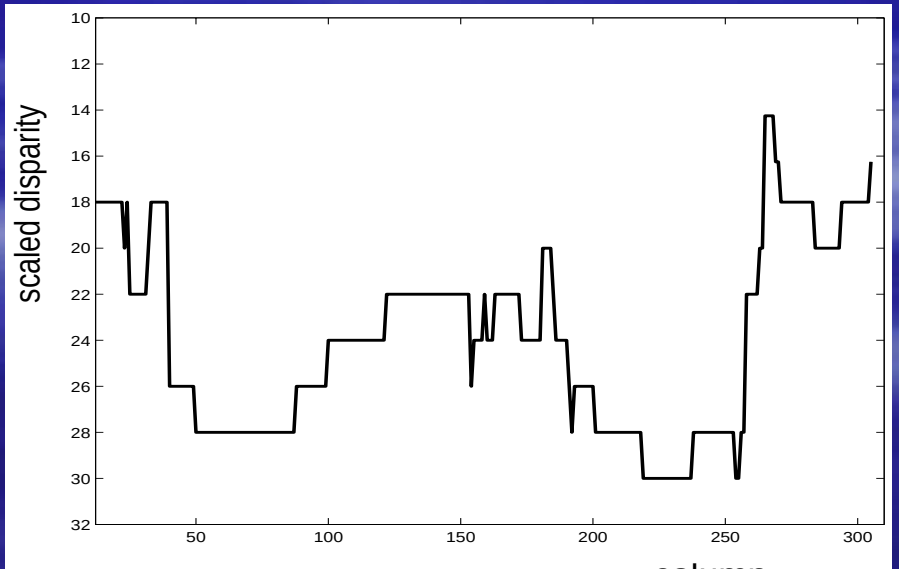
Skin Regions

Probability Map

From stereo to maps



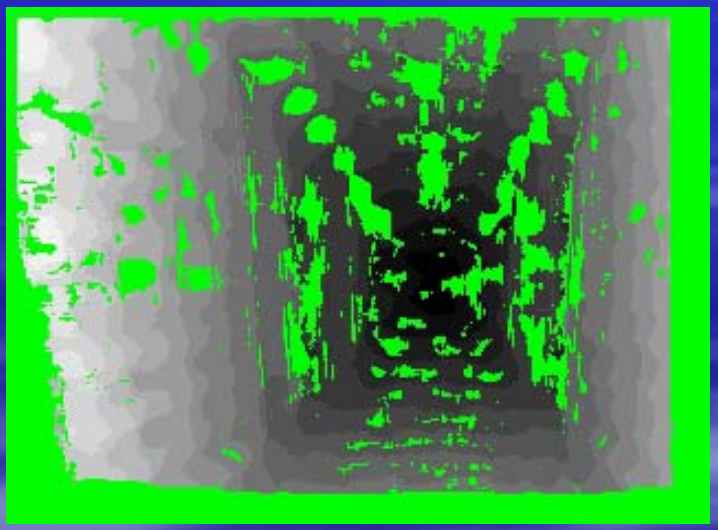




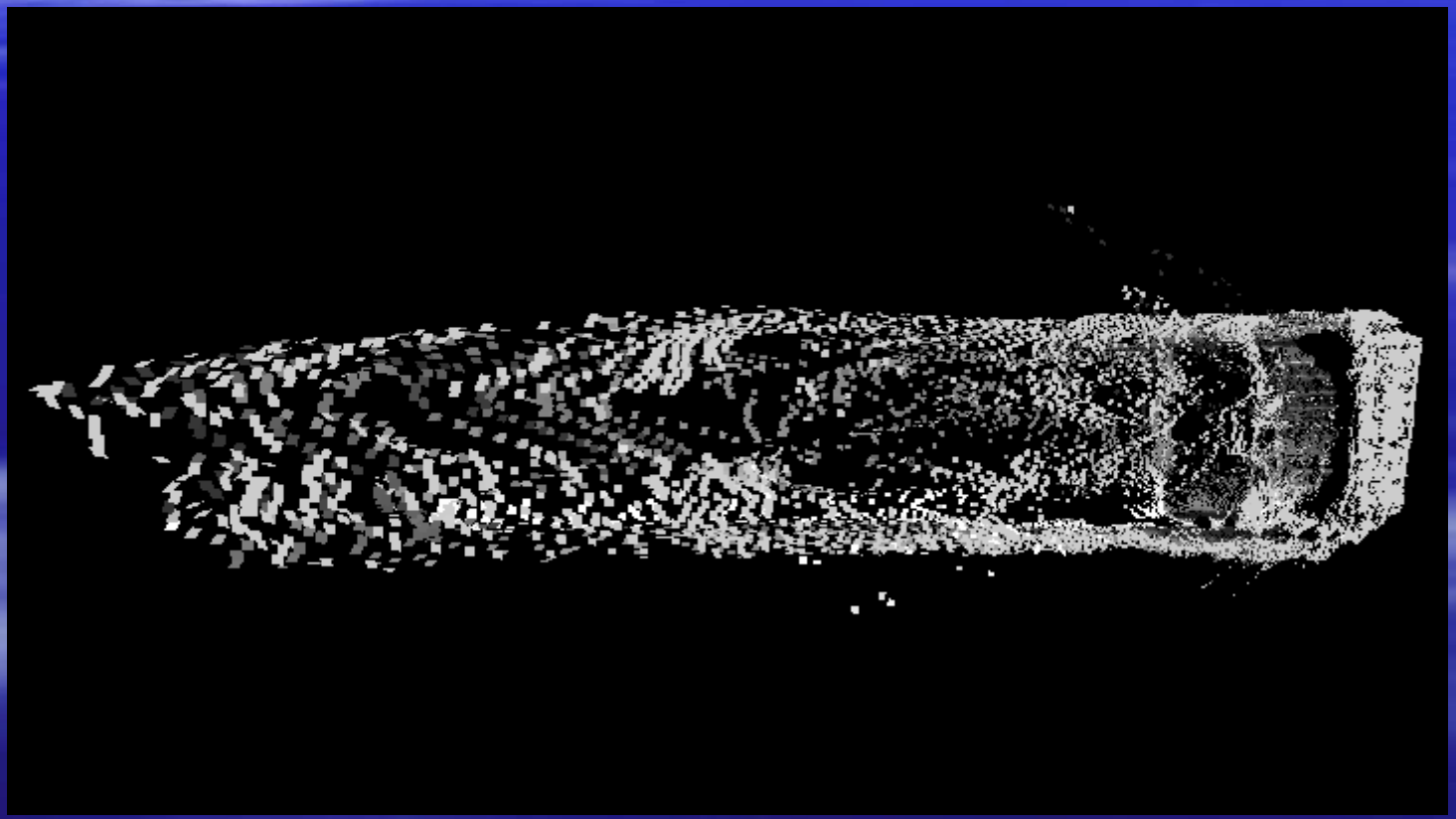
Patchlet Surface Representation

- Trying to properly interpret the uncertainty of stereo measurements in surface reconstruction.
- The sensor elements considered are local patches in the stereo image that create patchlets.
- These patchlets are fit to a plane and the uncertainty of the plane in orientation and position is determined from the stereo 3d points.

