

# Intelligent Robotics: Perception, Reasoning, Actuation and Human Interaction

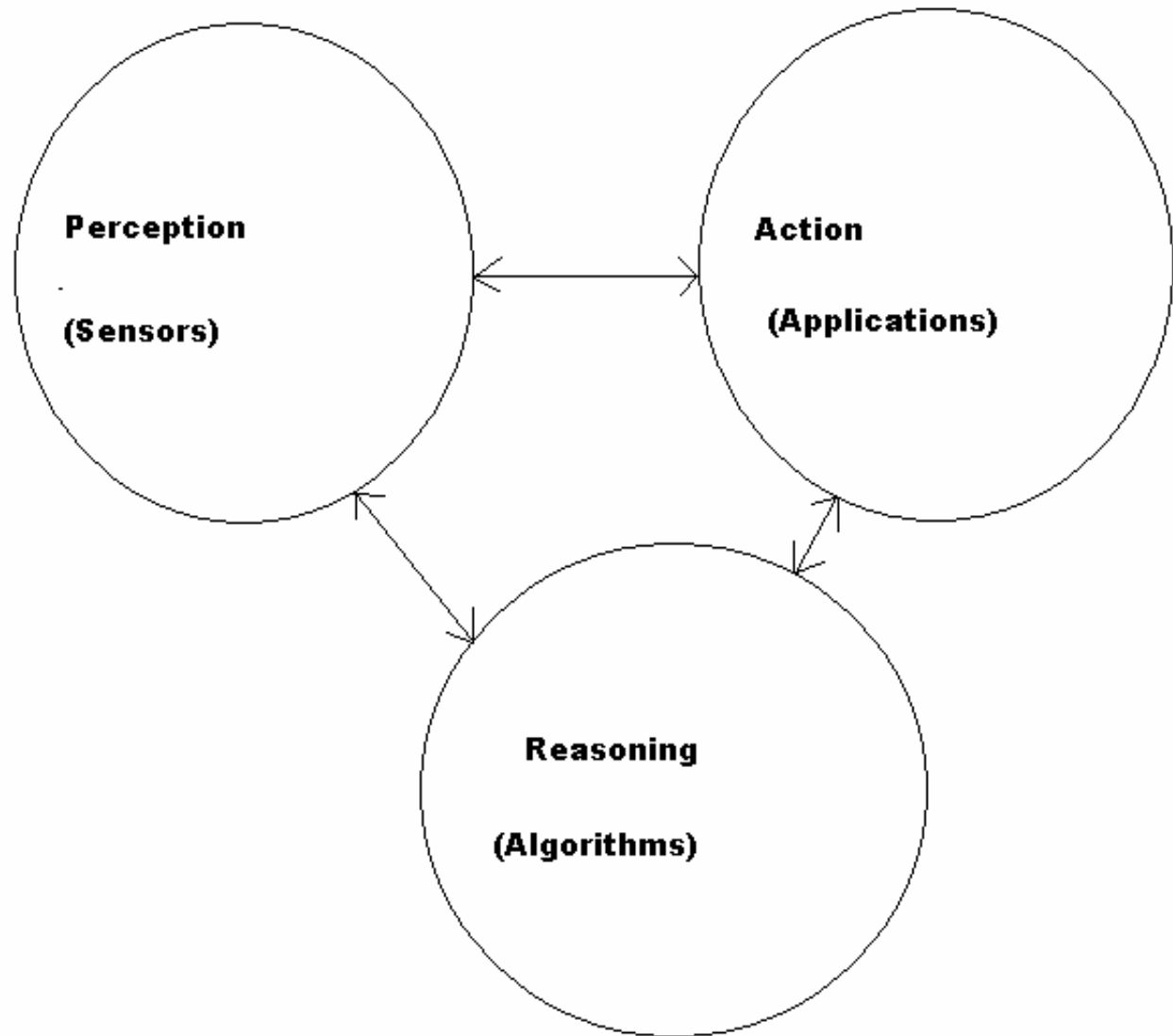
Ray Jarvis

Intelligent Robotics Research Centre  
Monash University

Gadgets  
Methodologies  
Robotic Applications

# Conceptual Mappings: Intelligent Robotics

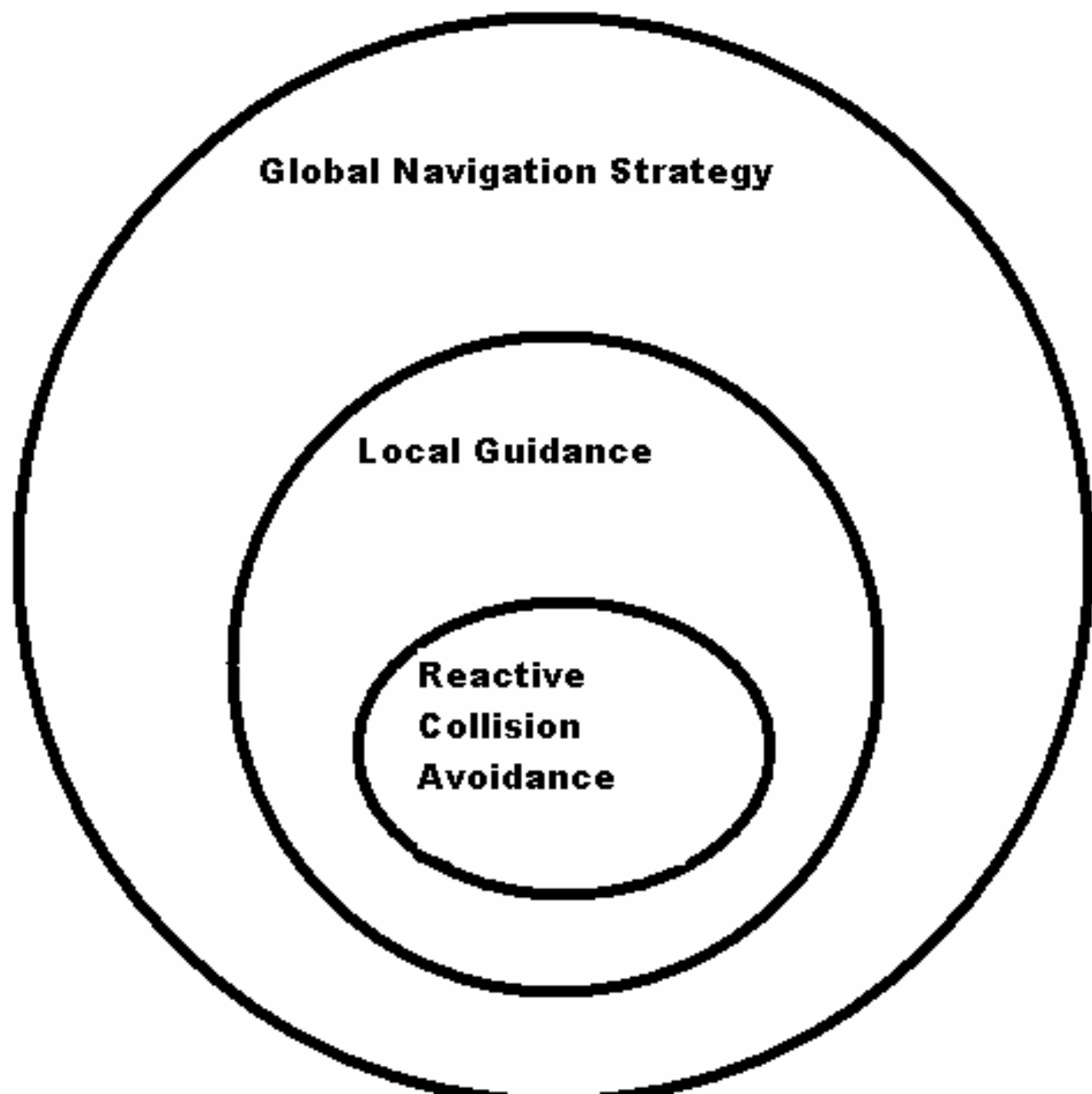
- Intelligent Robotics:
- Perception, Reasoning and Action
- Sensors, Algorithms and Applications
- Sensor Informed Purposeful Actuation



