

Sun, Surf and Automation: Fifteen Years of Field Robotics in Australia

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Three Key Ideas in Field Robotics



Four Project Exemplars



AutoStrad





AutoStrad: Automated Container Handling





AutoStrad: Integrity and Systems











Persistence and Integrity











Datasets

(http://sdi.acfr.usyd.edu.au/) [Peynot &Scheding, IJRR 2010]

















Decentralised Data Fusion





Oxford 1990: DDF, Early SLAM



Decentralised Modular Control (1992)

UAV Demonstrations of DDF [2000-2007]

BAE SYSTEMS

UAV/DDF: Systems Engineering

- UAVs are unforgiving:
- Multi-UAV operations are exponentially hard
- DDF makes system design tractable

DDF in Operation

DDF System and Design

Example: Future Cooperative UAVs

[Sukkarieh et.al 2006]

- How best to use tactical UAV fleets ?
- A list of candidate targets of interest
- Coordinate a UAV fleet with mixed sensors to:
 - Locate,
 - identify and
 - prosecute targets
- Demonstrate this

Metric: Information Gain

Environment

Two Vehicle Flight Demonstration (2006)

DDF Outcomes

- Key fusion algorithms in:
 - Naval Air Defence (RN)
 - Future UCAV ops (RAF)
 - UAV Networking (USAF)
 - Sensor Networks (ARL)

DDF as a Graphical Model

Cooperative Localisation Example

Cooperative Localisation Model

Implementation via Sparse Matrix Algebra

- Complete vector of observations contains IMU, GPS and vision observations
- H Matrix: 177,671 rows, 86,227 columns (1,990,638 non-zeros)
- H Matrix (columns):
 - 12,000 vehicle poses
 - 4,738 features
 - 6 IMU biases, 3 camera misalignments, 4 pinhole error parameters
- H Matrix (rows)
 - 12,000 IMU observations
 - 120 GPS observations
 - 52,654 camera observations

Red Robot Test Bed

- Upgraded Pioneer robots
- Camera, laser, encoders and inertial sensors

Four-Platform Example

- Four platforms:
- All four with lowrated IMUs
- Three with external sensing
- One without external sensing
- Relative range and bearing between platforms

Recognising Natural Features

Using NLDR for Feature Modelling

Weed Identification from UAVs [Salah Sukkarieh]

Sub-Sea SLAM

Autonomous Marine Systems

[Stefan Williams, Oscar Pizarro]

Sub-sea SLAM

- SLAM: Simultaneous Localisation and Mapping
- Use of sparse information graphs of trajectories
- Avoid explicit features: the data is the map

Post-SLAM Stereo Survey Reconstruction

IMOS – 5 Nodes and 11 Facilities

IMOS AUV Facility

Surveys on the Great Barrier Reef

Bag of Features Representation

Nocturnal Cuttlefish Camouflage

Tasmania 2008 – O'Hara Reef

SlideA39July 2011

Mine Automation

Mine Automation

A Grand Challenge for Field Robotics

Safety, Predictability and Efficiency

The Initial Strategy (1995-00)

Safety is a priority in mining !

Components for Automation

Mm-wave Radar Development

THE QUEEN'S AWARDS FOR ENTERPRISE: INNOVATION 2010

Automation of complete mining cycle – total benefit

Vertical integration into mining business

Mine Automation Program **RioTinto**

Architecture

Data Fusion

Automation

Architecture = Information and Control

Plug-in architecture and standards for all OEM components

Mine Picture Compilation (MPC)

[Fabio Ramos et. al.]

Best Possible Mine Model Available in Real Time

Equipment Automation

RioTinto

MPC-Spatial Information Fusion RioTinto

Multi-sensor, multi-scale composite spatial picture

MPC-Geology Information Fusion **RioTinto**

Prior Block Model

Drill and Face Data

Non-stationary, Multi-task Gaussian Process

Fusion into MPC with uncertainties

MPC-Geometry-Geology Fusion

RioTinto

Drill Rig in Operation

Auto Truck Trials

Capturing the Prize

RioTinto

- Technology
 - Rio Tinto controls enabling information technologies
 - Strong vertical integration into mining process and business
 - Encourage OEM engagement
- Commercial developments
 - Mine Automation System (MAS)
 - Autonomous drills (and trucks)
 - Remote operation centre
 - Integrated automated mine planning

A transformation in mining is coming

Next Directions in Field Robotics

Multi-Sensor Perception

Cooperative Operations

Human-Robot Interaction

Multi-Sensor Perception

BAE SYSTEMS

Cooperative Operations

[Alex Makarenko, Alex Brooks, Tobi Kaupp]

HRI: An application in Media Art [Mari Velonaki]

The Next Ten Years