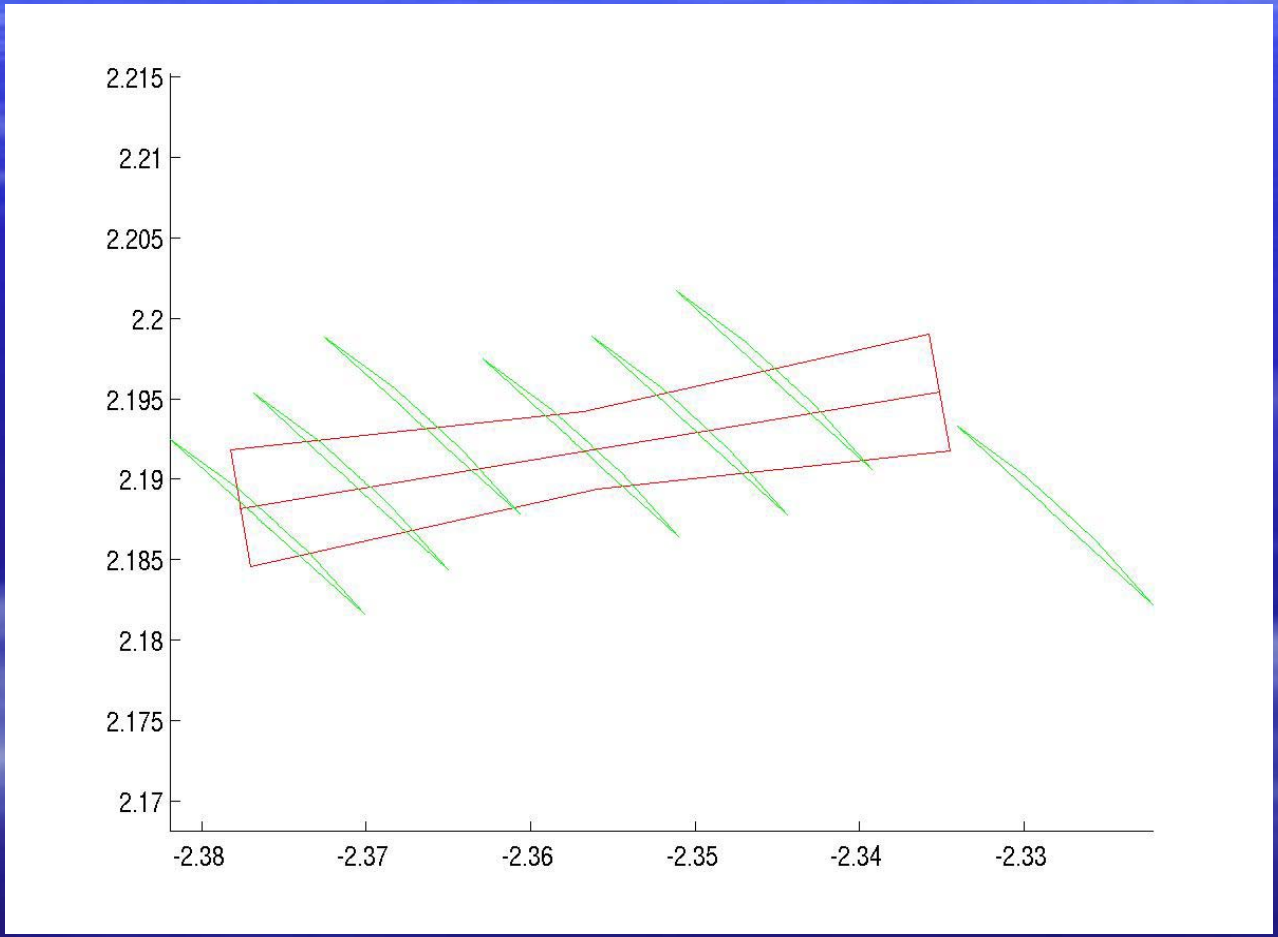
Brightness and Depth



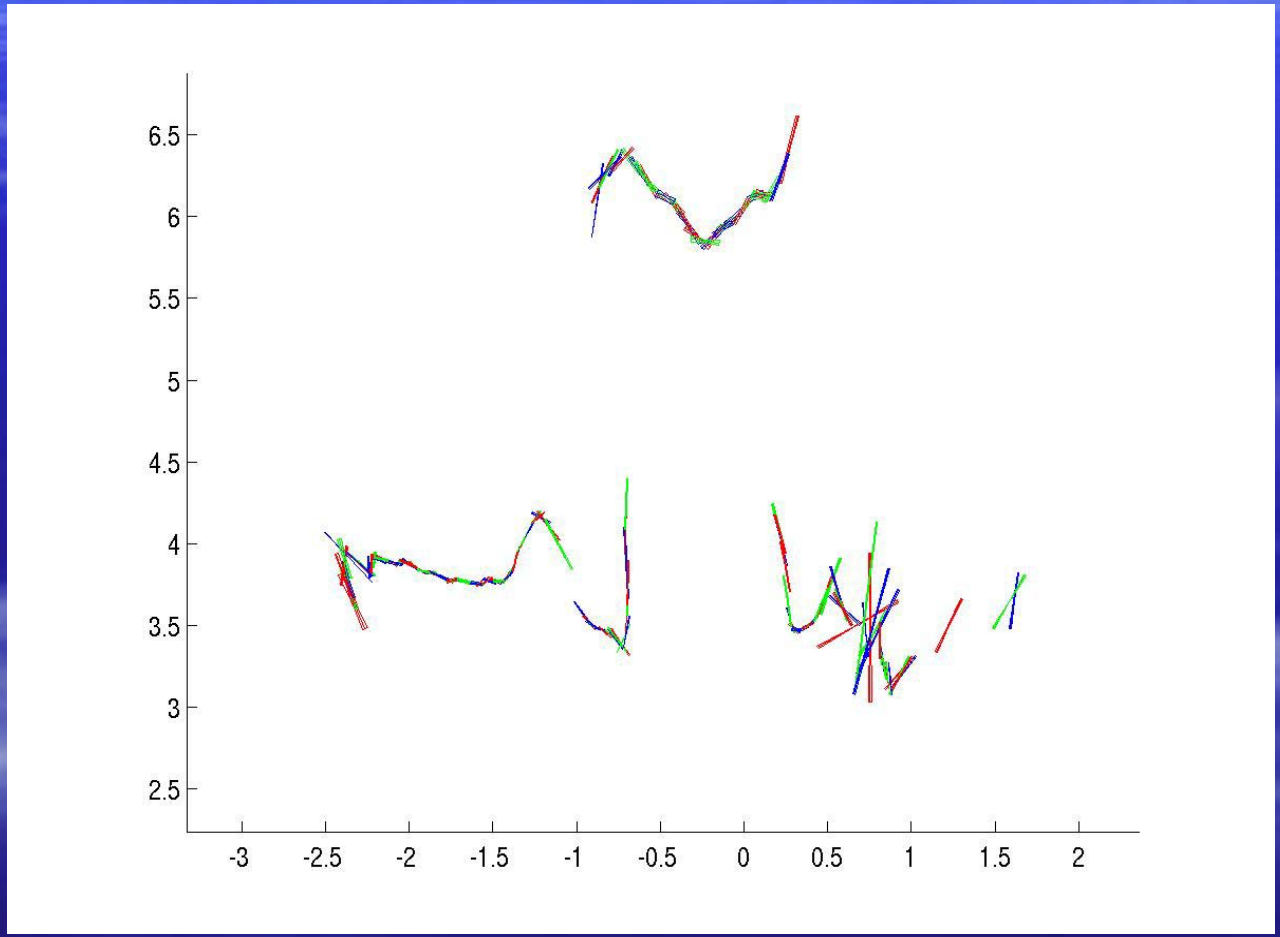
Depth Pixels and Scale



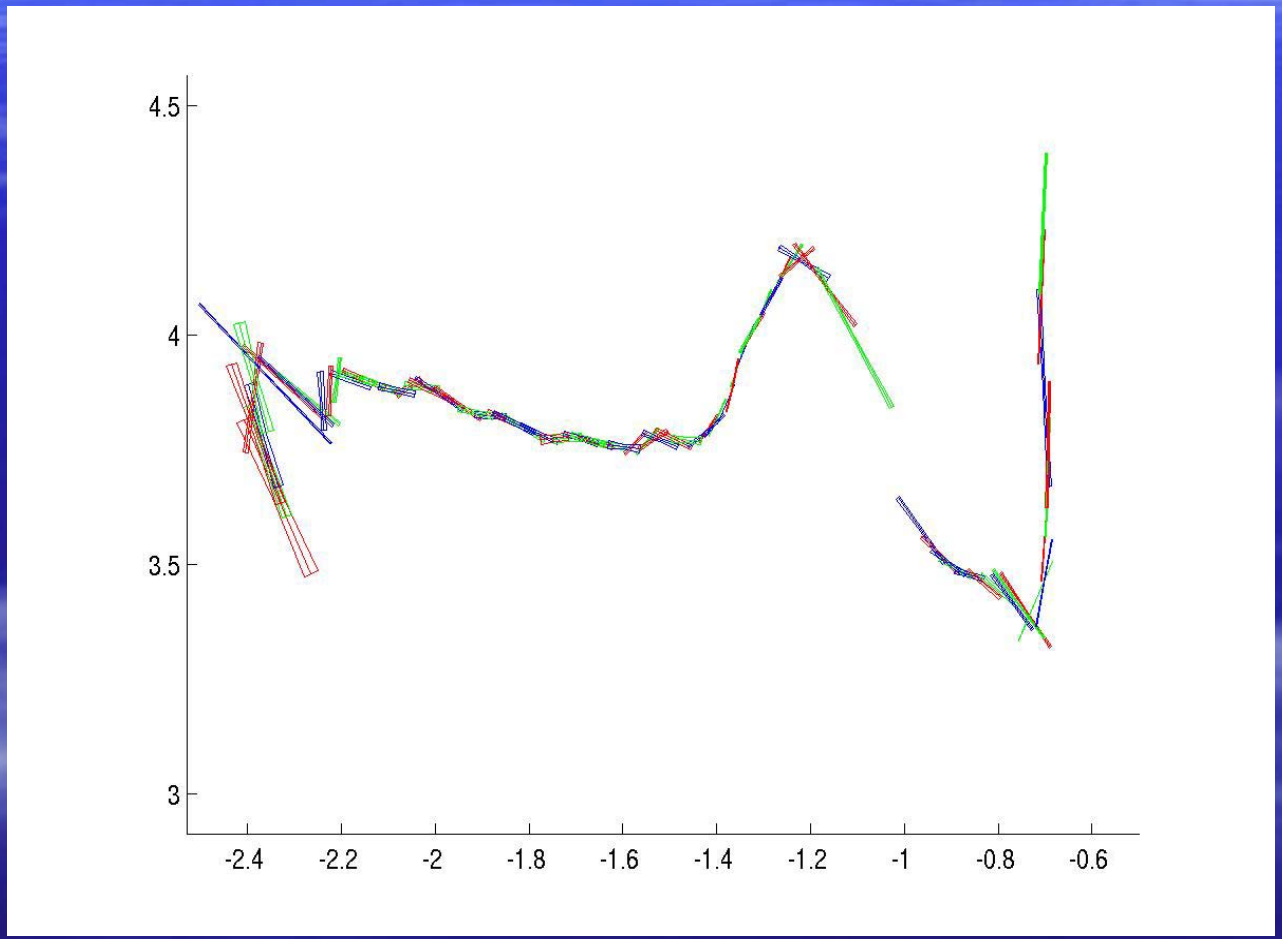
Patchlet Uncertainty



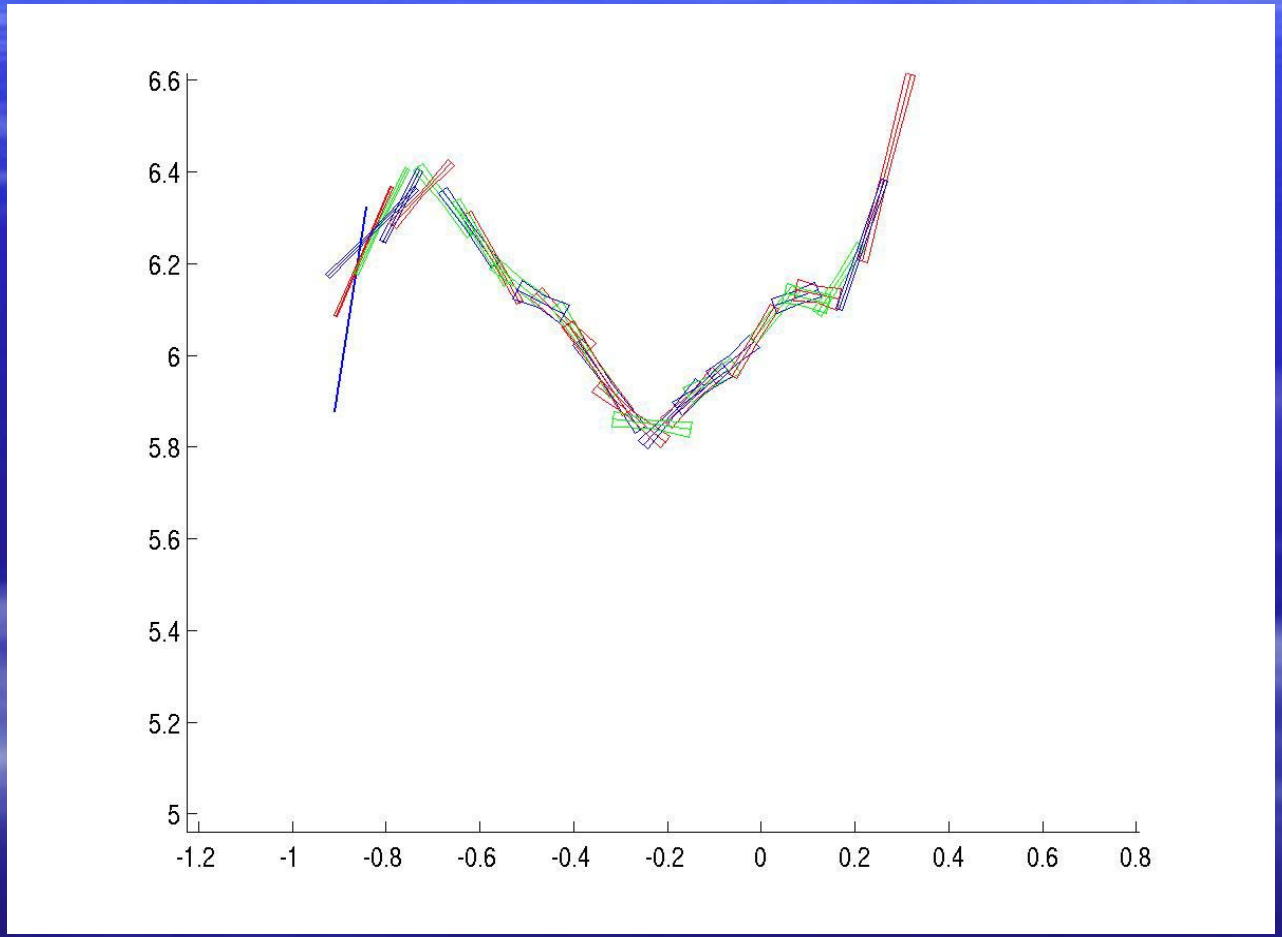
Patchlets



Near



Far



Recognizing Panoramas

- Matthew Brown and David Lowe
- Recognize overlap from an unordered set of images and automatically stitch together
- SIFT features provide initial feature matching
- Image blending at multiple scales hides the seams

Panorama of our lab automatically assembled from 143 images

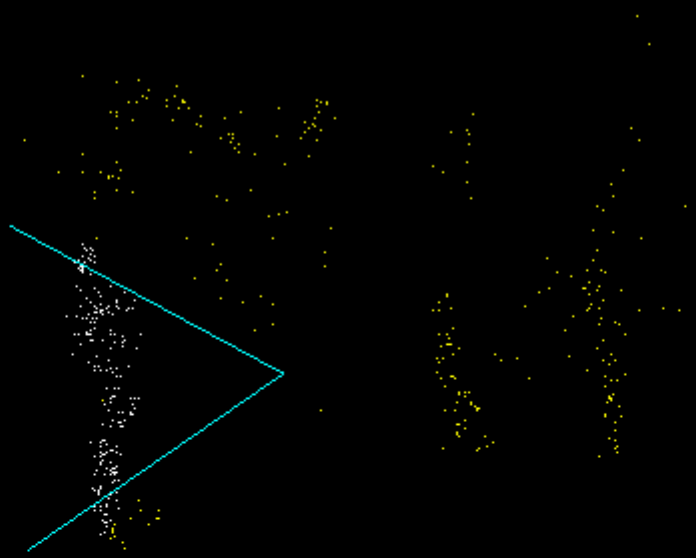
Multiple panoramas from an unordered image set

Input images

Output panorama 1

Volumetric Images

- The green regions are those grid cells that have occupancy of 60% or more. The floor is the usual occupancy grid map generated using the volume maps. The black pixels represent occupied regions where at least one cell on the volume above it is occupied. If none is occupied then the pixel is set to white i.e., empty space. The blue lines represent the field of view.
- The robot was looking at a wall and a desk with computers to its right.



