3D Vision

3D Cameras

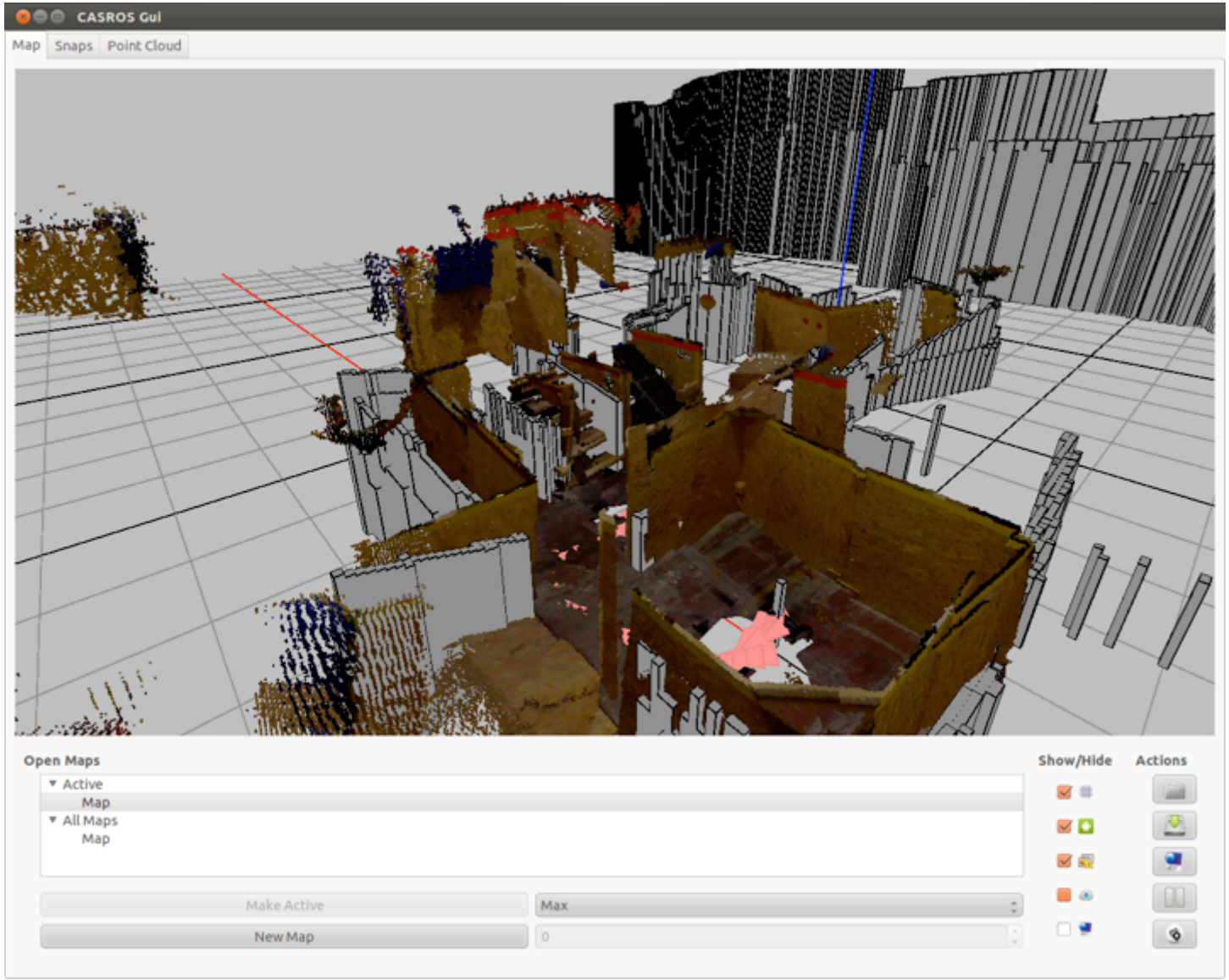
- Stereo used to be the only option
- Now, RGB-D cameras are easier (at least for indoor)
- Stereo still use lower power

