Roke Manor Research Ltd
a Siemens company

# Stable scene surfaces from computer vision

## EMRS DTC Project 4/12 - 3D computer vision

### What we are doing and why

3D computer vision techniques extract 3D information from image and video data. Our project objectives are:

- To develop and extend 3D processing techniques
  - Build on existing feature-based structure-from-motion algorithms
- Illustrate their applicability to real imagery
  - Robotic applications provide research focus
  - Ensures project responds to real-world issues.

Structure-from-motion is a passive 3D sensing technique with potential to support a host of military and civil applications.

- Autonomous vehicles
  - Navigation and obstacle avoidance
  - Mapping and mission support, e.g. optimised sensor placement
- Object recognition
- Assistance to remote operators
  - Virtual reality solution for use with limited bandwidth communications
- Rapid survey for familiarisation & training
- Development of virtual environments.

EMRS DTC 4/12 provides input to SEAS DTC project AA005 which is exploiting 3D vision algorithms in a system for autonomous exploration.

### What we have achieved

Project 4/12 builds on wide ranging work in earlier phases.

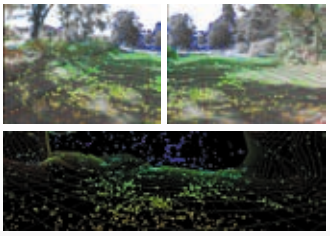
- Algorithm refinements, e.g.
  - Accommodating platform motion as over rough ground
  - Dynamic stereo exposure control for adverse lighting conditions
  - 3D processing of edge data
- Integration with simple robotics infrastructure
  - Route following, obstacle detection/avoidance, rudimentary mapping
- Implementation on experimental platforms
  - Smooth and rough-ground platforms to exercise vision system.

In recent work we've addressed the need for improved algorithms to interpret 3D point feature positions as surfaces. We have:

- Considered mesh processing options
  - Free-floating mesh – theoretically attractive but discounted as impractical
  - Post-processing to improve results of existing surface generation algorithms (based on so called Delauney triangulation) – preferred approach
- Identified a set of post-processing techniques
  - