Seabiscuit

The 2009 University of Bath Autonomous Underwater Vehicle

Student Autonomous Underwater Challenge Europe July 2009

Summer Sea Trials – Pacific Coast, BC, Canada July-October 2009

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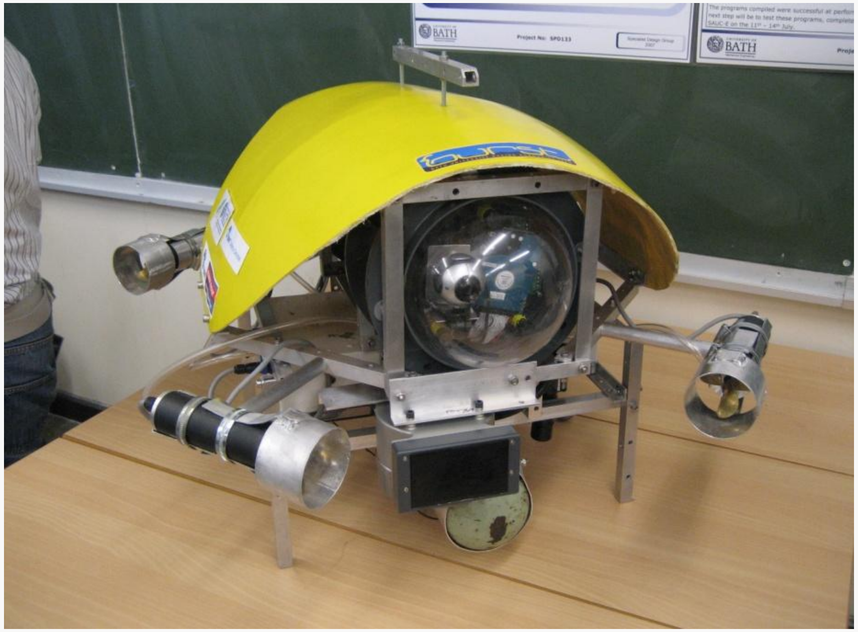
BURST
BATH UNIVERSITY RACING SUBMARINE TEAM

Ocean Technologies Laboratory

Design Evolution



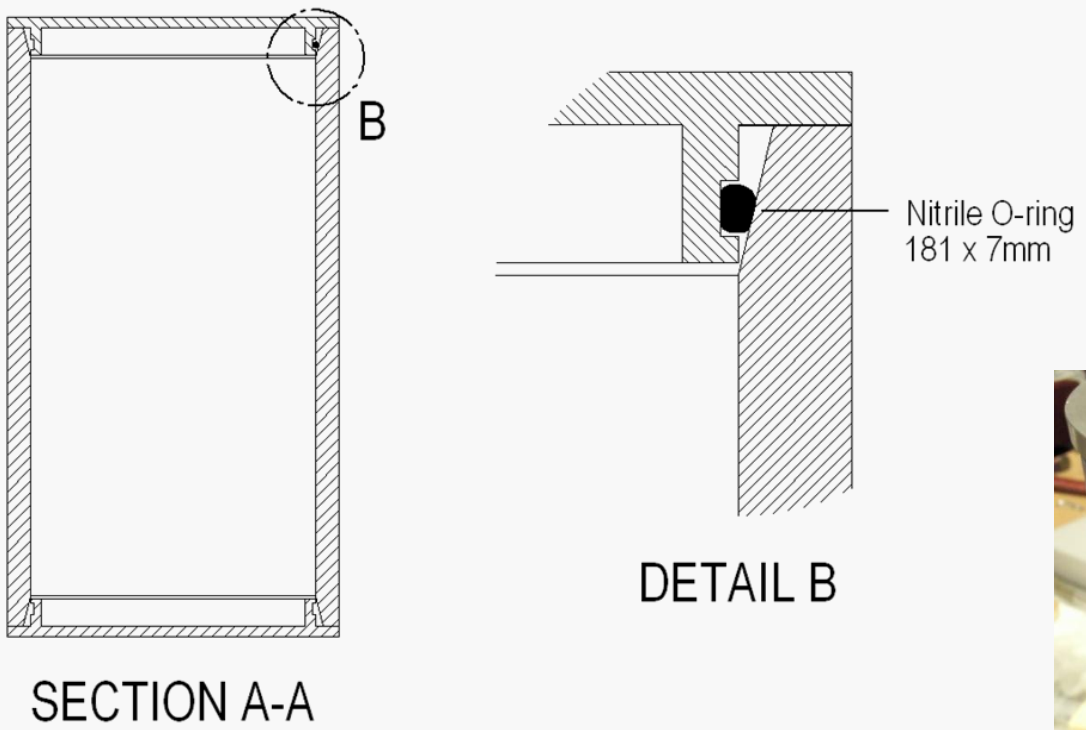
Design Evolution

BATH UNIVERSITY RACING SUBMARINE TEAM

Mechanical Design

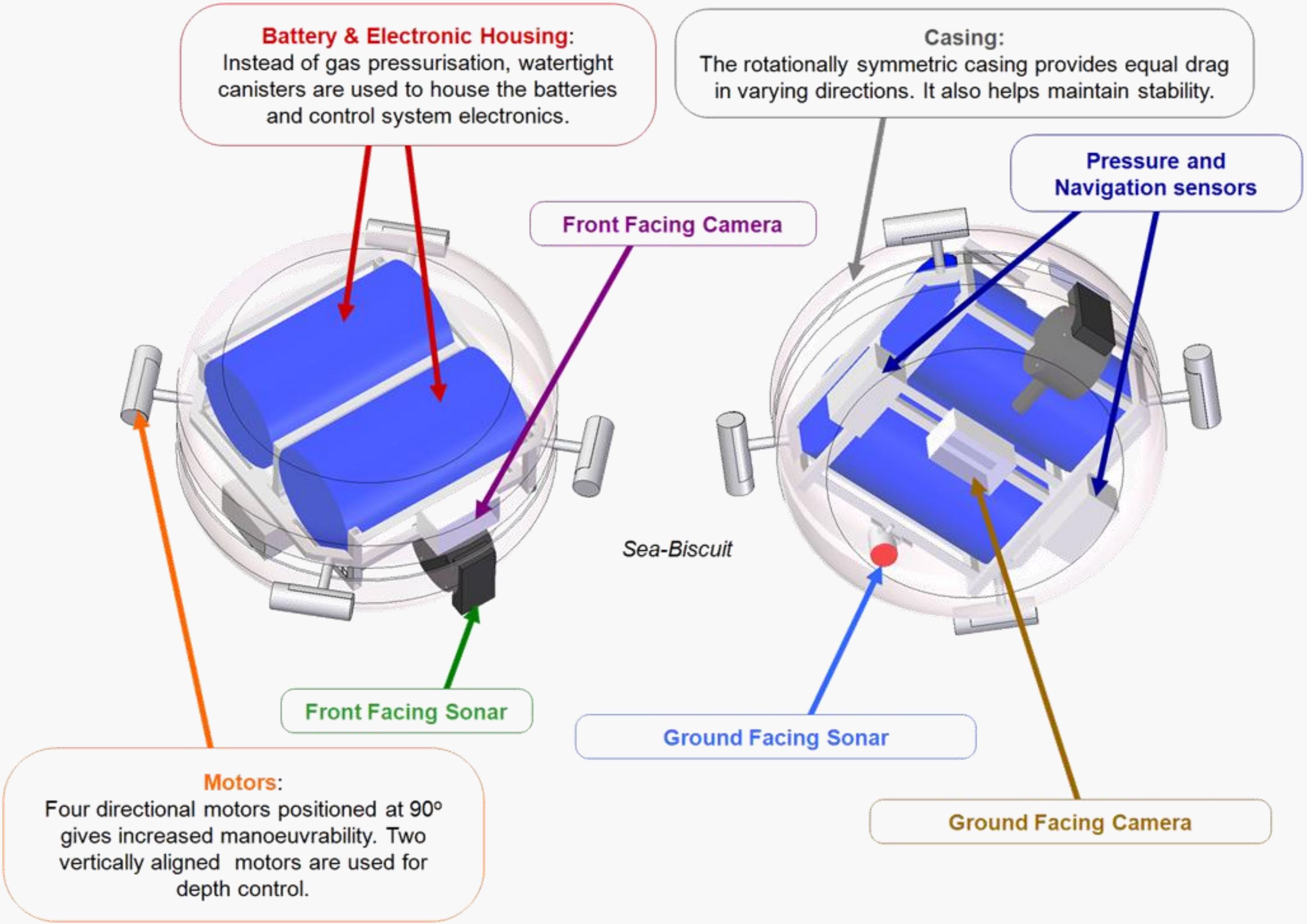
- Hydrodynamic fibreglass shell
- Aluminium frame supports dual pressure vessels and peripherals
- Student designed, student built in-house