Urban Search and Rescue

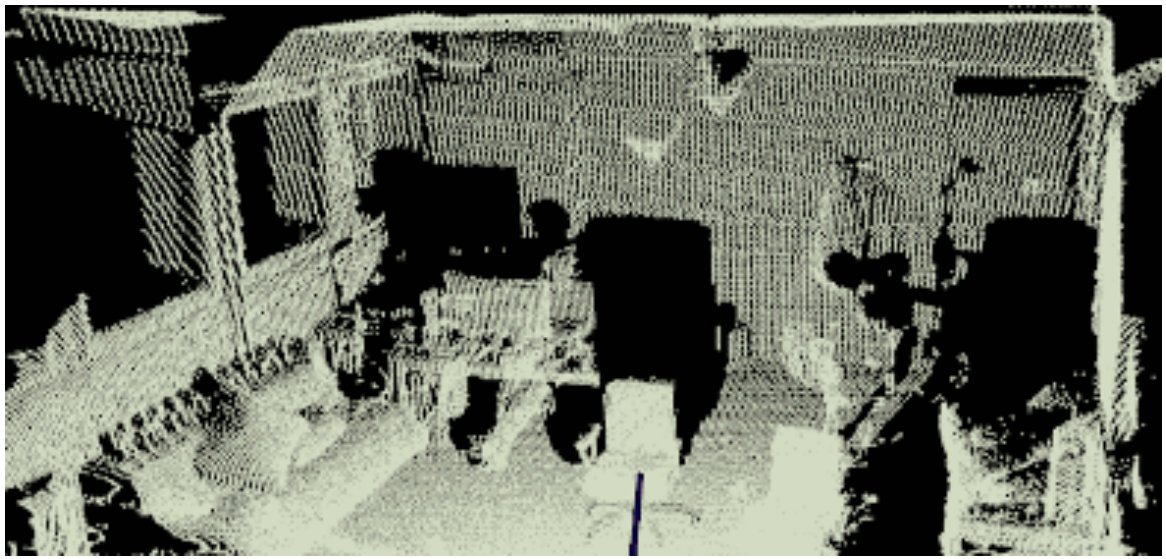
Rescue Arena

Rescue Arena

Explore, map and find victims

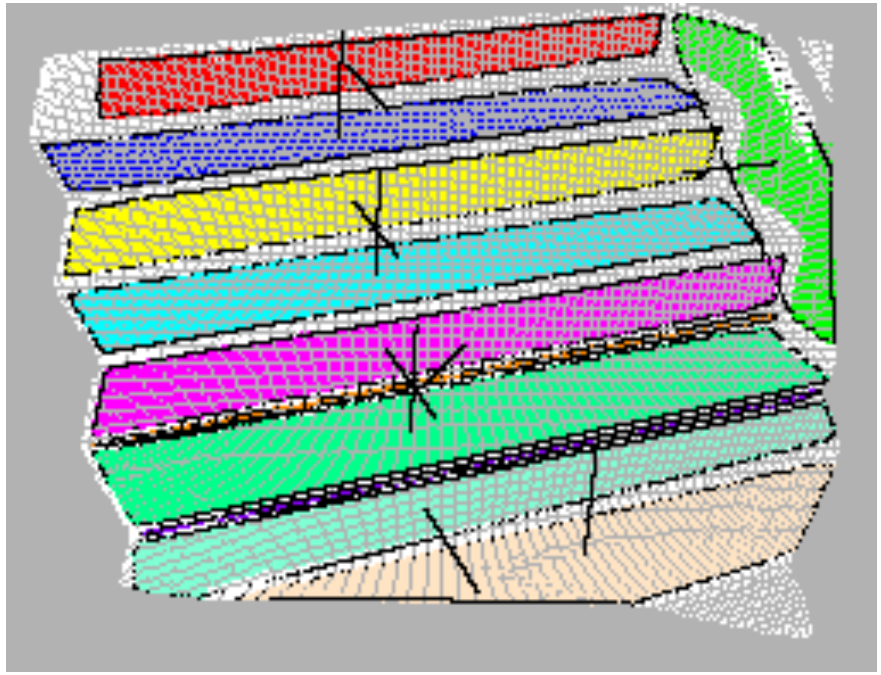


What does the world look like?