Live

Init
Localize

Image View
Map View
Plot View
Point View
Time View

C->P | <- | ->
L->R | <- | ->

Do Global

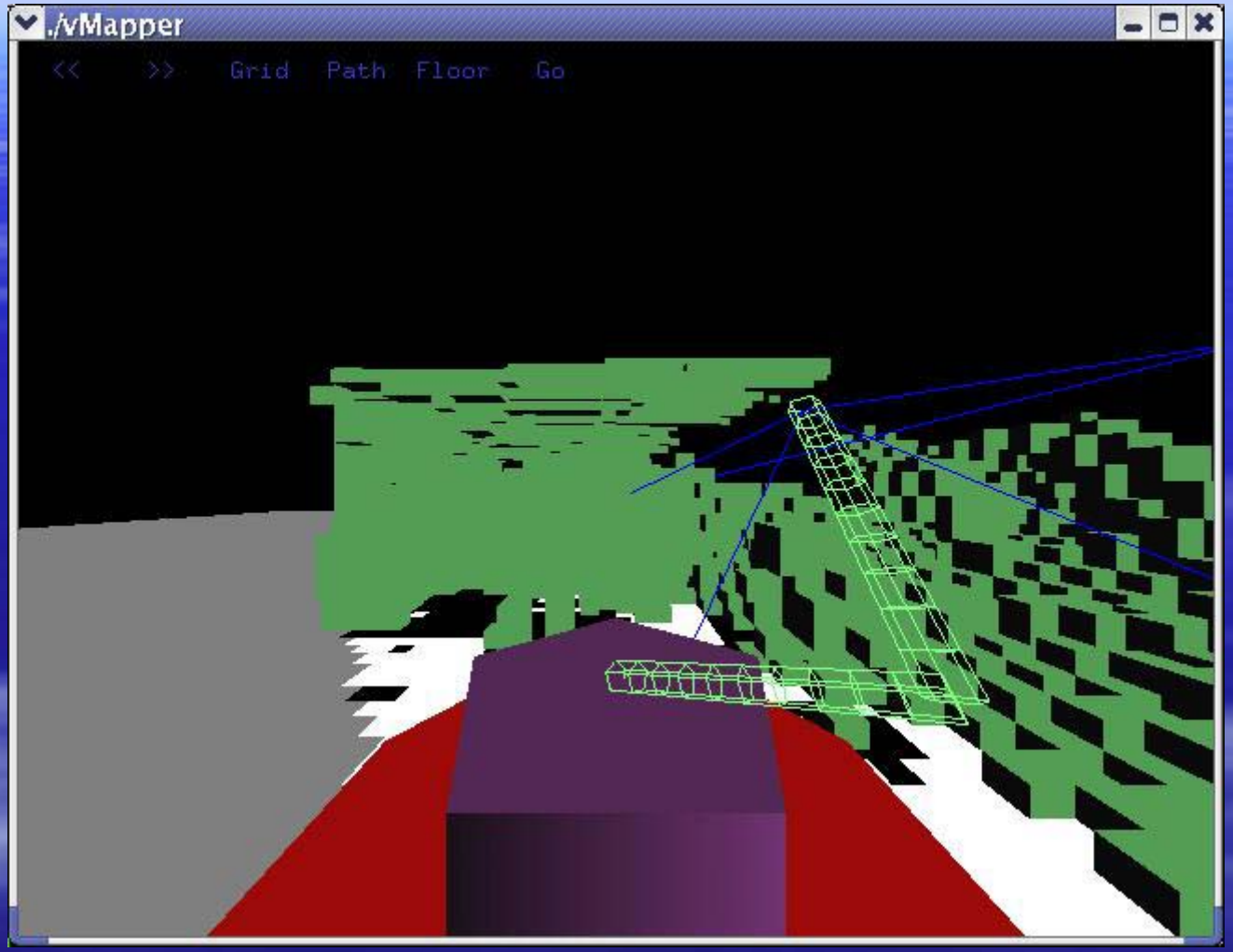
Save Map
Load Map

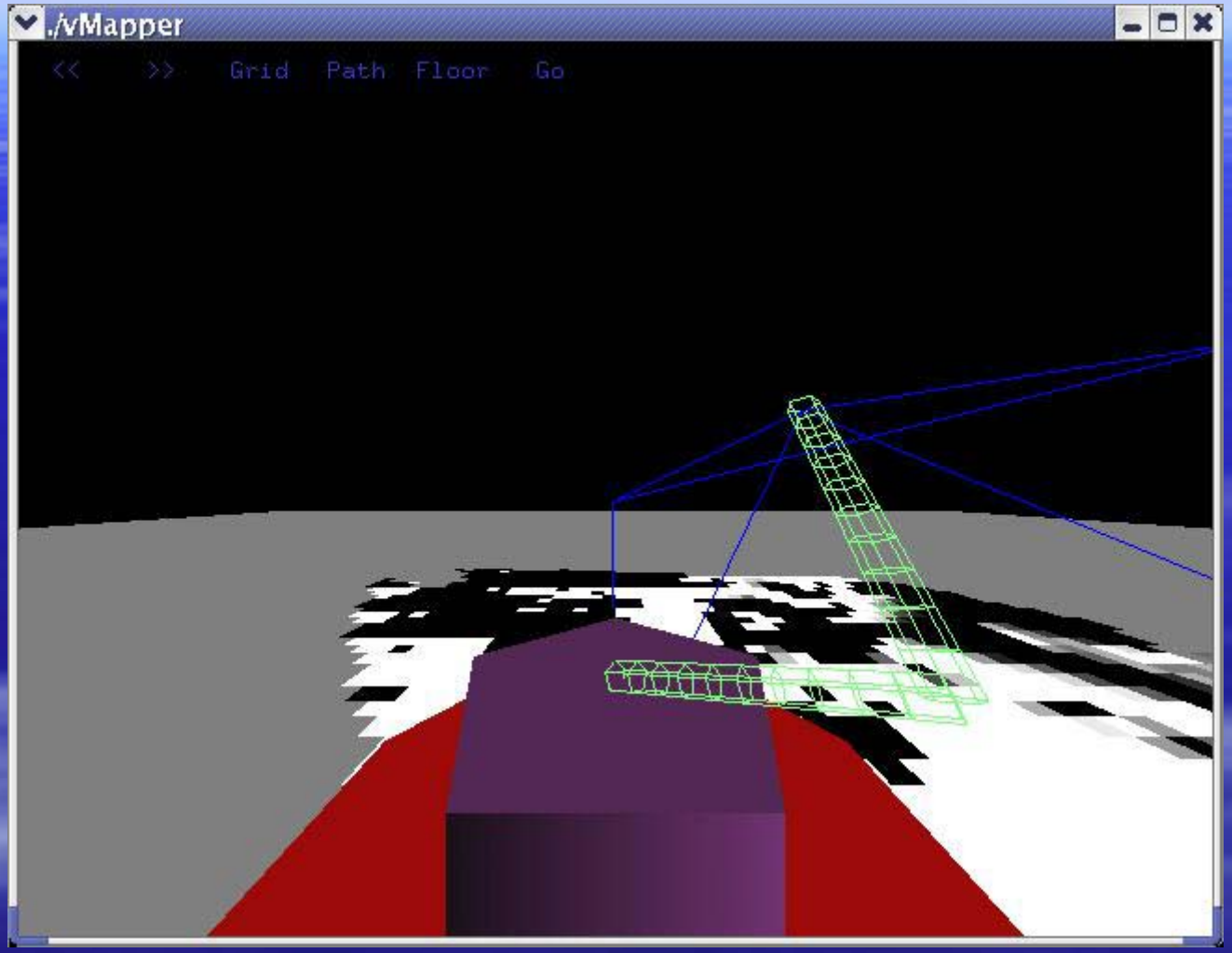
Advance | <- | ->

```
FPS                 :::::    1.961
Keys Found          :::::    (L  294)  (R 281)
Landmarks           :::::    139
Database size       :::::    1065
Got  T  = [ 0.000 0.000 0.000 ]          ch odo -0.008 0.026 0.000
Got  R  = [ 1.000  0.000  0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]
Got  To =[ -0.026 0.000 -0.008 ]
Got  Ro =[ 1.000  0.000  -0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]

Got  Tg =[ -1.477 0.000 2.877 ]
Got  Rg =[ -0.055  0.000  -0.998 0.000  1.000  0.000 0.998  0.000  -0.055 ]
Got  Tog =[ -1.477 0.000 2.877 ]
Got  Rog =[ -0.055  0.000  -0.998 0.000  1.000  0.000 0.998  0.000  -0.055 ]
```

```
Rob 2.88 1.48 93.164
PTU    0    0
Est 0.00 93.16 0.00
Est 0.00 0.00 0.00 per frame
```