**Intelligent Robotics**

Sensory Intelligence +  
Reasoning to Support  
Unstructuredness

**Navigation Hierarchy**



# Intelligent Robotic Themes

- Robotic Hand/Eye Coordination
- Mobile Robot Navigation
- Humanoid Robotics
- Robot Swarms

# Application Domains

- Manufacturing Technology
- Exploration
- Search and Rescue
- Emergency Services
- Security and Surveillance
- Assistive Technology/Prosthesis
- Entertainment
- Domestic Duties
- Dangerous Environments  
(e.g. Mining/Space/Underwater/Nuclear Plant etc.)
- Medical Applications (e.g. Surgery/Physiotherapy)
- Defence



# Robotic Hand/Eye Coordination





IN CASE OF  
**FIRE**  
1. CALL THE FIRE DEPARTMENT AT  
MARRASCO PLACE AND TELL THEM  
THE ADDRESS OF MARRASCO PLACE ALBANY  
2. CALL EXTENSION 2317  
THE FIRE DEPARTMENT THE WAY IN  
3. TRY TO PUT OUT THE FIRE  
USE WEIGHED ESTIMATIONS  
4. IF THE FIRE GETS OUT OF CONTROL

# Stair Climber Robot



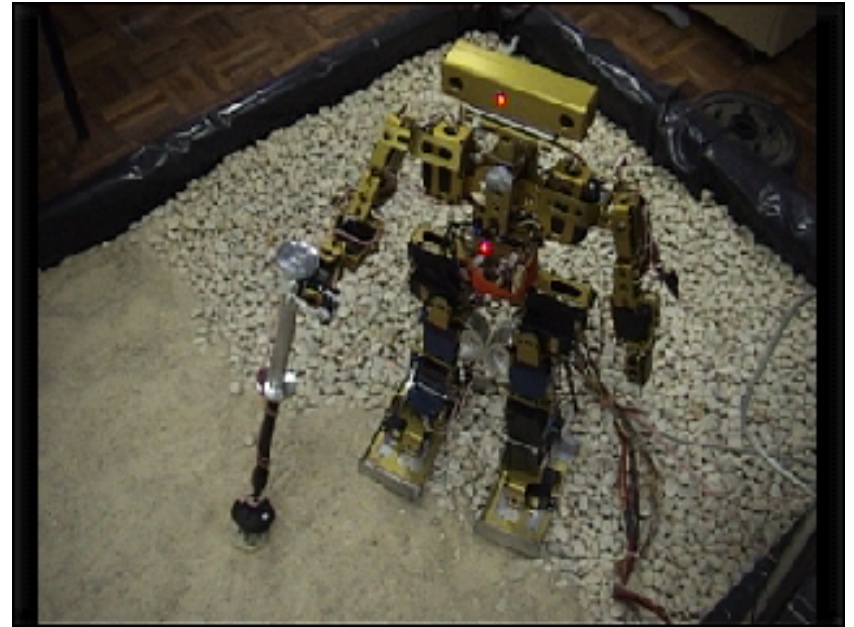
# Tracked Robot Vehicle



# Etherbot Robot



# Humanoid Robots



# Robot Swarms



# Sensors

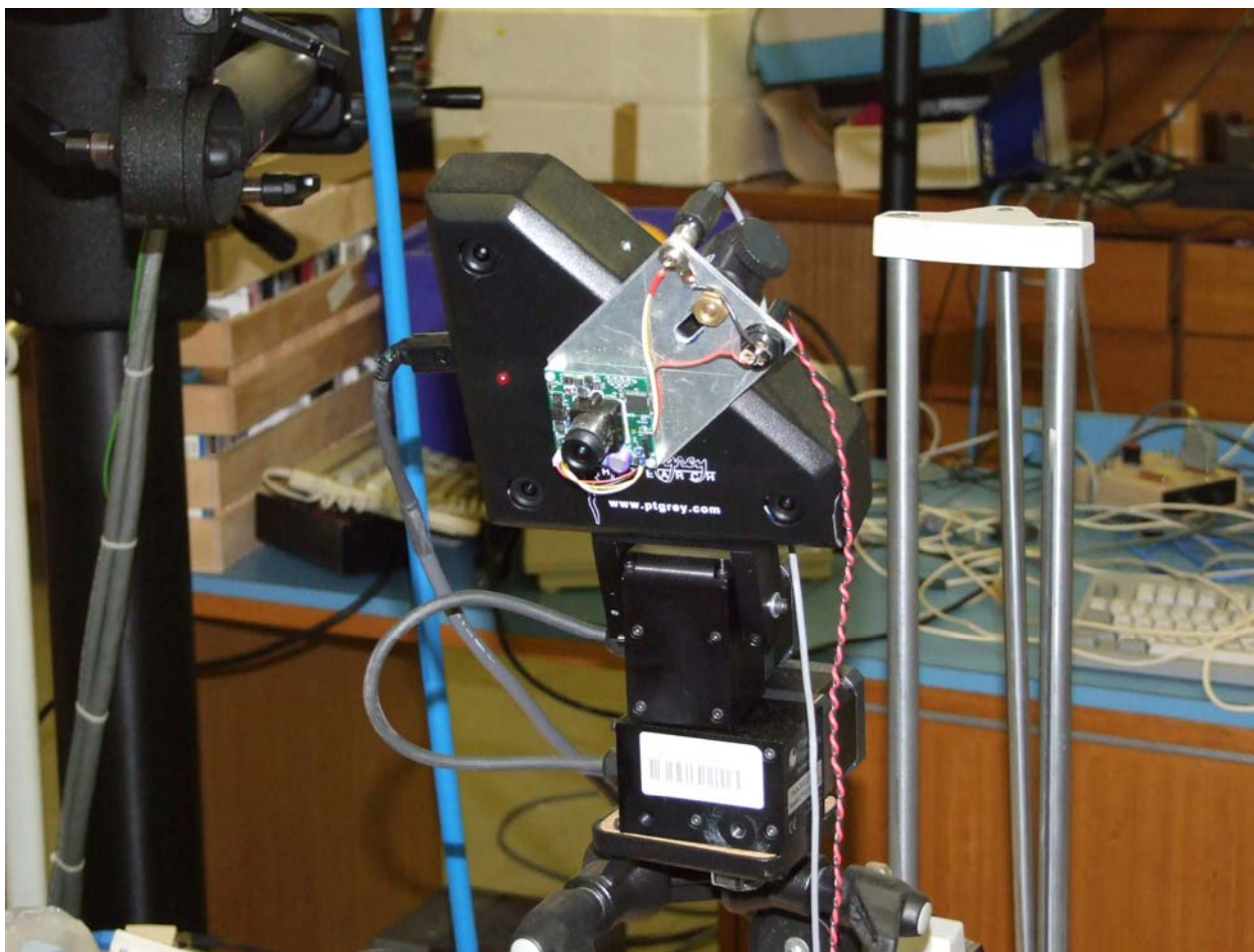
- PointGrey Triclops/Bumblebee Stereo
- Velodyne Laser Range Scanner
- Riegl Laser Range Scanner
- Coded Striped Light System
- Panoramic Mirror Cameras
- Sick Rotating Range Finder
- Eye Gaze Tracker
- PMD Parallel Laser Range Camera
- Novint Falcon 3D Joystick