Segmentation

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



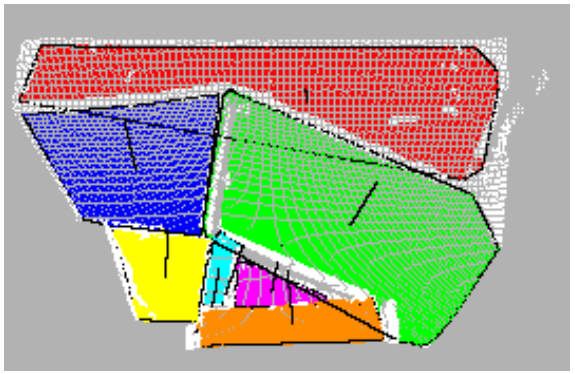
Normals Vectors

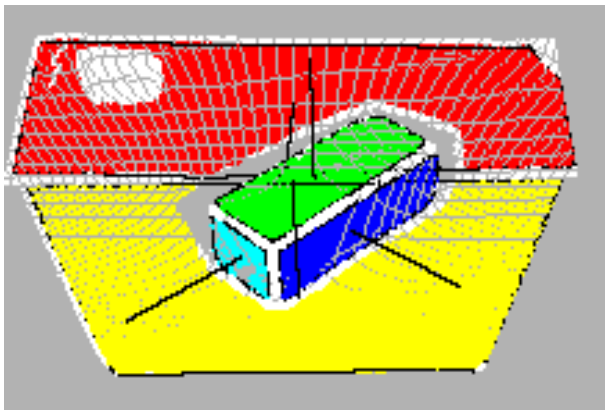
- Point P_1 has 8 neighbours in depth plane
- Form eight triangles:
  $P_1P_2P_3$, $P_1P_3P_4$, …., $P_1P_8P_9$, $P_1P_9P_2$
- Calculate normal vector from the cross product of P_1P_i and P_1P_j
- The normal vector for P_1 is average of eight normal vectors, and normalising the result

Segmentation

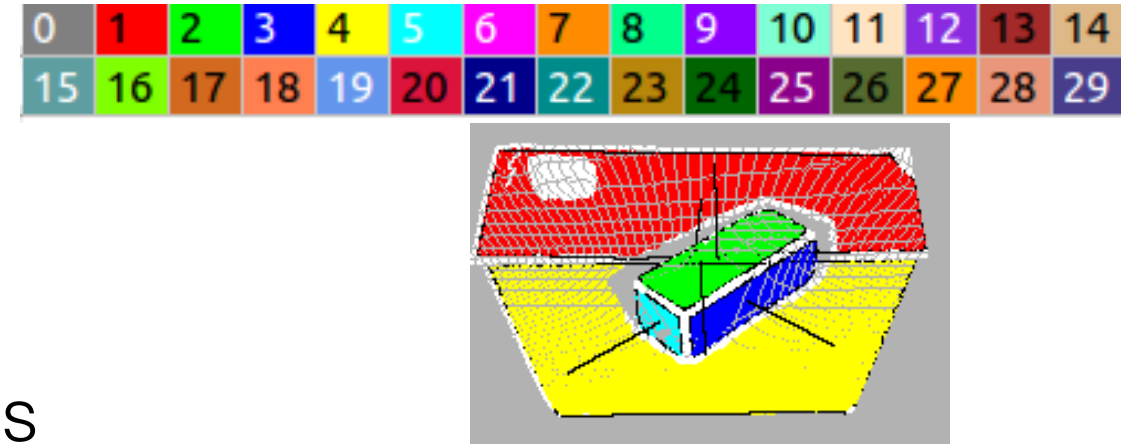
- Form regions by clustered neighbouring points that have (almost) the same normal vectors
- Find convex hull around points in the same region