Mechanical Design: Pressure Vessels



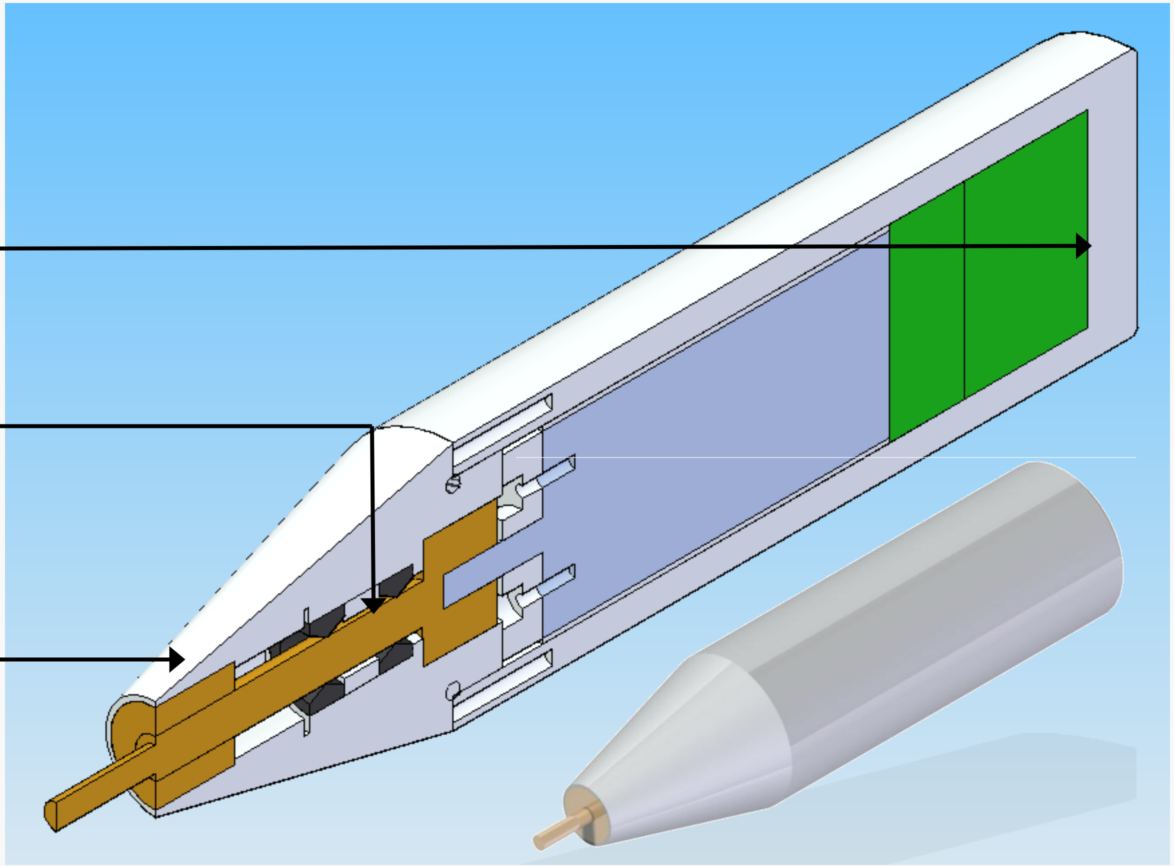
- Reliability and ease of access

Seabiscuit


Battery & Electronic Housing:
Instead of gas pressurisation, watertight canisters are used to house the batteries and control system electronics.
Casing:
The rotationally symmetric casing provides equal drag in varying directions. It also helps maintain stability.
Pressure and Navigation sensors
Front Facing Camera
Sea-Biscuit
Front Facing Sonar
Ground Facing Sonar
Ground Facing Camera
Motors:
Four directional motors positioned at 90º gives increased manoeuvrability. Two vertically aligned motors are used for depth control.

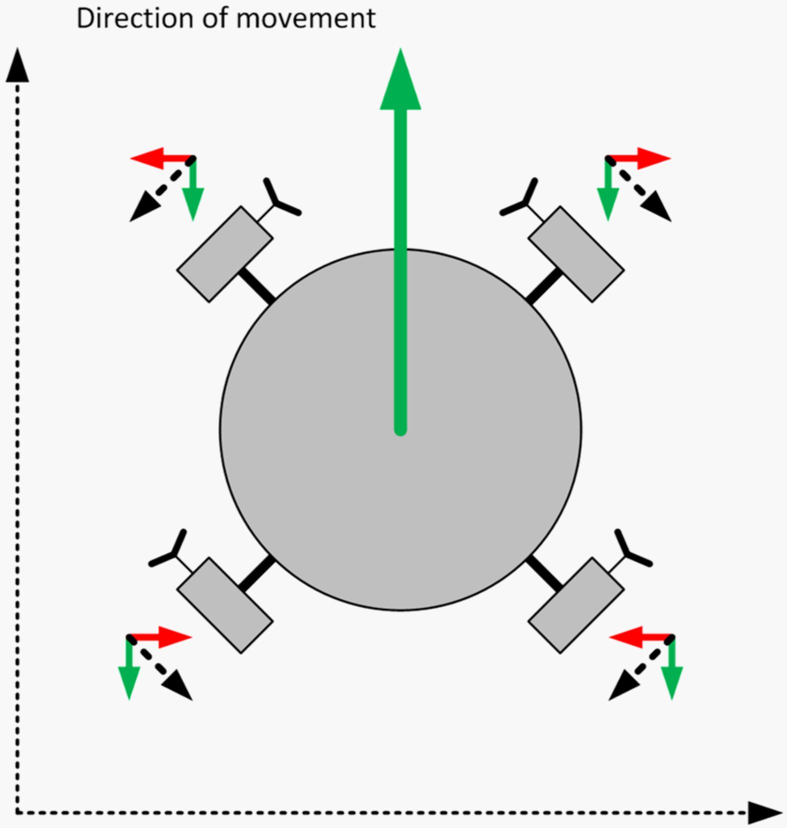
Motor housings

- Built in-house
- Materials
- Blind bore
  - One O-ring
- Double lip seal
  - Bilge
  - Pressure gradient
  - Oil filled
- Tapered housing
  - Efficiency



Holonomic Propulsion

- 6 fixed thrusters
  - 70W Maxon motors
- Holonomic movement in the horizontal plane
  - Benefits to sensing, mapping and station-holding
- Holonomic control
  - Benefits of inertial navigation
- Electrical power
  - 24V SLA battery pack
  - Reversible PWM motor controllers
  - Auto-tuning PID Controller

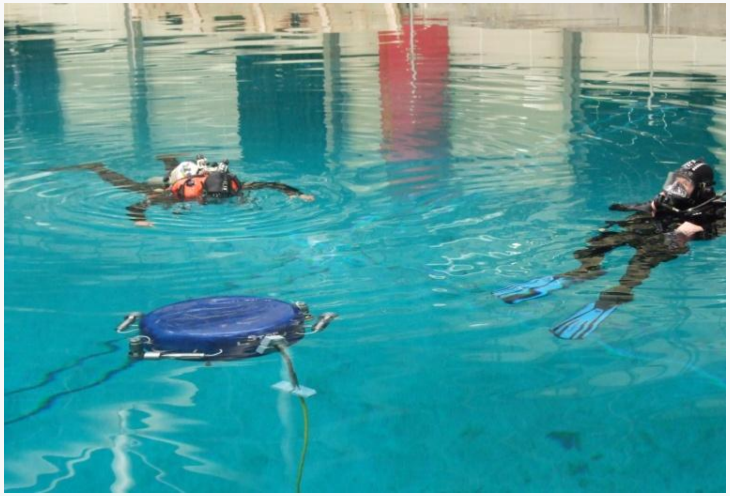


Design Brief

- Student Autonomous Underwater Challenge – Europe (SAUC-E)
  - DSTL and Industry sponsored competition