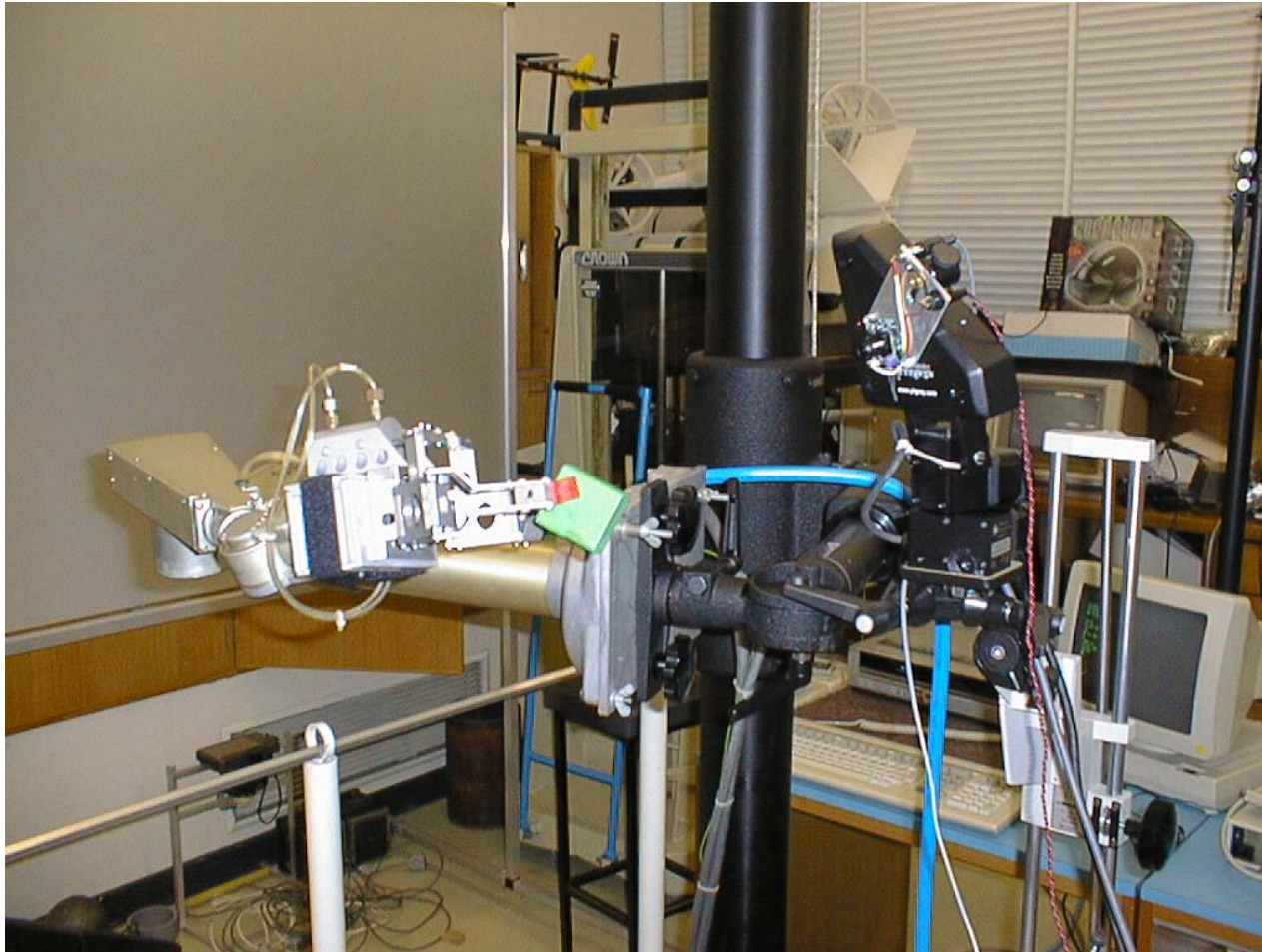
# Bumblebee



# Triclops



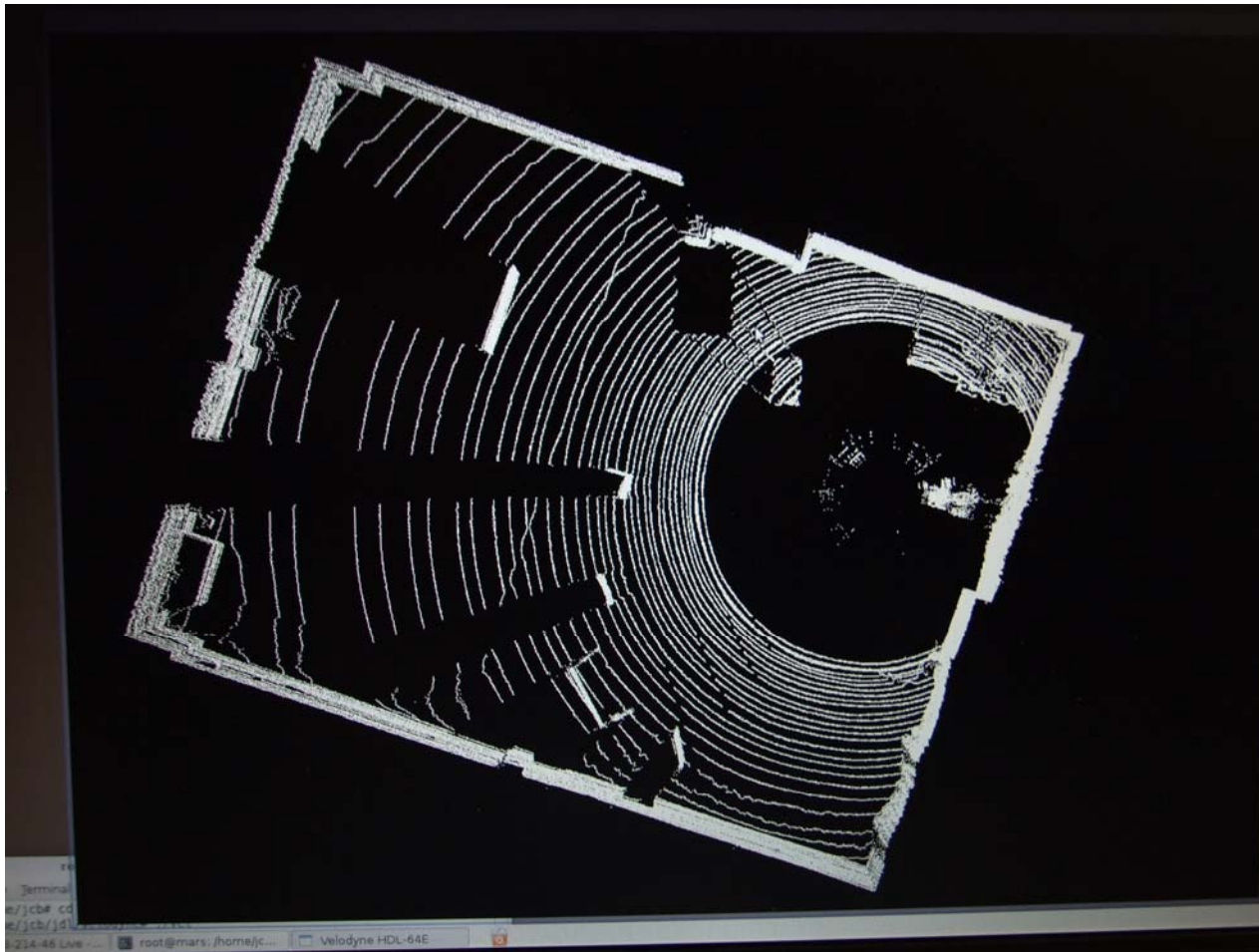
# Basic Centre of Disparity Tracking



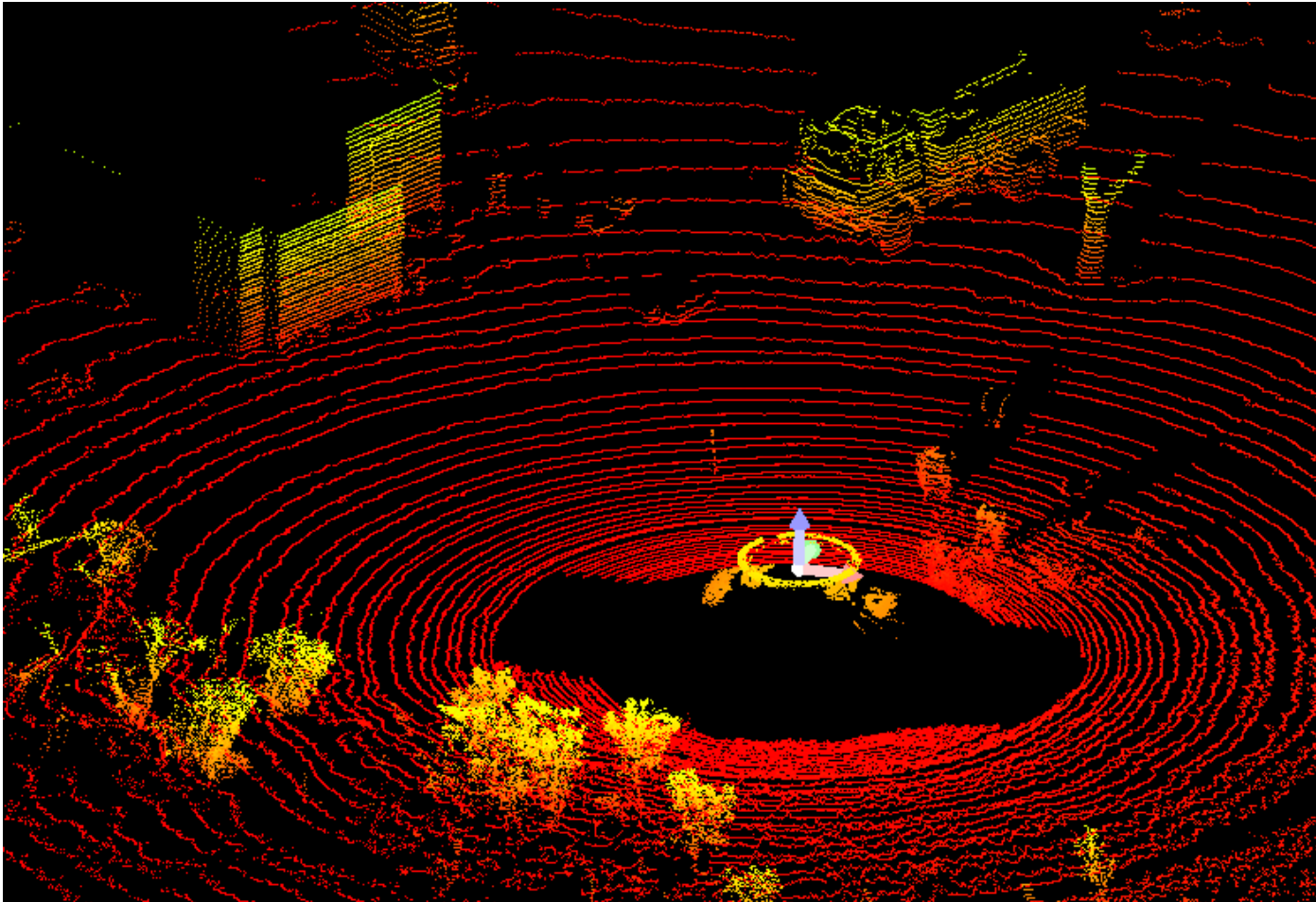
# Velodyne Laser Range Scanner



# Typical indoor Velodyne Scan



# Outdoor Velodyne Scan



# Mounted Velodyne

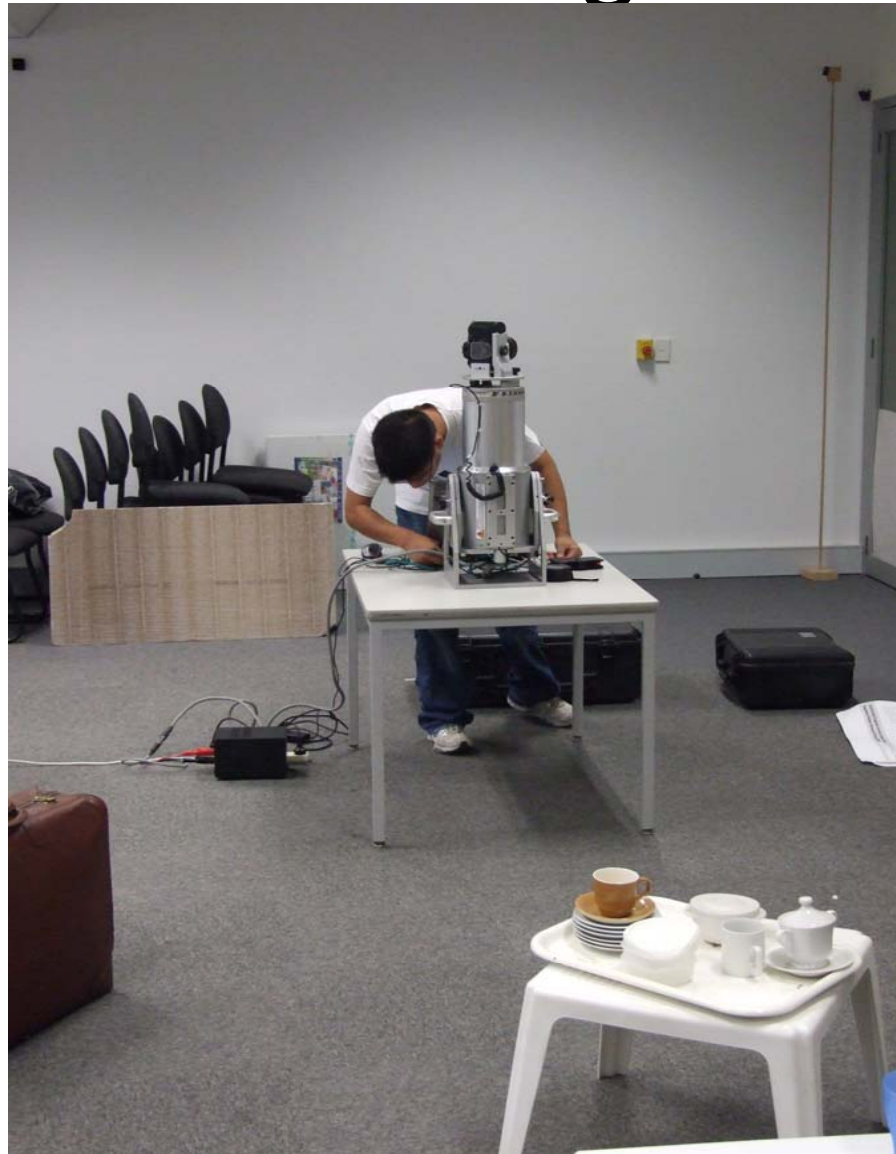


# Range/Image Fusion

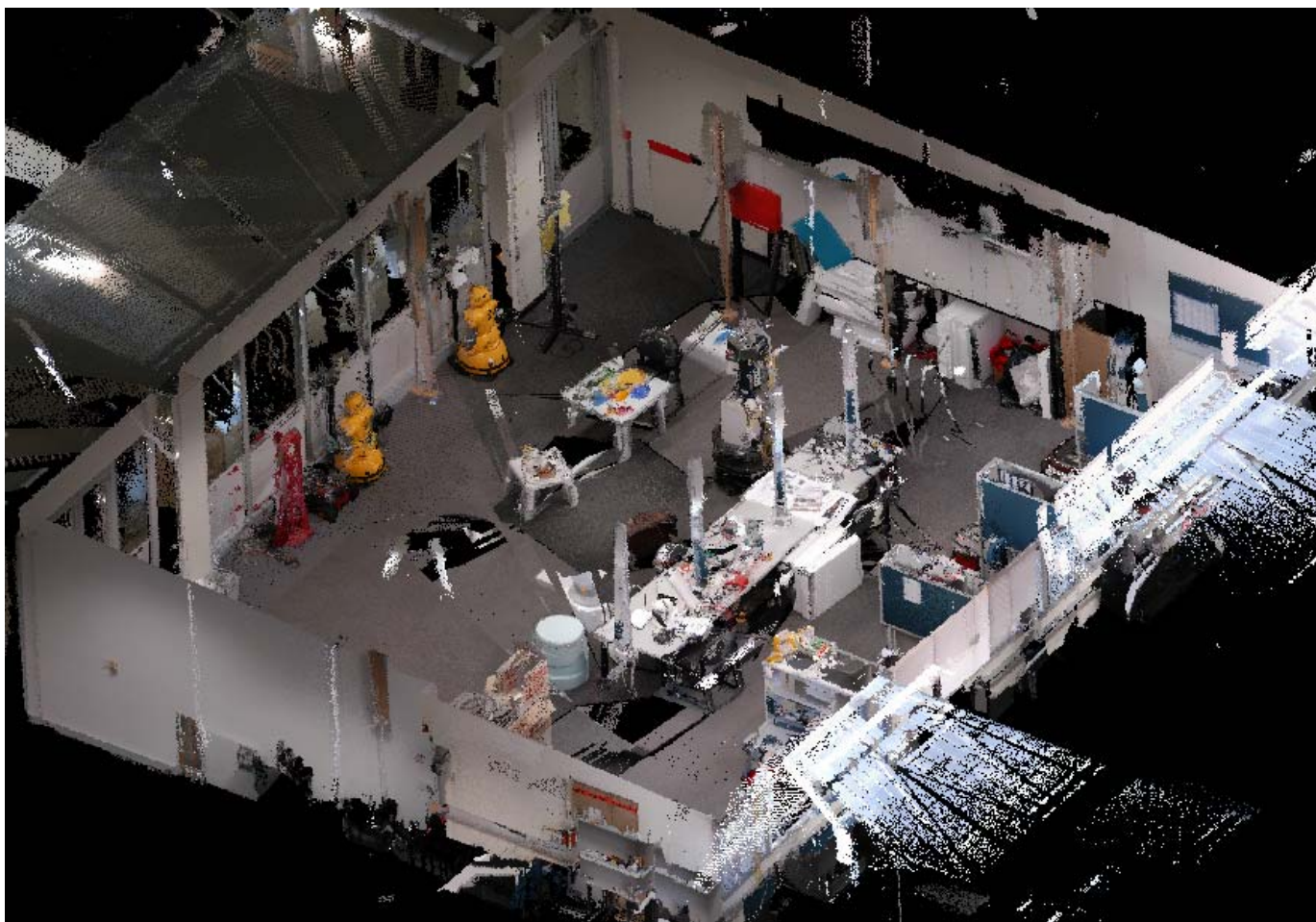




