3D Vision
3D Cameras

• Stereo used to be the only option
• Now, RGB-D cameras are easier (at least for indoor)
• Stereo still use lower power
Urban Search and Rescue
Rescue Arena
Rescue Arena
Explore, map and find victims
What does the world look like?
Segmentation

- Point cloud segmentation
- Using planes as primitives
- Represent each region’s boundary by a convex hull
- Using plane’s normal vector for orientation
Normals Vectors

- Point $P_1$ has 8 neighbours in depth plane
- Form eight triangles: $P_1P_2P_3$, $P_1P_3P_4$, …, $P_1P_8P_9$, $P_1P_9P_2$
- Calculate normal vector from the cross product of $P_1P_i$ and $P_1P_j$
- The normal vector for $P_1$ is average of eight normal vectors, and normalising the result
Segmentation

- Form regions by clustered neighbouring points that have (almost) the same normal vectors
- Find convex hull around points in the same region
Segmentation
Feature Extraction

• Two sets of features
  • Properties of individual planes
  • Relationships between pairs of planes
• Represented as PROLOG predicates
Feature Extraction

plane(pl1). plane(pl2).
plane(pl3). plane(pl4). plane(pl5).

distributed_along(pl1,axisX). distributed_along(pl2,axisX).
distributed_along(pl3,axisX). distributed_along(pl4,axisX).
distributed_along(pl5,axisY).
Feature Extraction

Convex Hull Ratio

ch_ratio(pl1,'4.0±0.25').
ch_ratio(pl2,'2.5±0.25').
ch_ratio(pl3,'3.5±0.25').
ch_ratio(pl4,'2.0±0.25').
ch_ratio(pl5,'1.5±0.25').
Angle Bins

112±7.5
90±15
135±15
157±7.5
180-15

67±7.5
45±15
22±7.5
0+15
Feature Extraction

- Region’s normal vector in spherical coordinates

  `normal_spherical_theta(pl1,'-90±15').`

  `normal_spherical_phi(pl1,'135±15').`

  ...

  `normal_spherical_theta(pl5,'-135±15').`

  `normal_spherical_phi(pl5,'112±15').`
Angle between two regions

\[
\begin{align*}
\text{angle}(p1,p2, '90\pm15'). \\
\text{angle}(p1,p3, '45\pm15'). \\
\text{angle}(p1,p4, '90\pm15'). \\
\text{angle}(p1,p5, '45\pm15'). \\
\text{angle}(p2,p3, '90\pm15'). \\
\text{angle}(p2,p4, '0\pm15'). \\
\text{angle}(p2,p5, '90\pm15'). \\
\text{angle}(p3,p4, '90\pm15'). \\
\text{angle}(p3,p5, '90\pm15'). \\
\text{angle}(p4,p5, '90\pm15').
\end{align*}
\]
Learning Object Classes

staircase([pl1,pl2,pl4,pl5]).
staircase([pl2,pl4,pl5,pl7]).
staircase([pl4,pl5,pl7,pl8]).
staircase([pl5,pl7,pl8,pl10]).
staircase([pl1,pl2,pl4,pl5,pl7]).
staircase([pl2,pl4,pl5,pl7,pl8]).
staircase([pl4,pl5,pl7,pl8,pl10]).
staircase([pl1,pl2,pl4,pl5,pl7,pl8]).
staircase([pl2,pl4,pl5,pl7,pl8,pl10]).
staircase([pl1,pl2,pl4,pl5,pl7,pl8,pl10]).
Learning Object Classes

- Positive and negative example for each object class
- The result of labelling as PROLOG predicates
- Using relational learning system to construct a classifier for each type of object
Description of a Staircase

staircase(B) : –
    p_a(B).

staircase([X, Y, Z|B]) : –
    p_a([X, Y, Z]),
    staircase([Z|B]).

p_a(B) : –
    member(X, B),
    member(Y, B),
    angle(X, Y, ‘90±15’),
    member(Z, B),
    angle(X, Z, ‘0±15’)
New data, New camera

- Spiral stairs
- 950 more positive examples
- accuracy: 99% (sampled from one staircase over several floors)
Non-planar surfaces
Structural relationships