Segmentation



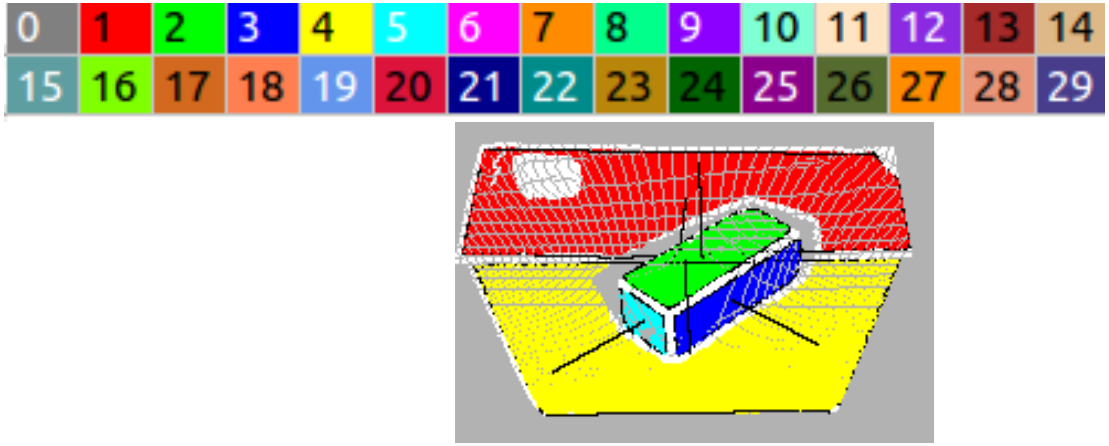


Feature Extraction



- Two sets of features
  - Properties of individual planes
  - Relationships between pairs of planes
- Represented as PROLOG predicates

Feature Extraction



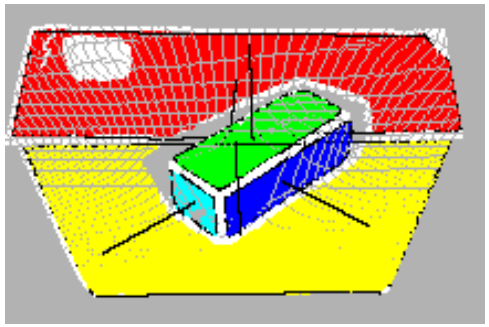
plane(pl1). *plane(pl2).*
plane(pl3). *plane(pl4).* *plane(pl5).*

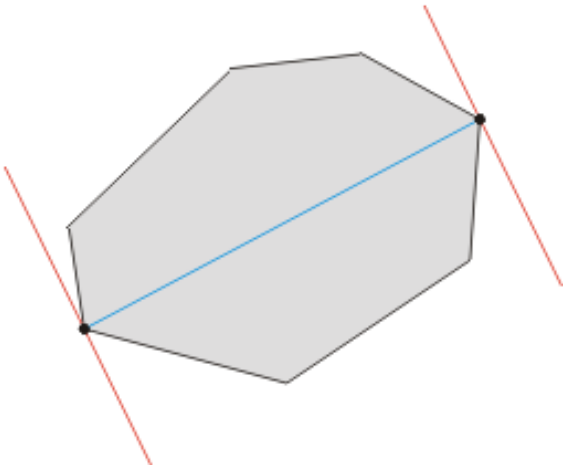
distributed_along(pl1,axisX). *distributed_along(pl2,axisX).*
distributed_along(pl3,axisX). *distributed_along(pl4,axisX).*
distributed_along(pl5,axisY).