# Riegl Laser Range Scanner

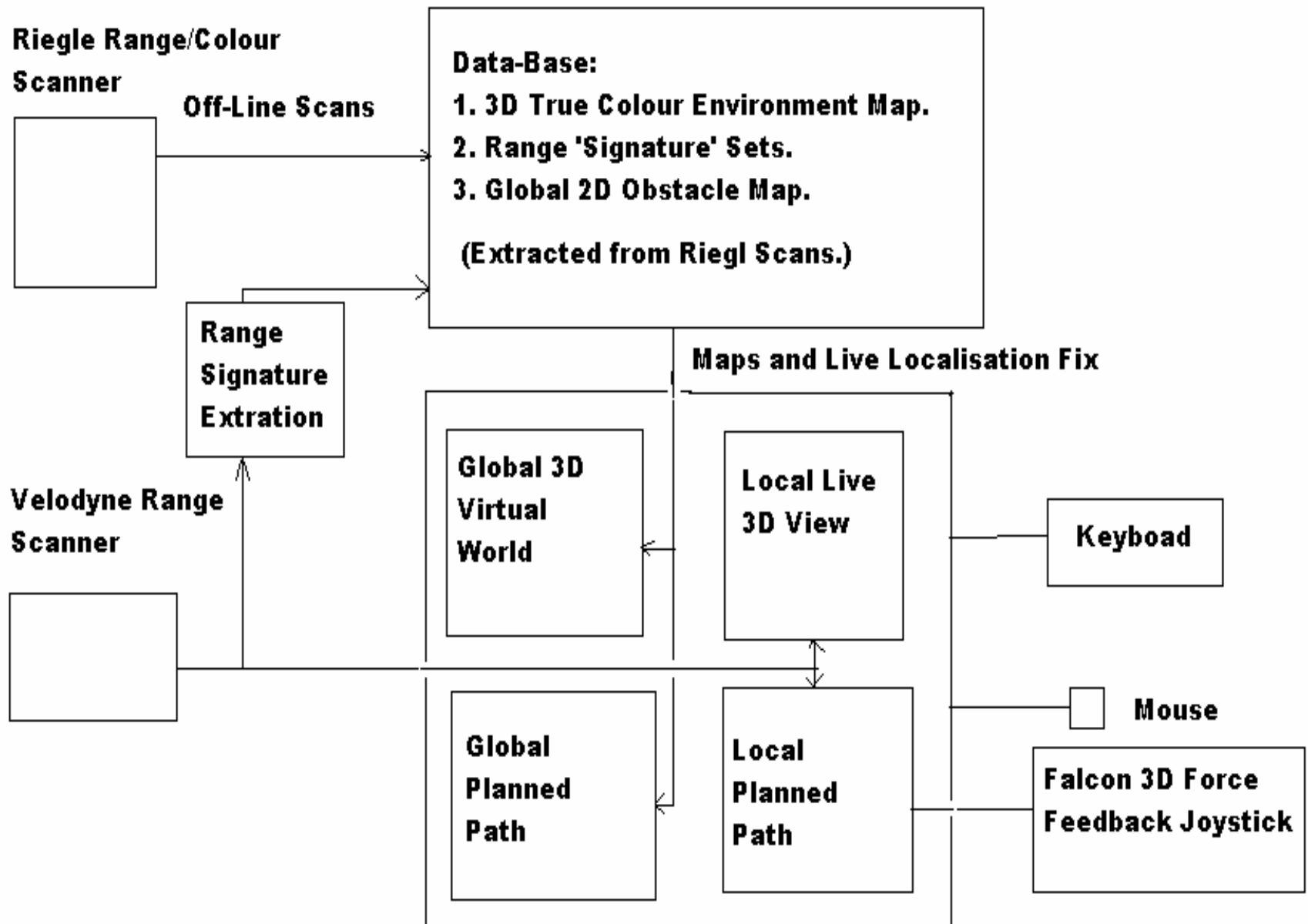


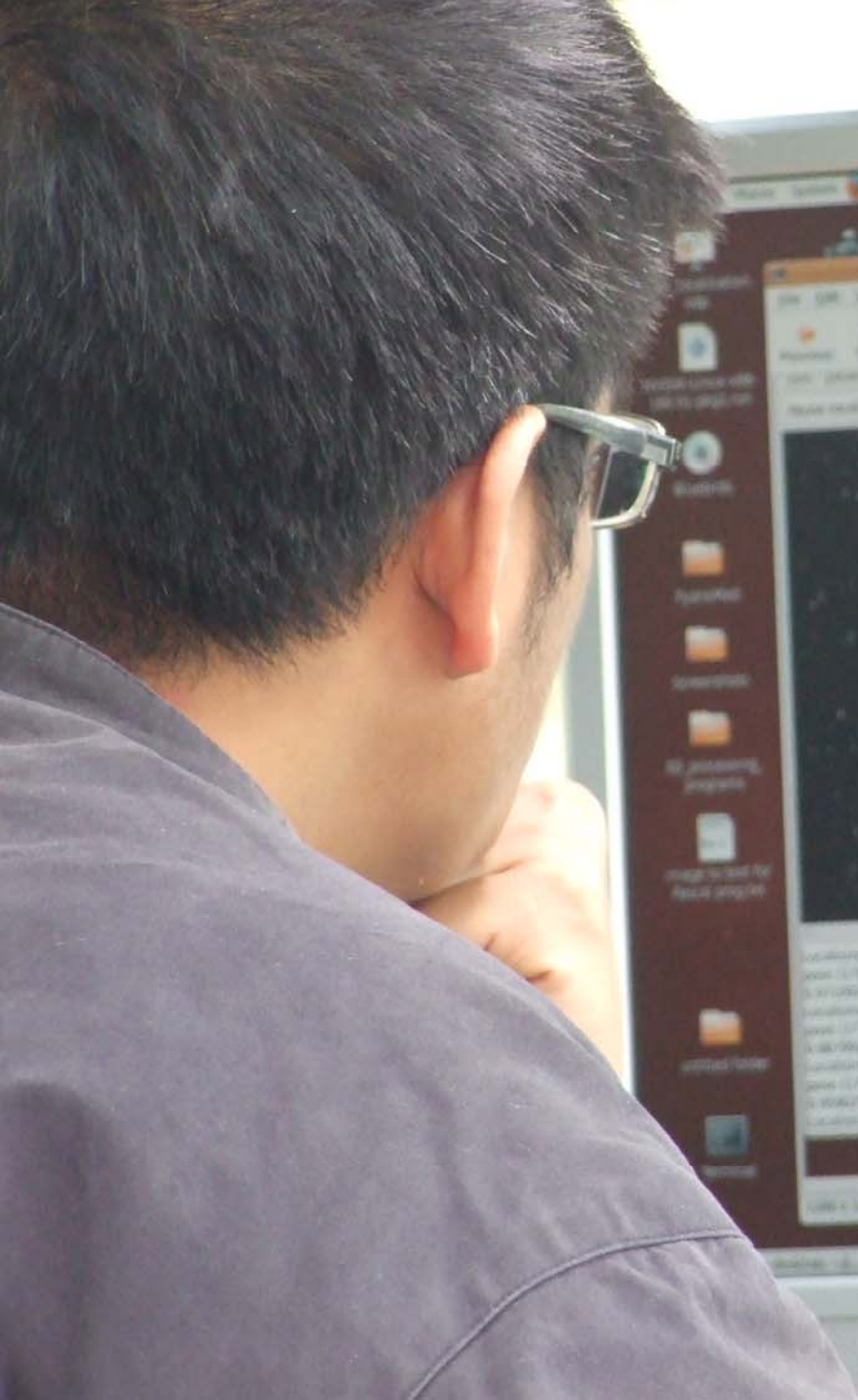
# Typical Riegl Scan



# Outdoor Riegl Scan Walkthrough







**LaserLocalise**

File Localise Zoom

Pause localisation Map info

Localising using file /home/ray/jdl/velodyne/vel.dat 100% - image pose (1922, 1162, 178) real pose (-18.10, 15.32, 178) score: 0.516687 map augmented  