./vMapper
<< >> Grid Path Floor Go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Live

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Localize

Image View
Map View
Plot View
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Time View

C->P | <- | ->
L->R | <- | ->

Do Global

Save Map
Load Map

Advance | <- | ->

```
FPS                  4.545
Keys Found           (L  180)  (R 190)
Landmarks            73
Database size        146
Got  T  = [ 0.000 0.000 0.000 ]        ch odo 0 0 0.000
Got  R  = [ 1.000  0.000  0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]
Got  To =[ -0.000 0.000 0.000 ]
Got  Ro =[ 1.000  0.000  -0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]

Got  Tg =[ 0.000 0.000 0.000 ]
Got  Rg =[ 1.000  0.000  0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]
Got  Tog =[ 0.000 0.000 0.000 ]
Got  Rog =[ 1.000  0.000  0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]

Rob -0.001 -0.001 0.000
PTU   0    0
Est 0.00 0.00 0.00
Est 0.00 0.00 0.00 per frame
```

Right Gray

Left Gray

Live

Init
Localize

Image View
Map View
Plot View
Point View
Time View

C->P | <- | ->
L->R | <- | ->

Do Global

Save Map
Load Map

Advance | <- | ->

```
FPS                 :::::    4.545
Keys Found          :::::    (L  180)  (R 190)
Landmarks           :::::    73
Database size       :::::    146
Got  T  = [ 0.000 0.000 0.000 ]          ch odo 0 0 0.000
Got  R  = [ 1.000  0.000  0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]
Got  To =[ -0.000 0.000 0.000 ]
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Got  Tg =[ 0.000 0.000 0.000 ]
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Got  Tog =[ 0.000 0.000 0.000 ]
Got  Rog =[ 1.000  0.000  0.000 0.000  1.000  0.000 0.000  0.000  1.000 ]
```