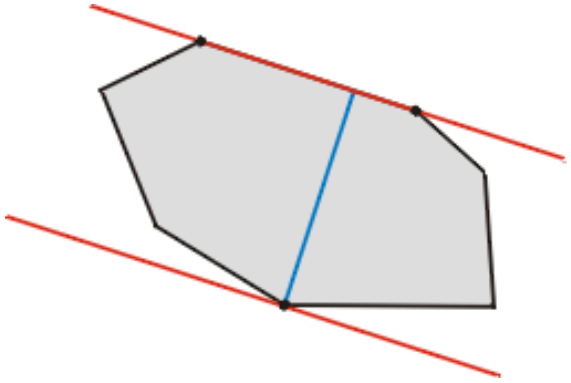
Feature Extraction

Convex Hull Ratio

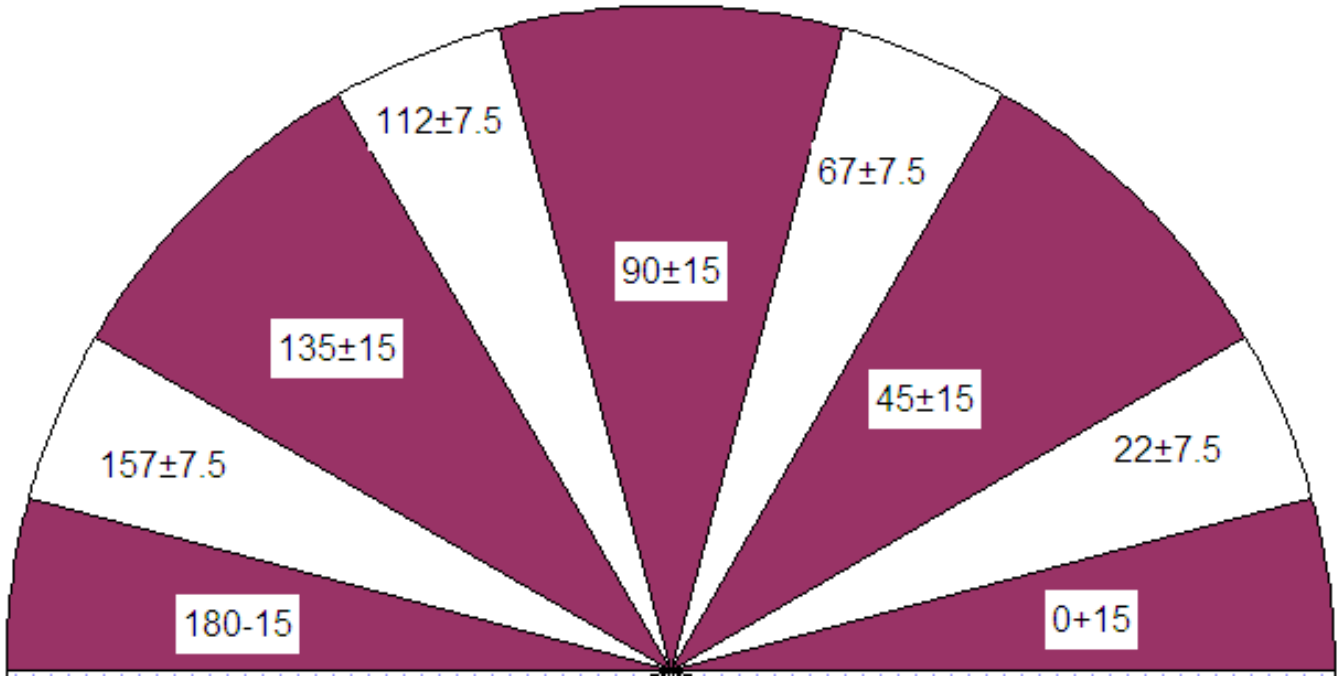
ch_ratio(pl1,'4.0±0.25').
ch_ratio(pl2,'2.5±0.25').
ch_ratio(pl3,'3.5±0.25').
ch_ratio(pl4,'2.0±0.25').
ch_ratio(pl5,'1.5±0.25').