 Localising using file /home/ray/jdl/velodyne/vel.dat 100% - image pose (1937, 1165, 176) real pose (-16.60, 15.62, 176) score: 0.676758 map augmented  
 Localising using file /home/ray/jdl/velodyne/vel.dat

**Walkthrough3D**

File Help

Planes: 6,007 Points: 18,630,955 FPS: 18.83

Pascal prog.txt

Screenshot-4.png

untitled folder

Terminal

Screenshot-5.png

Screenshot-6.png

Screenshot-14.png

**root@ray-desktop: /home/ray/Projects/LaserLocalise**

File Edit View Terminal Tabs Help

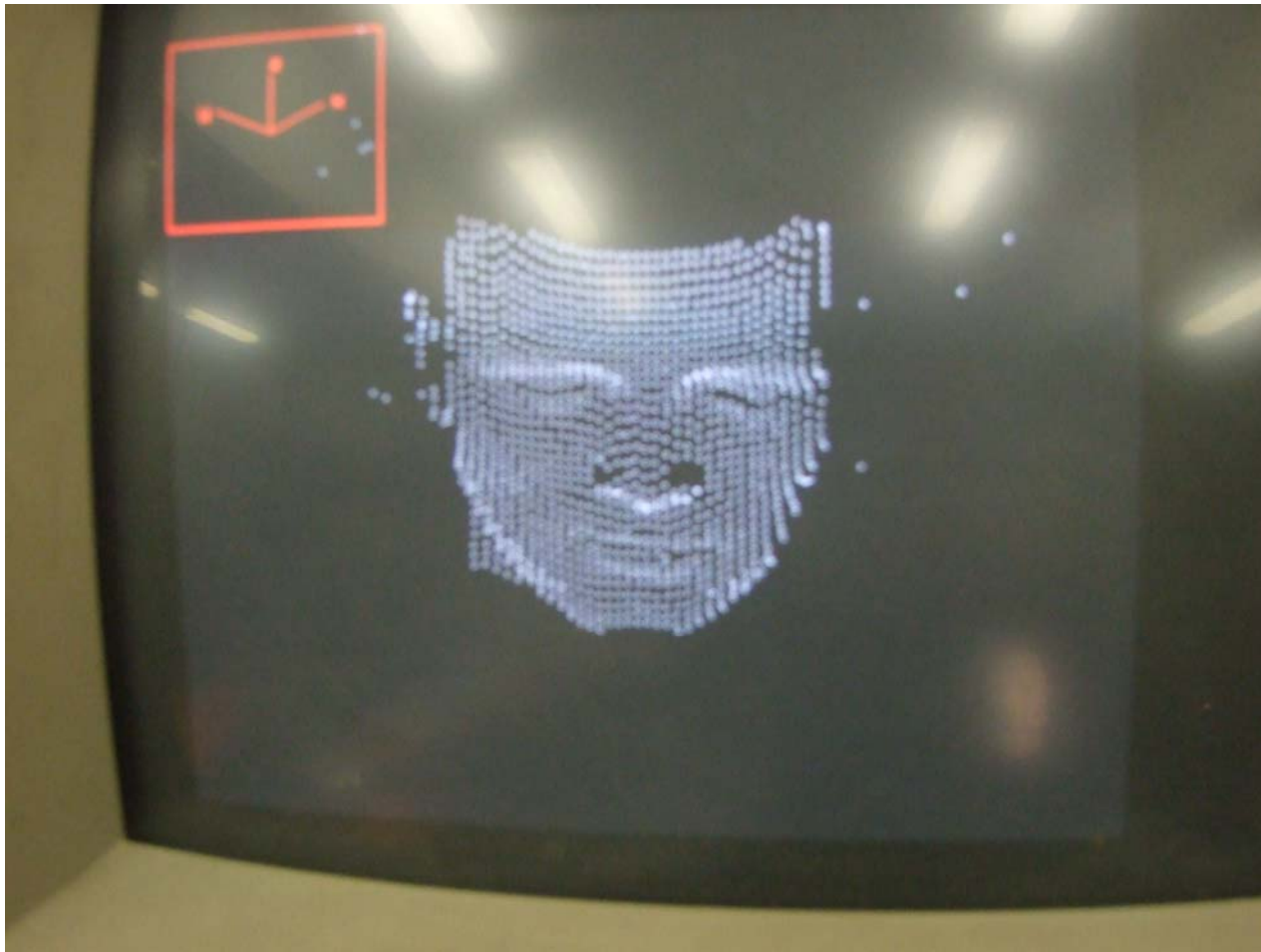
```

root@ray-desktop: /home/ray/jdl/velodyne x root@ray-desktop: /home/ray/Projects/Laser... x
points: 500000
-93.0858 -99.6498
98.1279 88.6466
Creating an image of size: 1913 1883
1942 1162 178
Refine: 1937 1165 176 - 0.676758
map_augmentation_on 0.676758
points: 500000
-91.5189 -98.1022
96.8992 84.3847
Creating an image of size: 1885 1825
  