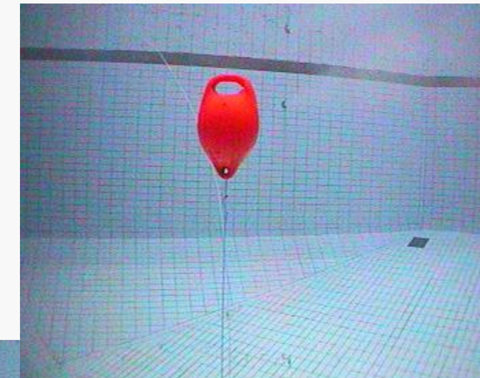
  - Held in Portsmouth, UK
  - Submarine test tank (120m*60m*6m deep)

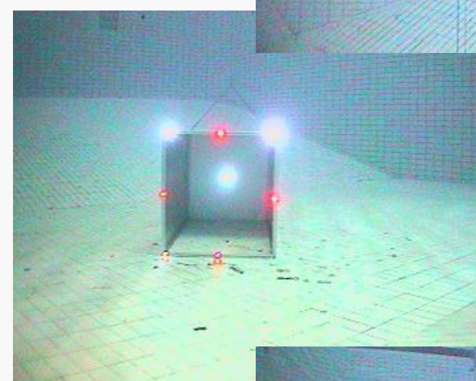
  - Designed to advance the field of AUVs
  - Foster the development of new ideas and techniques

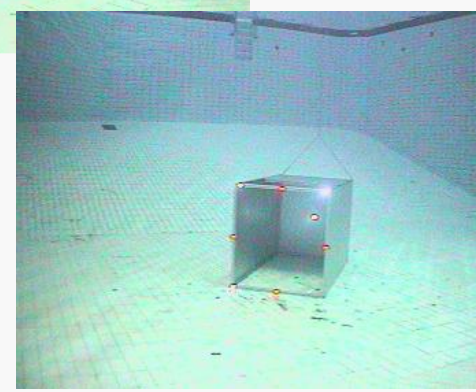


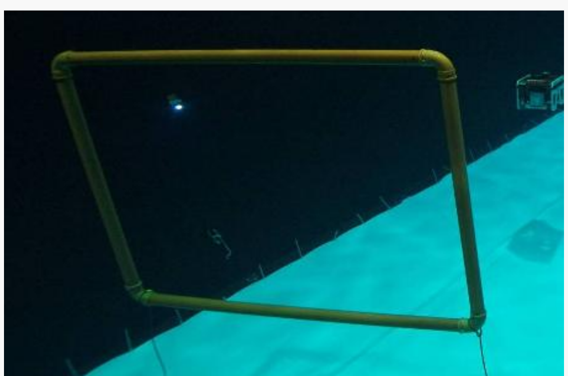
SAUC-E Competition

- Competition tasks designed to simulate real life tasks and challenges facing AUVs, including:
  - Searching & identifying objects in the mid-water and on the floor
  - Passing through gates, navigating confined passages
  - Sonar and visual surveys
  - Mapping the environment and object location
  - Tracking moving targets
  - Autonomous docking into 1*1m docking bay