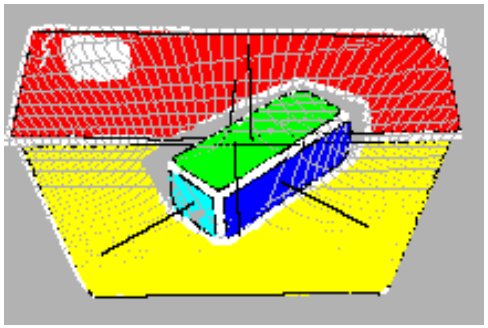




Angle Bins



Feature Extraction



- Region's normal vector in spherical coordinates

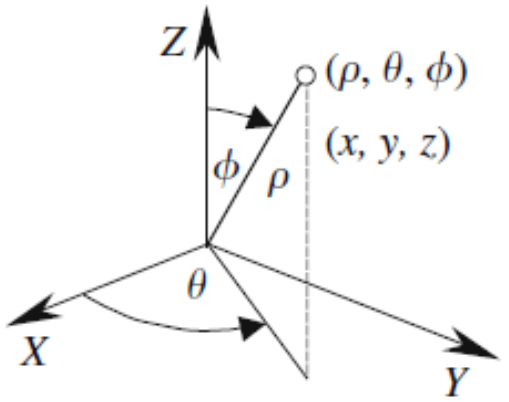
  normal_spherical_theta(pl1,'-90±15').

  normal_spherical_phi(pl1,'135±15').

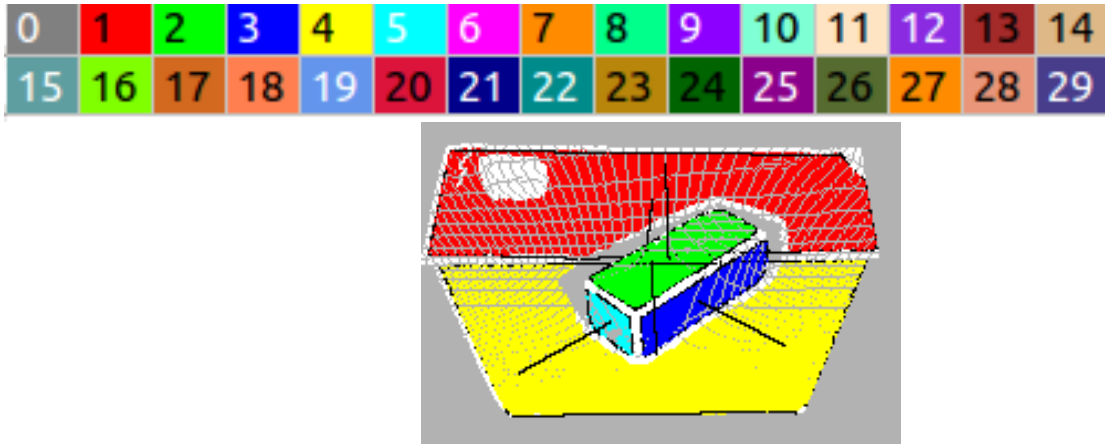
  …

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

  normal_spherical_phi(pl5,'112±15').