```

# Coded Light Stripe Stereo Ranging



# Coded Stereopsis Output

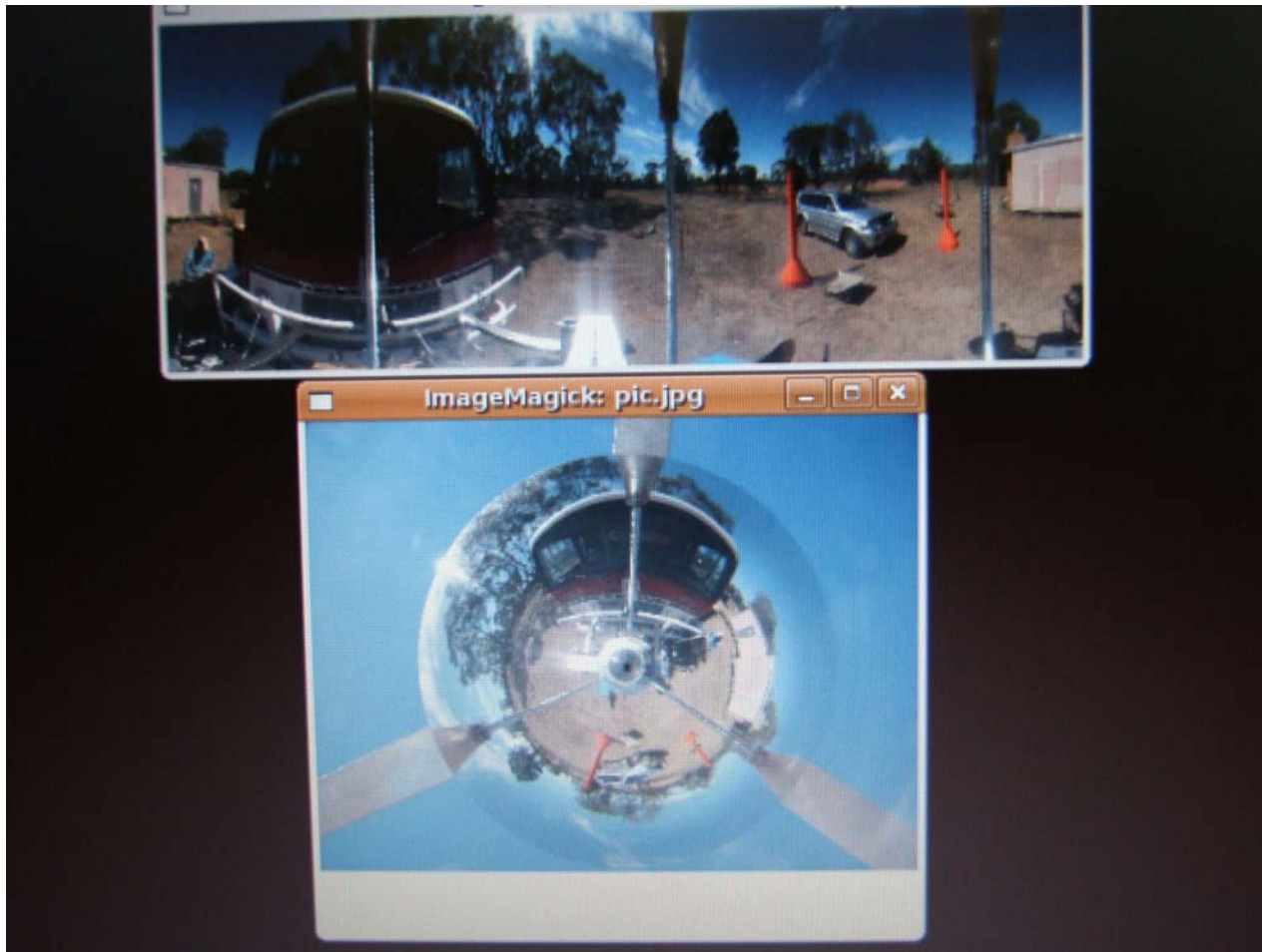




# Panoramic Mirror Camera



# Unwrapped Panoramic Camera Image



# Rotating Sick Laser/Image Sensor



# Scene

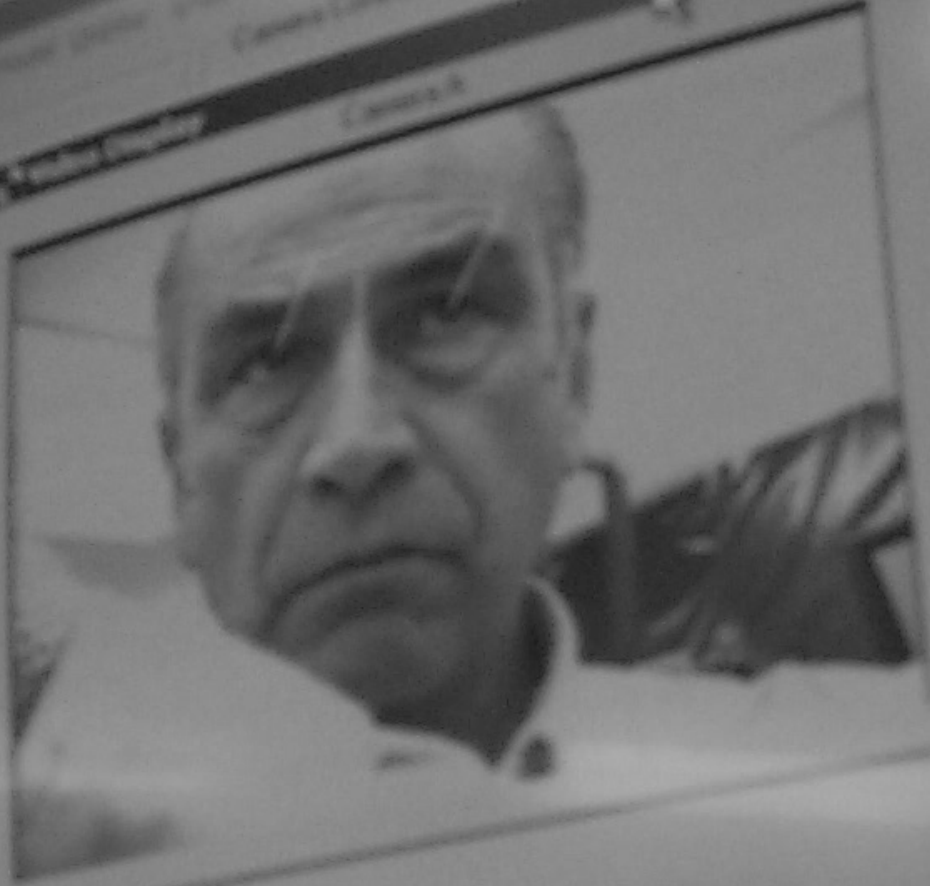


# Range/Colour Fusion



# Eye Gaze Tracker





Camera 6  
Camera 7  
Camera 8  
Camera 9  
Camera 10  
Camera 11  
Camera 12  
Camera 13  
Camera 14  
Camera 15  
Camera 16  
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Camera 89  
Camera 90  
Camera 91  
Camera 92  
Camera 93  
Camera 94  
Camera 95  
Camera 96  
Camera 97  
Camera 98  
Camera 99  
Camera 100

Eye  
Eye Object Working  
Head Object Working  
Eye View 1000 x 1000  
Eye View 1000 x 1000  
Eye View 1000 x 1000

Eye View 1000 x 1000  
Log to Disk: No  
Log File: F:\eye  
Map View: 417 x 2  
Log to Net: 10000  
Send To: Net 1