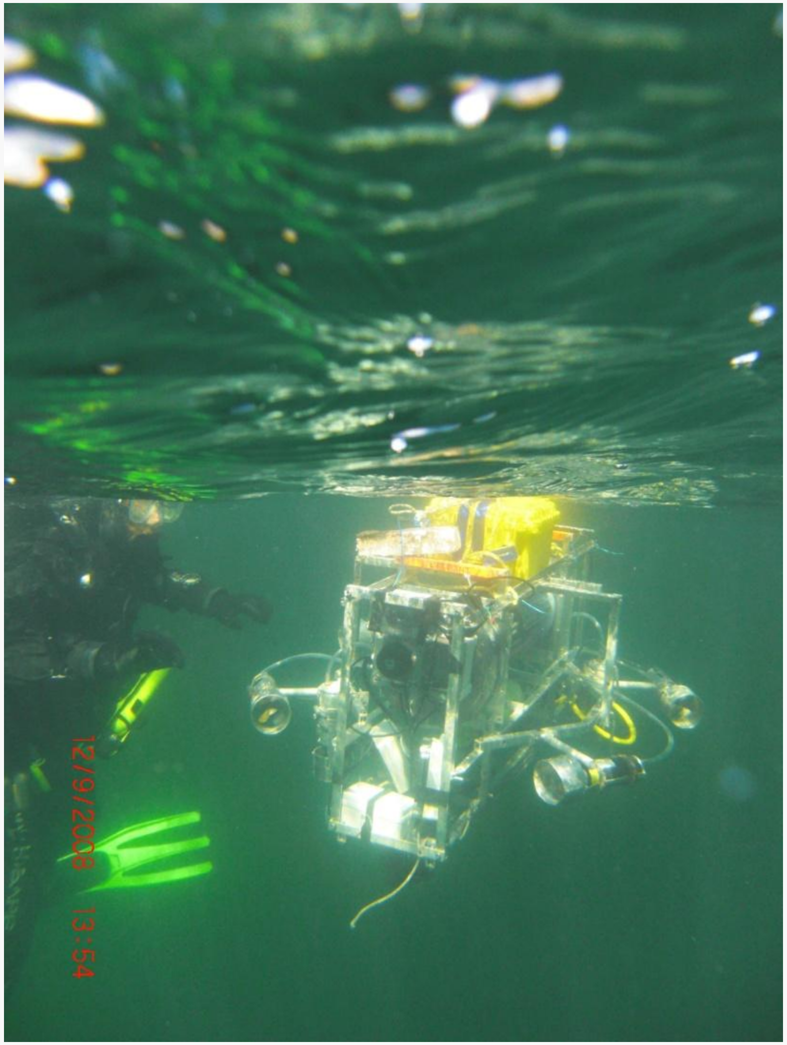






Background

- Multi-purpose:
  - SAUC-E Competition
  - Canada Field Trials



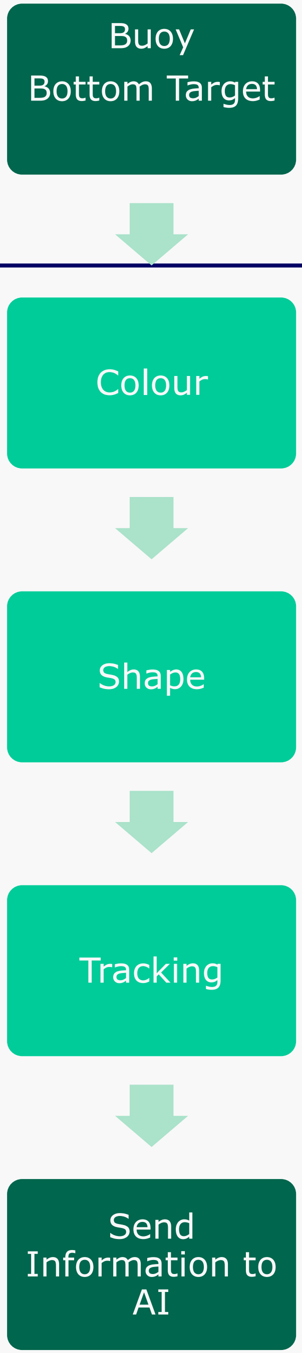
Background

- Grey whale conservation

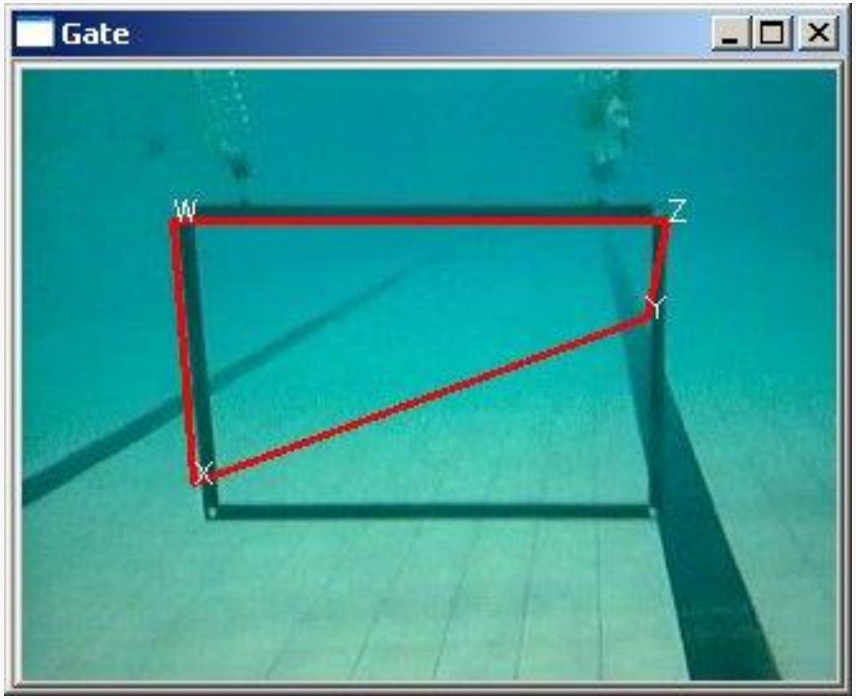
Sensing

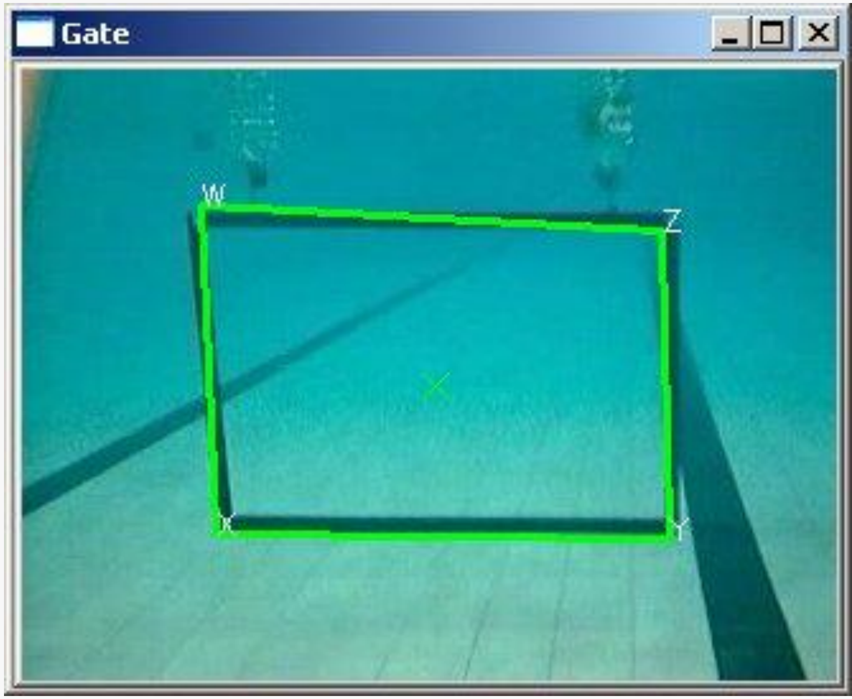
- Vision (dual cameras)
- Sonar (dual sonars)
  - Mapping
- Inertial Measurement Unit, Pressure, Compass
  - 6-axis INS to benefit holonomic movement
- Machine health
  - Battery status (voltage, current, SoC)
  - Motor current consumption
  - Temperature
  - Internal pressure
  - Humidity & leak detection

Bottom Target



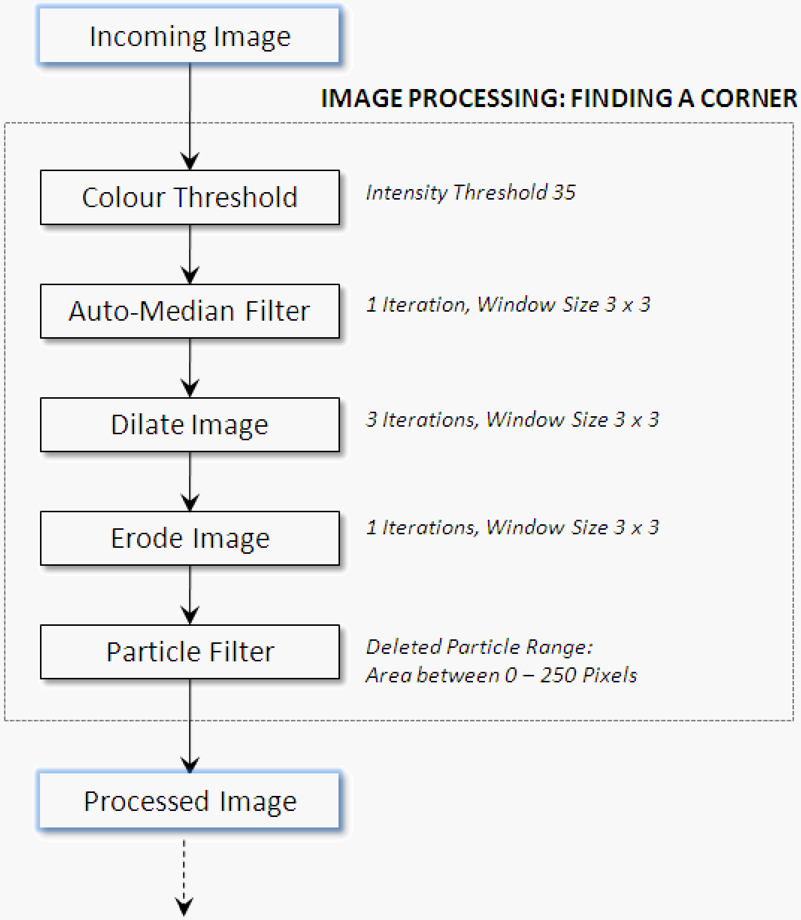
Gate Finder





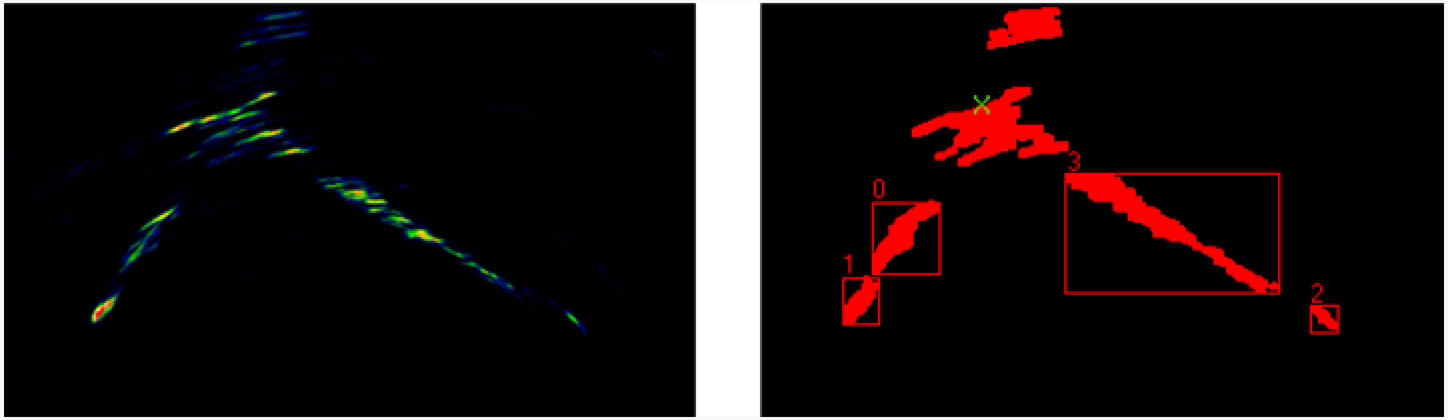
Sonar - Image Processing

- 360° Sonar – Horizontal Plane
- 120° Sonar – Vertical Plane
- Image analysis through LabVIEW