Feature Extraction

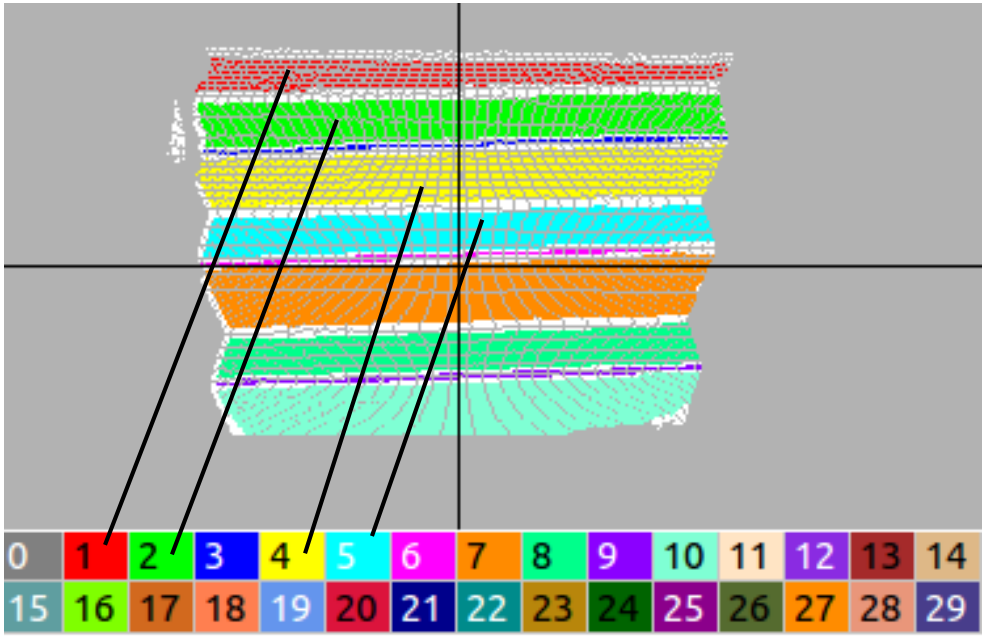


Angle between two regions

```
angle(pl1,pl2,'90±15').
angle(pl1,pl3,'45±15').
angle(pl1,pl4,'90±15').
angle(pl1,pl5,'45±15').
angle(pl2,pl3,'90±15').
angle(pl2,pl4,'0±15').
angle(pl2,pl5,'90±15').
angle(pl3,pl4,'90±15').
angle(pl3,pl5,'90±15').
angle(pl4,pl5,'90±15').
```

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

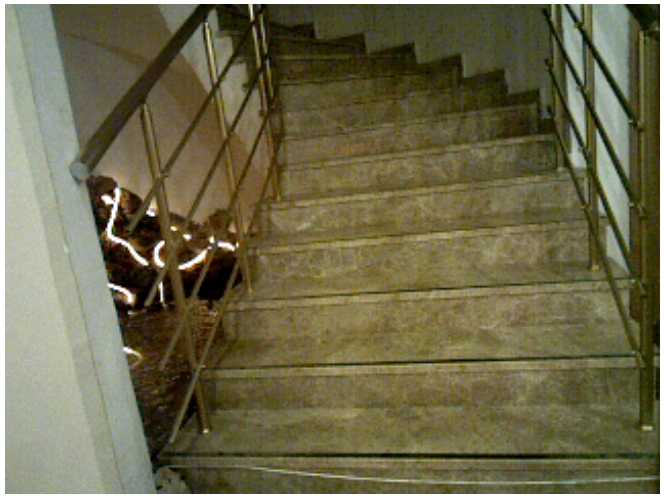
- Positive and negative example for each object class
- The result of labelling as PROLOG predicates
- Using relational learning system to construct a classifier for each type of object