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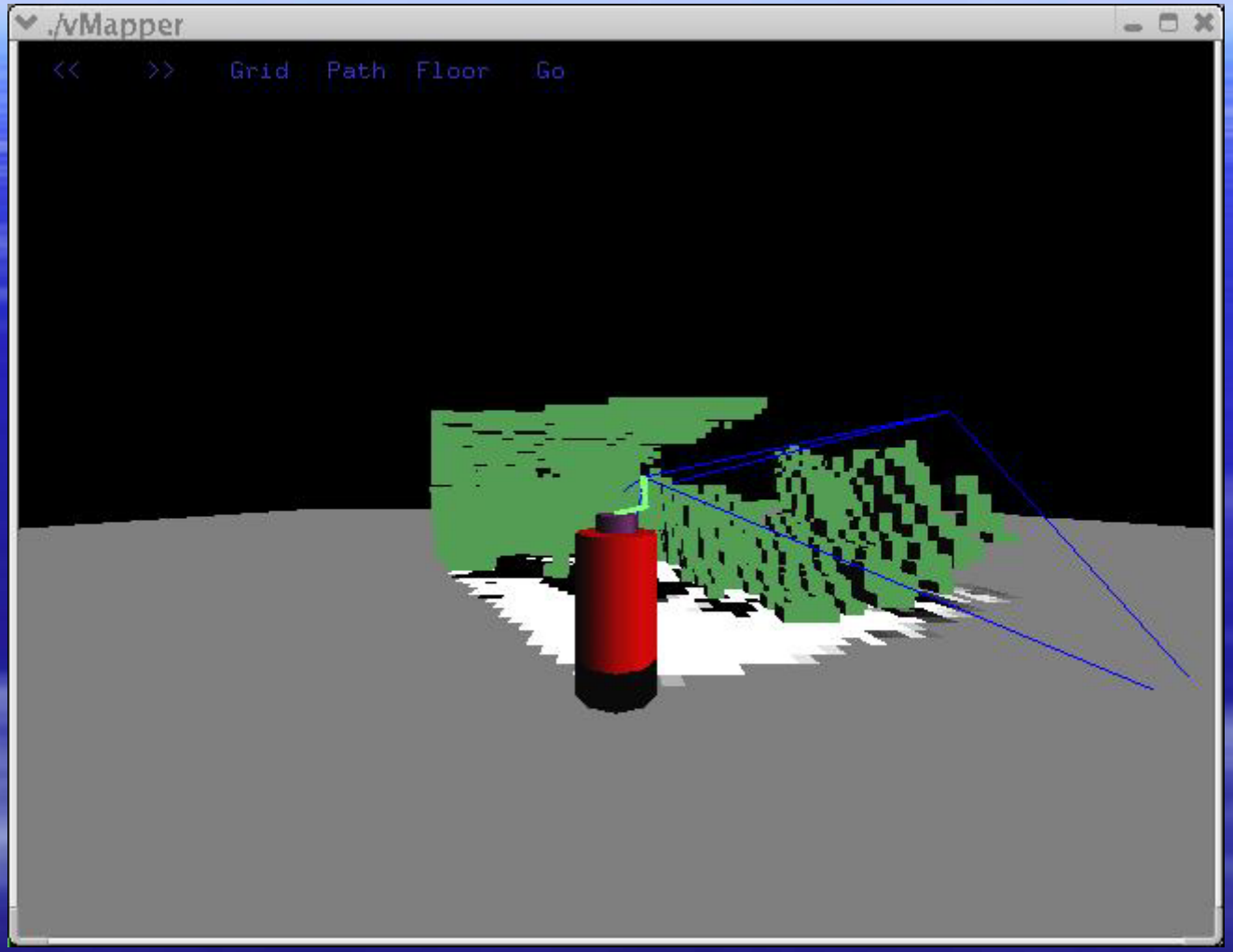
Rob -0.001 -0.001 0.000
PTU    0     0
Est 0.00 0.00 0.00
Est 0.00 0.00 0.00 per frame
```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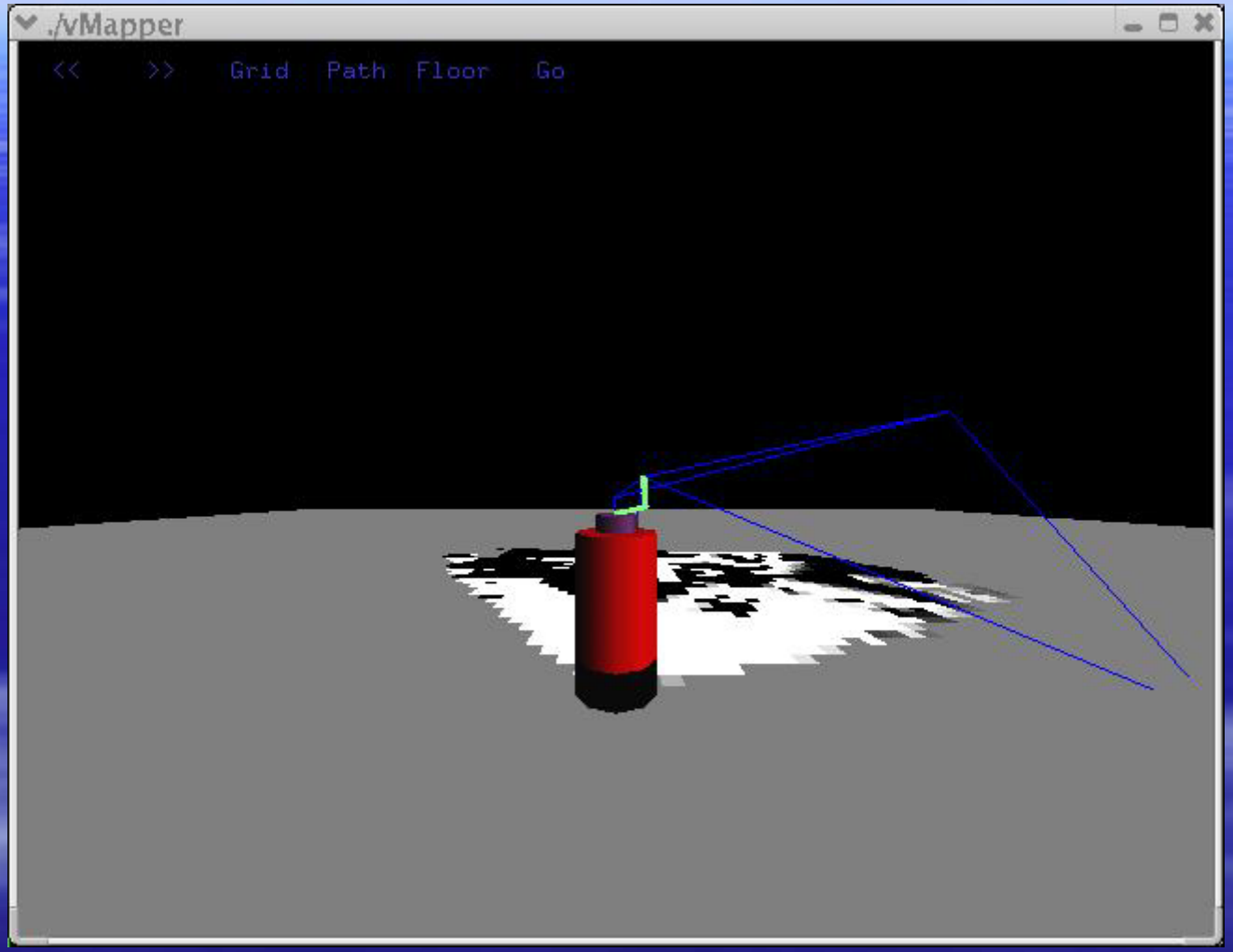