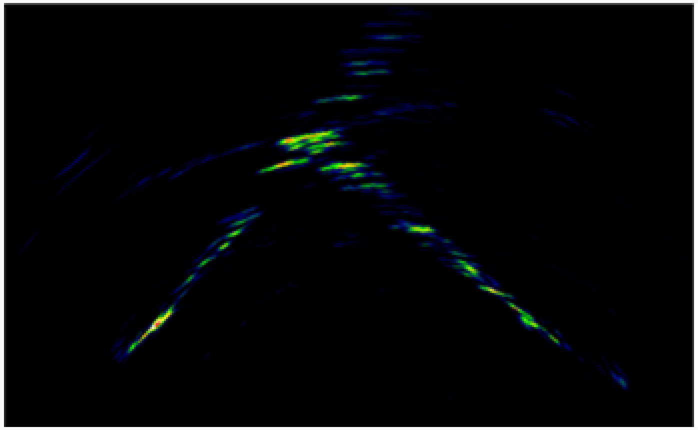


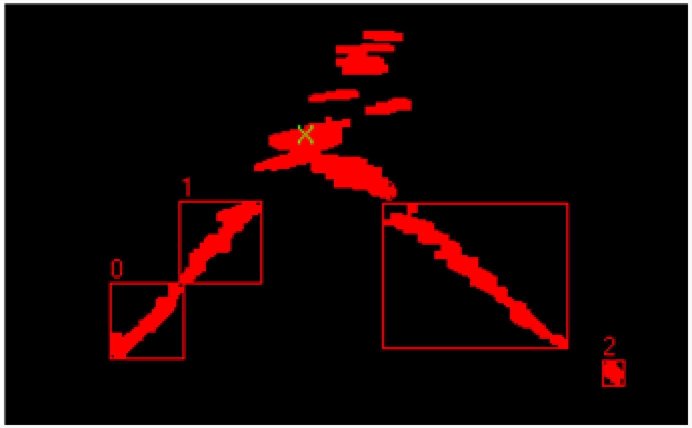
Sonar - Image Processing

Locating a corner



Sonar - Image Processing
Locating a corner





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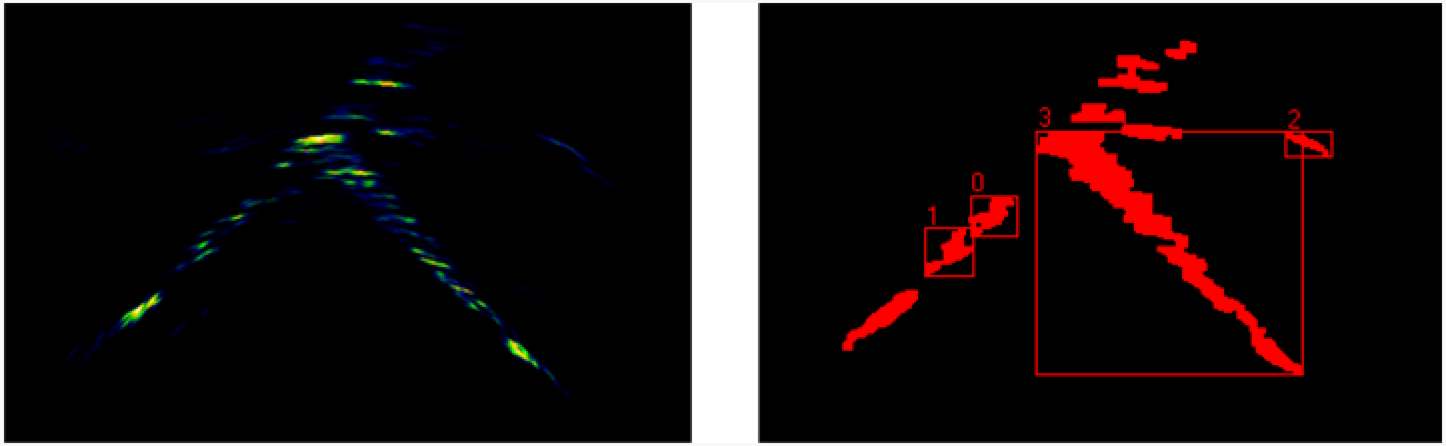

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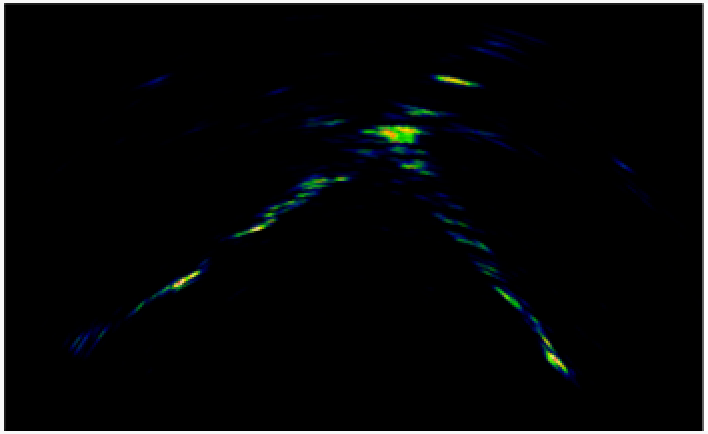
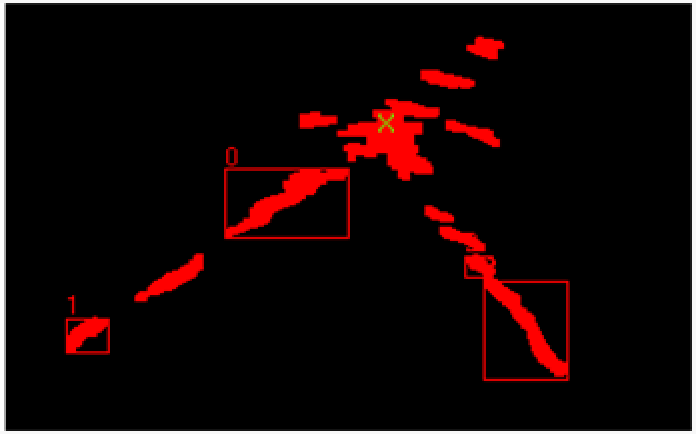
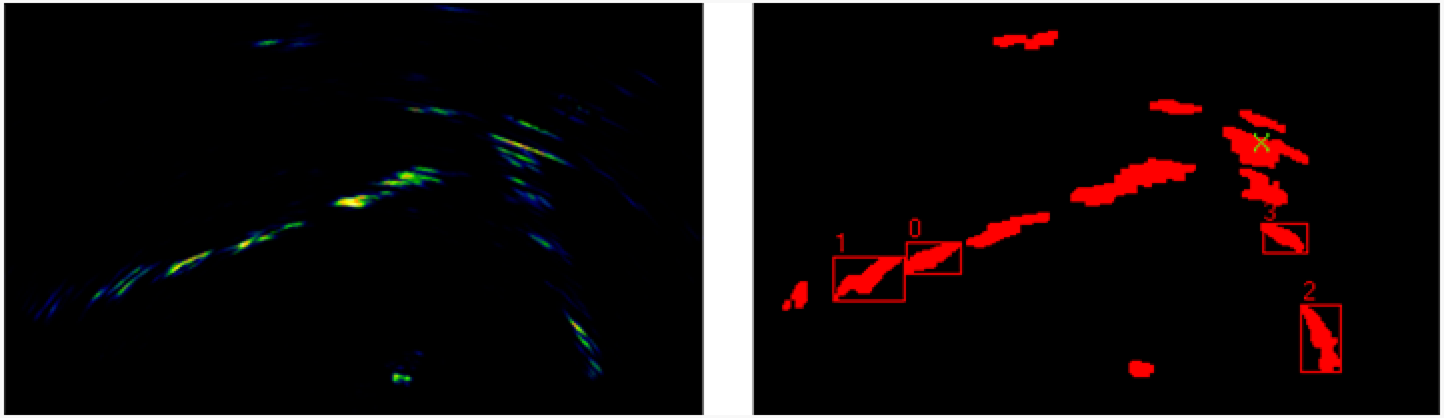
Locating a corner