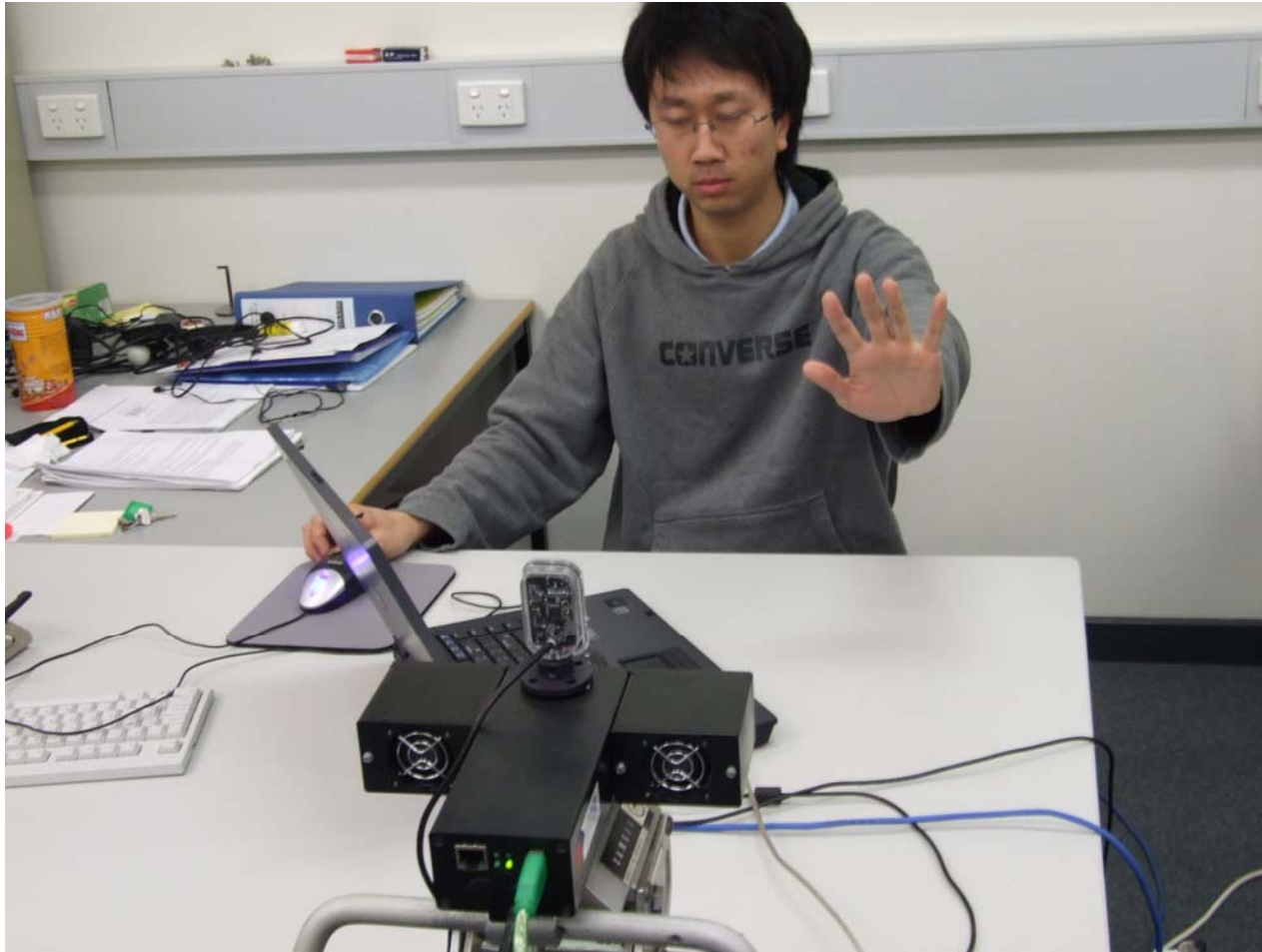
10/19/1999 8:24pm

# PMD Range Camera





# PMD Capture



# PMD Output



# Combining Sensors



# Novint Falcon Force Feedback Joystick



# Obstacle Growing for A\* Path Planning

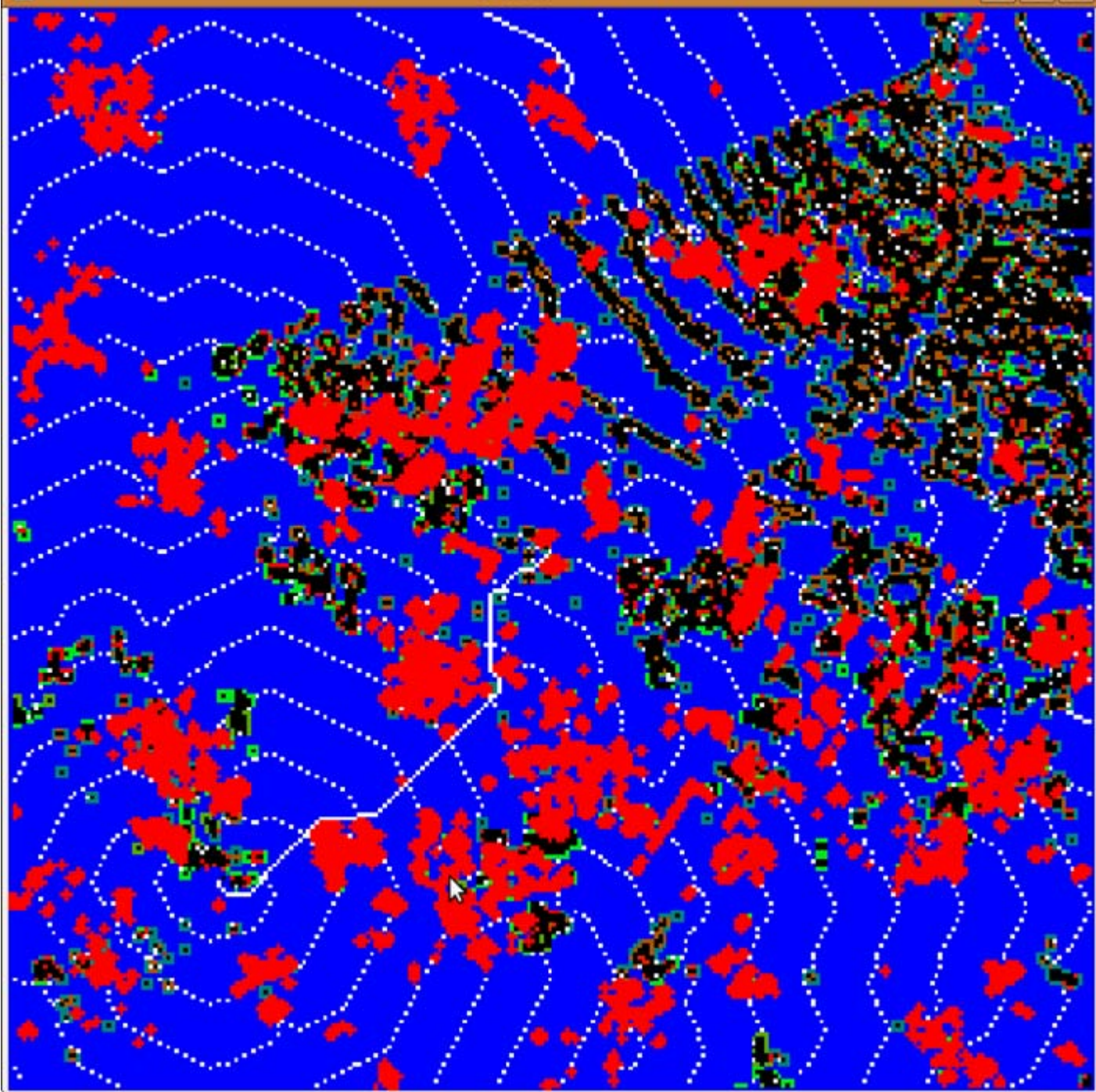
- Convex Polygonal Obstacles and Vehicle
- Shrink Vehicle to a Reference Point
- Grow Obstacles instead
- Exact for 2D
- Approximate for more than 2D
- Easy to Compute

# Distance Transform based Path Planning

- Tesselated Space Approach
- Propagation Process
- Local Neighbourhood Evaluations
- Global Plans without Local Entrappment
- Ease of Computation
- Accommodation of Wide Variety of Costing Structures
- Extends to Higher Dimensioned Spaces
- Accommodates Time/Space
- Variety of Extensions of Applicability



Wheel





# Application Examples

- 3D Segmentation (Colour and Range Fusion)
- 3D Space Cube Analysis (Robotic Hand/Eye Coordination)
- Centre of Disparity Tracking
- Appearance Based Localisation (Nghia's stuff)
- Distance Transform Based Path Planning (including Dark Paths)
- Robot Teleoperation (with Force Feedback Assistance in Rough Terrain)
- 3D Cyberspace Exploration
- Shape Hulls
- Obstacle Growing for A\* Algorithm
- Time/Space Path Planning
- Etherbot Indoor Navigation
- Gesture Recognition (David Li's stuff)
- 'Eye-Full' Tower Panoramic Stereo Topological Map Building and Navigation
- Look Where You Go Wheelchair
- Video Plane Swarms