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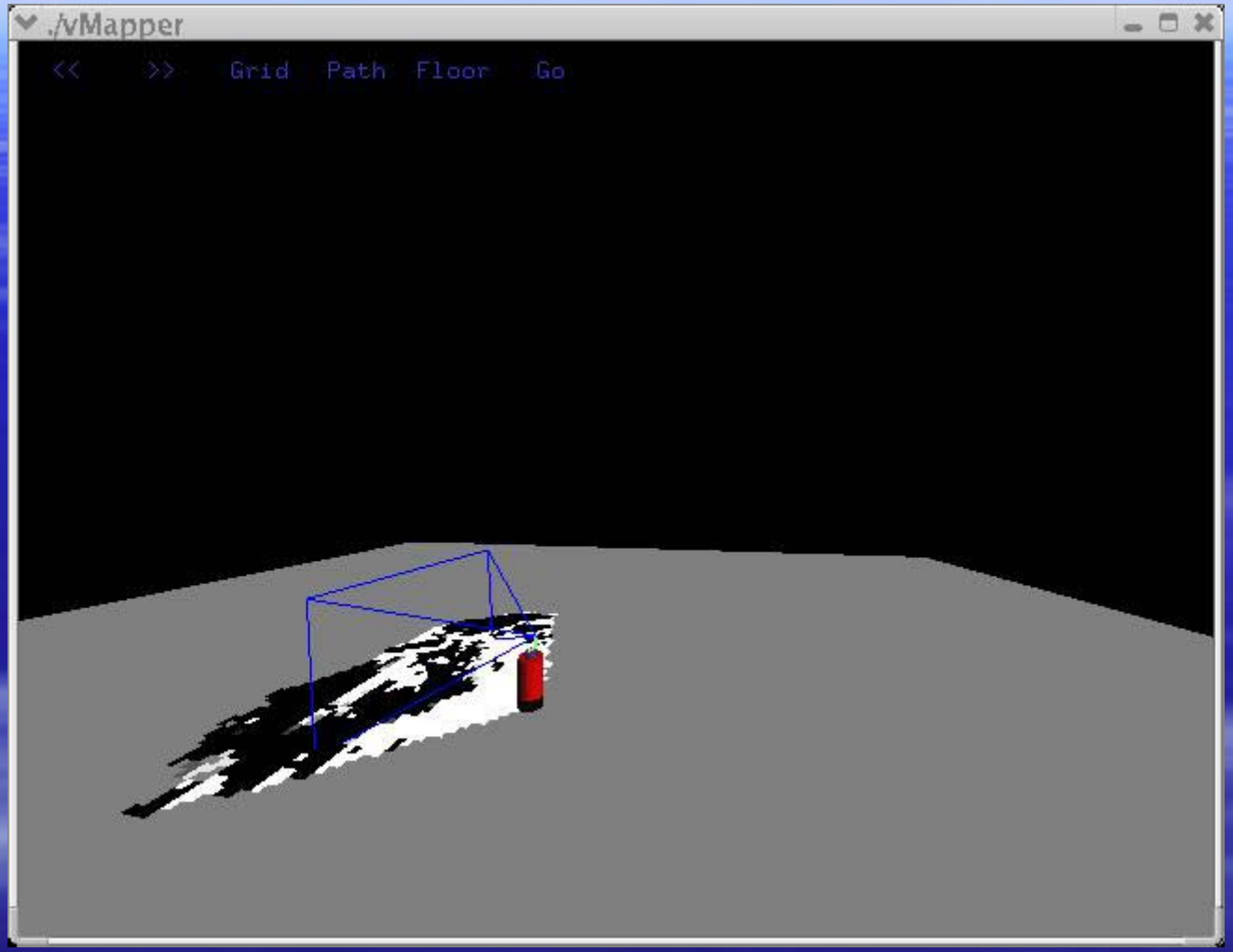
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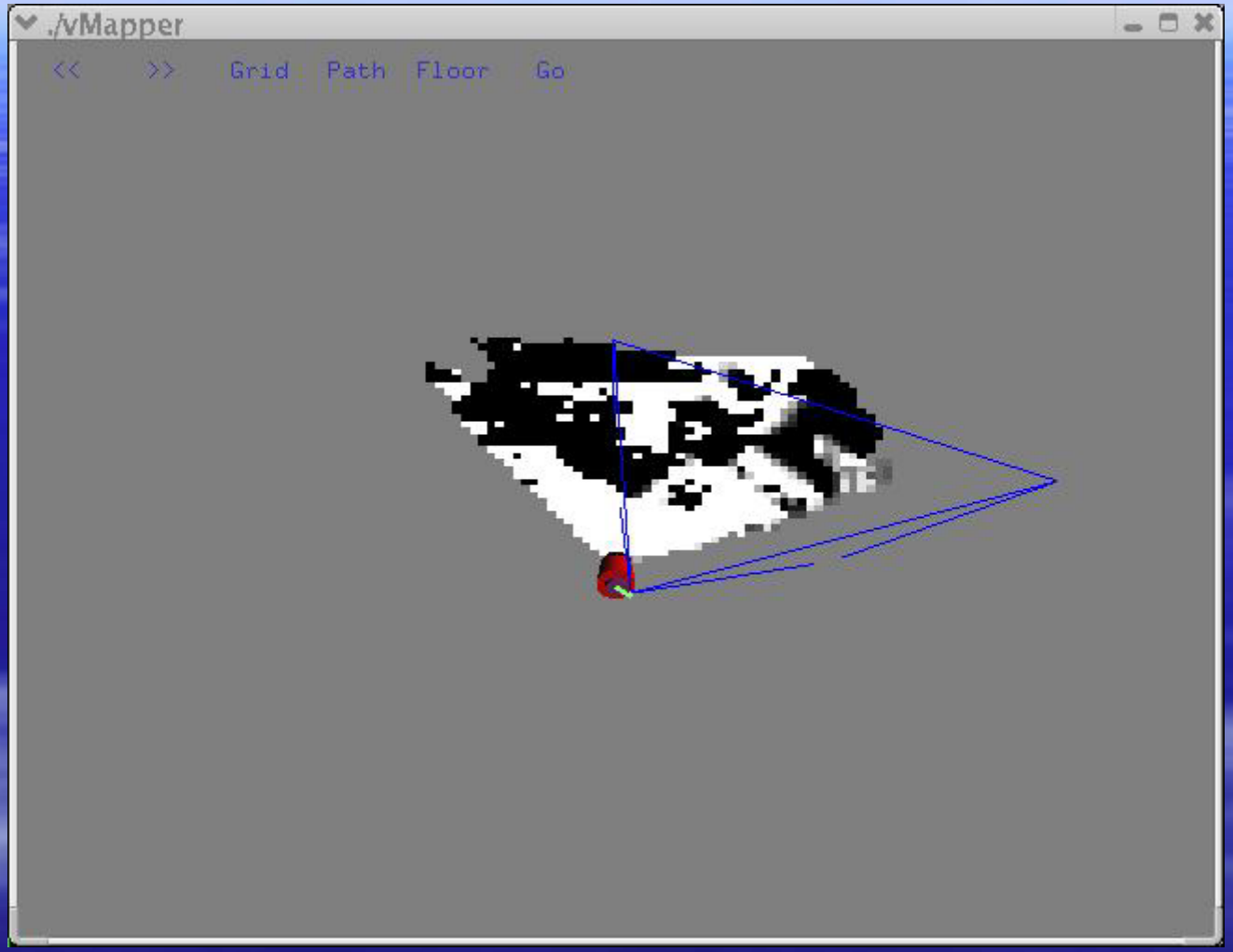
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