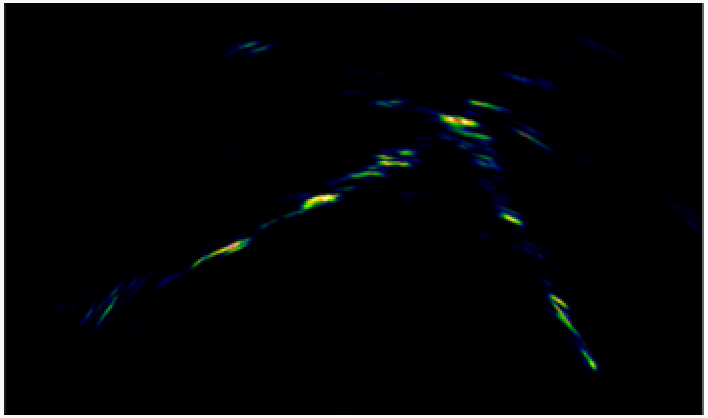
Sonar - Image Processing

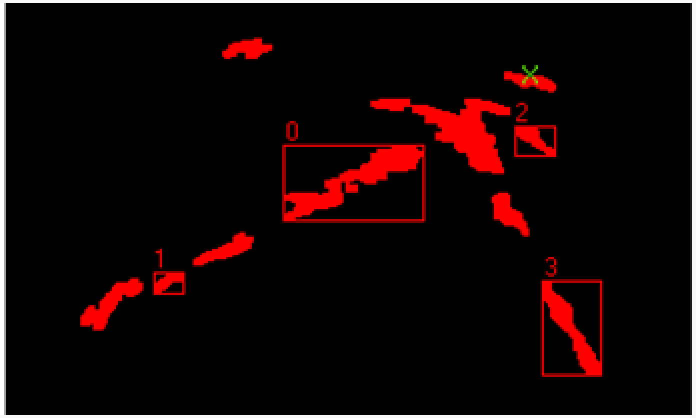
Locating a corner



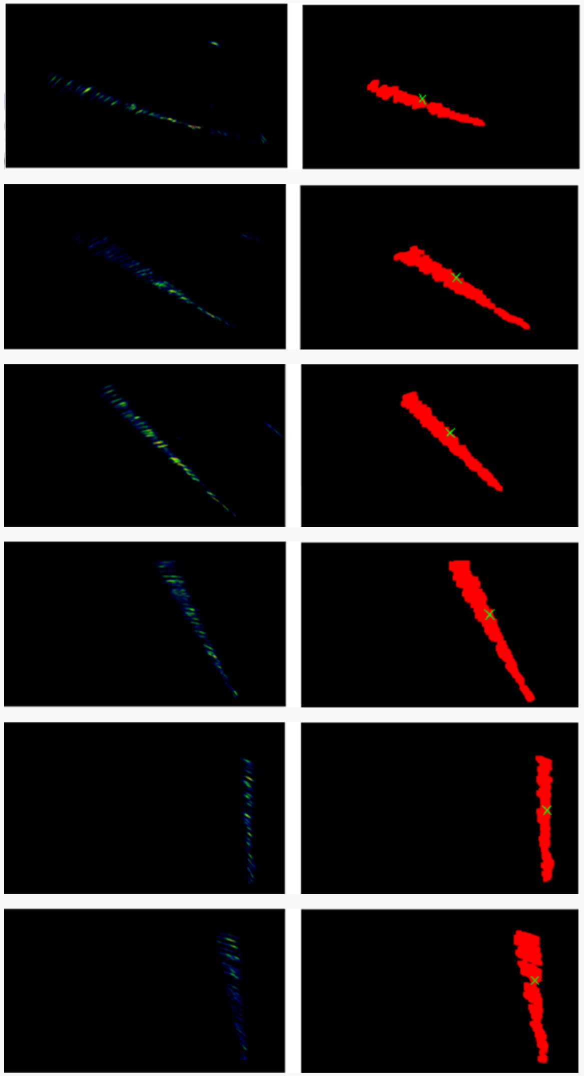
Sonar - Image Processing

Locating a corner

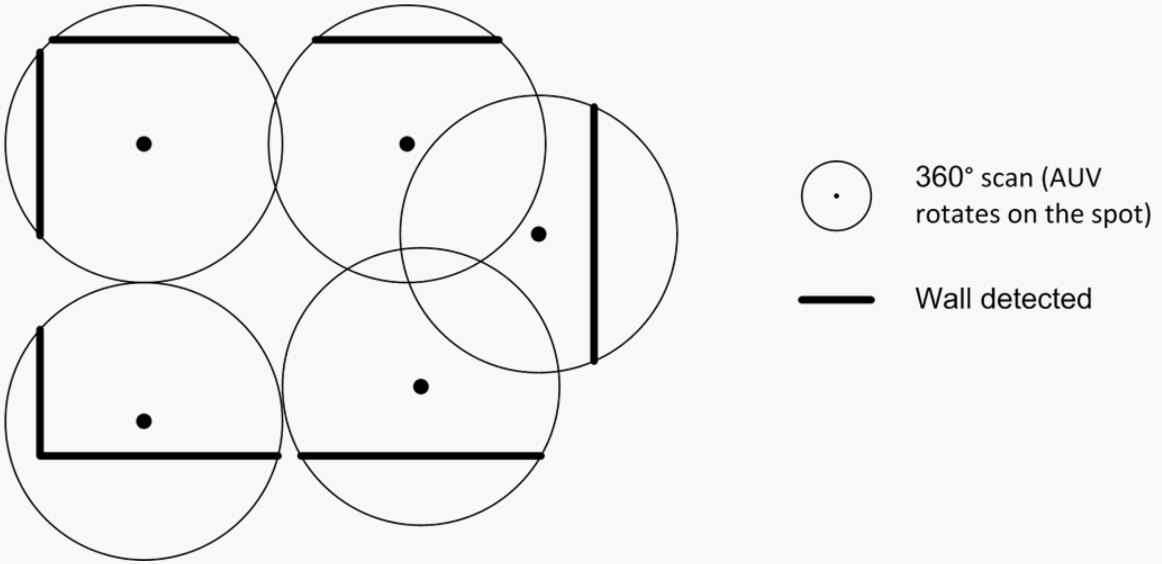




Sonar - Mapping



- The same principle applies to wall detection
- Gathered information can be used for mapping