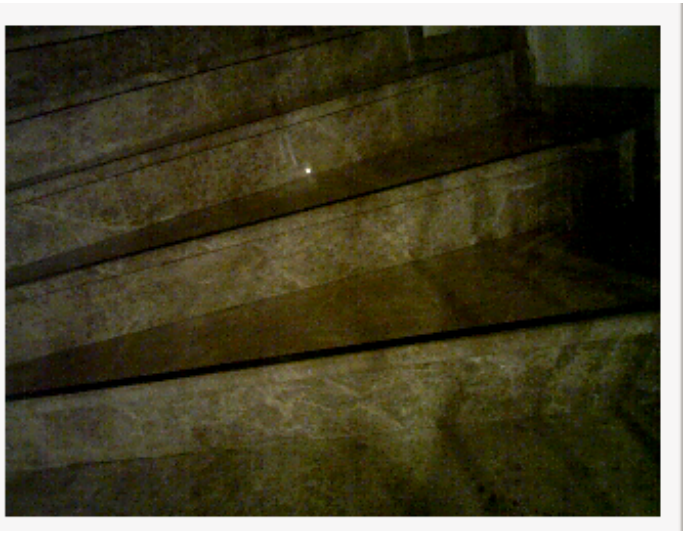
Description of a Staircase

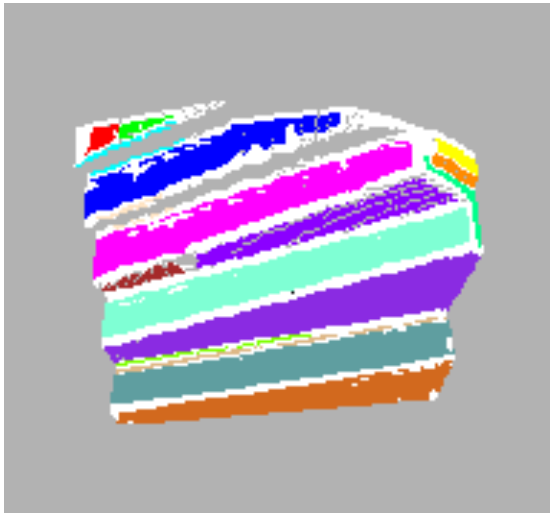
```
staircase(B) : –
    p_a(B).
staircase([X, Y, Z|B]) : –
    p_a([X, Y, Z]),
    staircase([Z|B]).

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

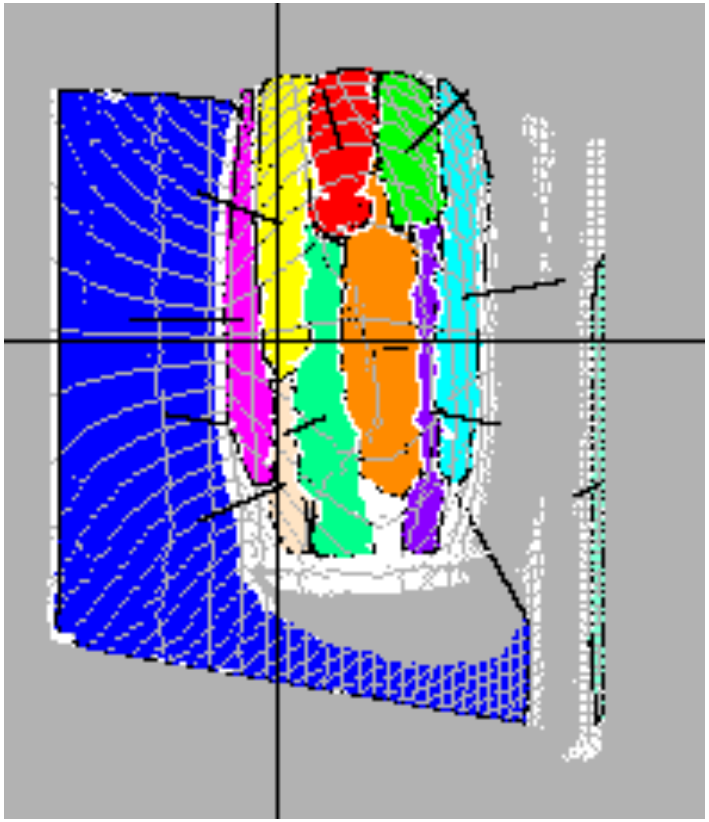






- Spiral stairs
- 950 more positive examples
- accuracy: 99% (sampled from one staircase over several floors)

Non-planar surfaces



Structural relationships