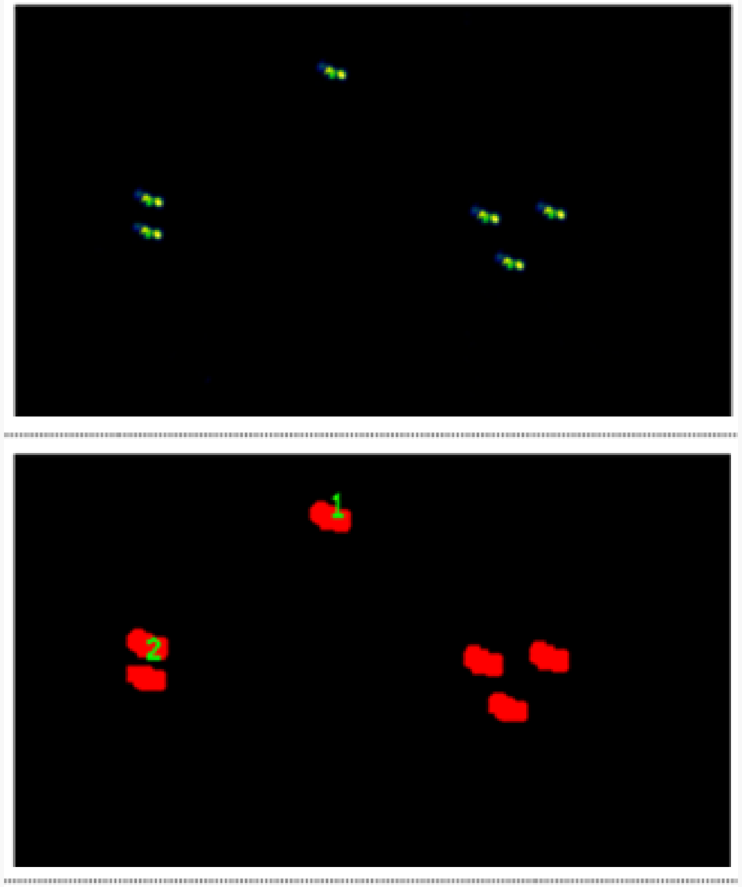
Sonar - Identifying Objects

OBJECT FILTERS

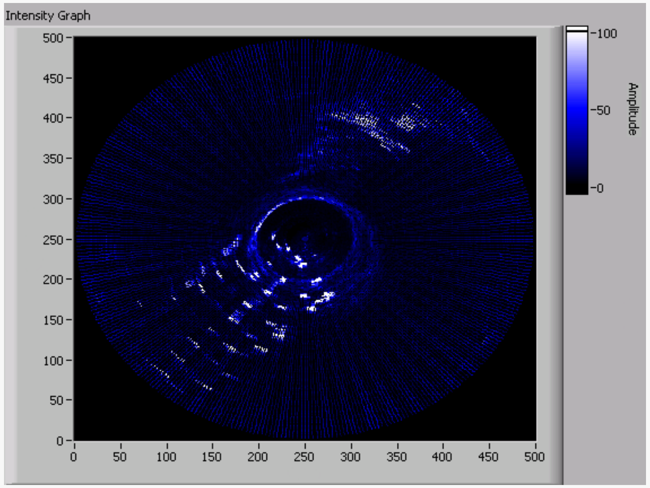
- Nearest Neighbour

If a particle has ONE close neighbour then the program classifies the two particles as one object.

If a particle has TWO close neighbours then the program classifies the particle as noise.

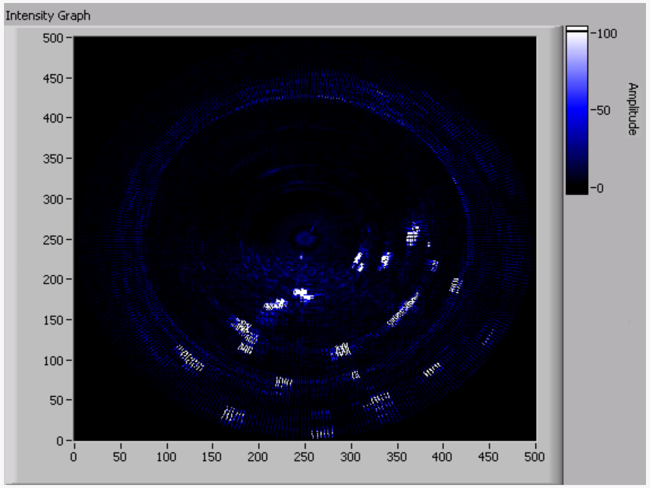


Sonar - Identifying Objects

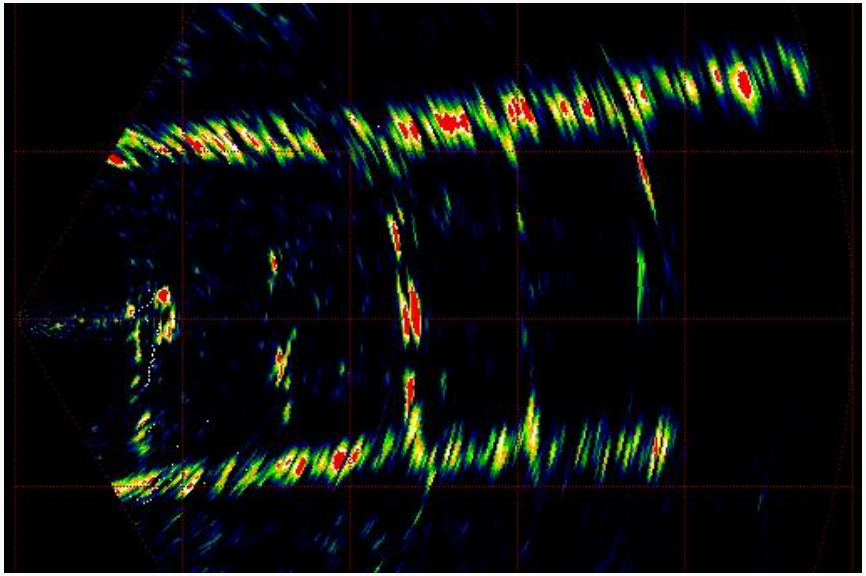


Right: Survey area, the piling dock and shoreline

360° Sonar Scan of Dock Pilings



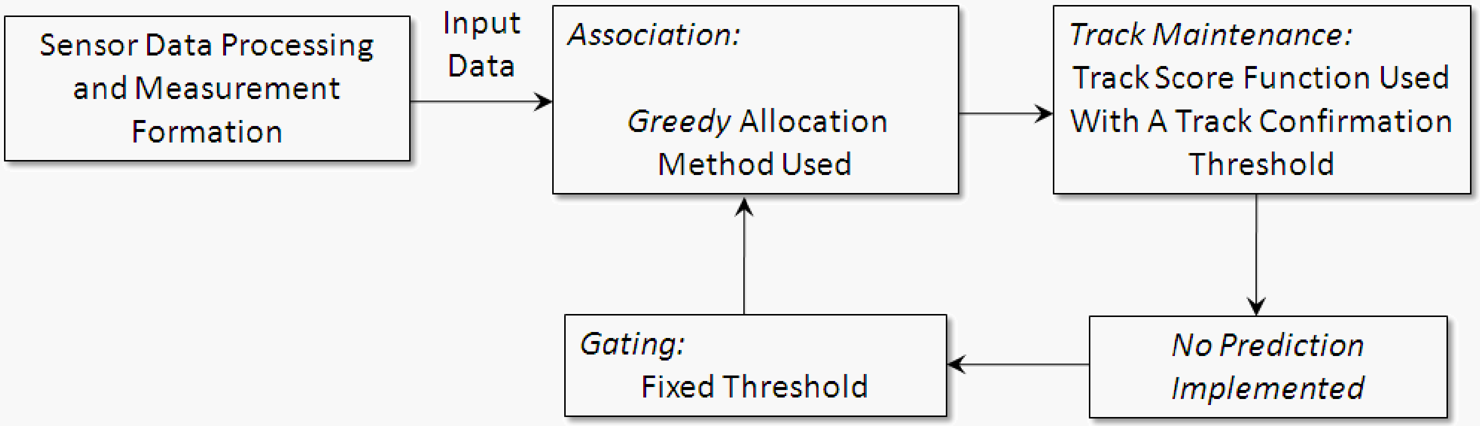
Below: Forward-facing profiling sonar of repeated dock pilings



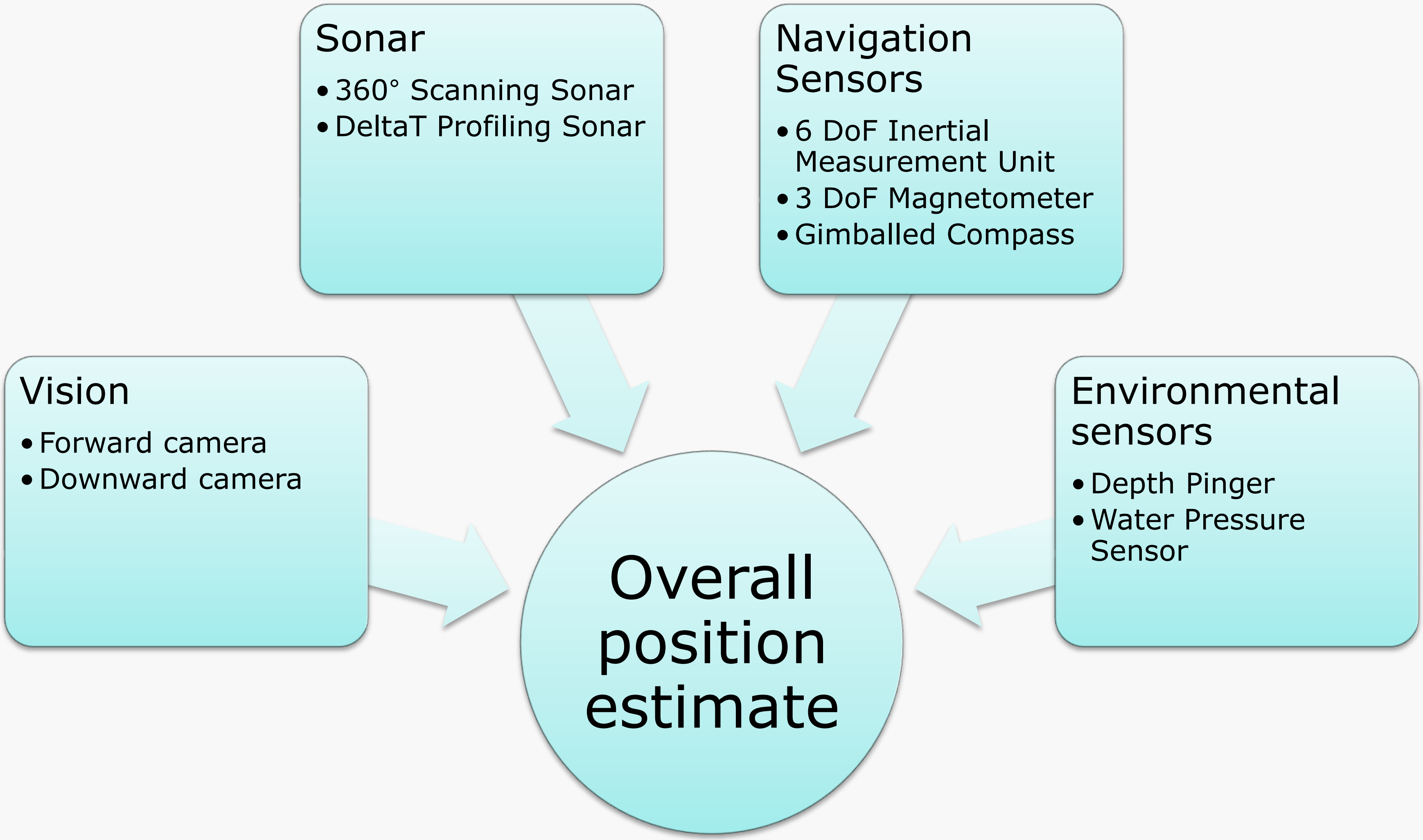
Sonar - Object Tracking

Two key parameters are used to track objects from one frame to the next; particle location and area.

The framework used for the tracking part of the program is shown below:



Sensor Fusion & Mission Planning



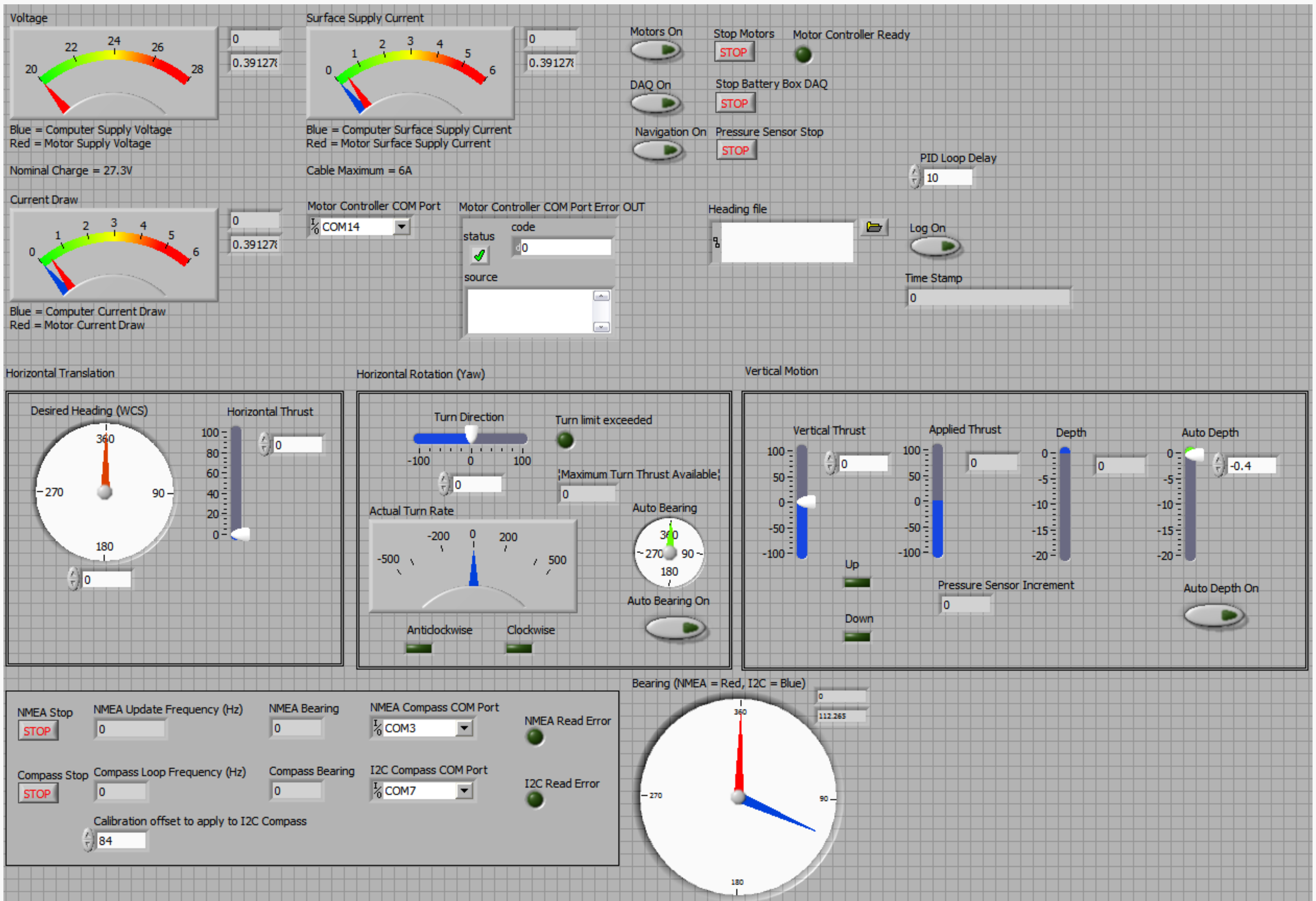
Sensor Fusion

- Combines positional estimates from a *variety of sensors*, each with different *characteristics*
  - e.g. update frequency, noise, accuracy, etc.
- Each sensors positional estimate is assigned a *reliability estimate;*
  - this determines its *weighting* (influence) on the overall positional estimate when combining conflicting data.
- As environmental conditions change, the weightings are adjusted, e.g.:
  - turbid water (murky so lower weighting of vision)
  - turbulent water (increased sonar noise)
  - magnetic disturbances (reduced magnetometer accuracy)
- Provides an overall **position estimate** and **accuracy estimate**

Program Structure

- Hierarchical Program
  - Overall mission plan runs subtasks
  - Allows for mission variation, either for competition or for difference ocean tasks
- Artificial Intelligence
  - React to unforeseen circumstances – e.g. object found / not found, allows mission to continue

Flexible program structure - Control as ROV (fly by wire)



Future Design

- Sensor fusion
- Navigation in the near-shore environment
- Station keeping in unsteady flows
- Mechanical design for deepwater operation

Sponsors & Acknowledgements

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To get involved...

- SAUC-E Competition – July 2010
- Canadian Field Trials – July-October 2010

- Come and visit the lab
  - 4 East 1.24

- Email
  - b.j.williamson@bath.ac.uk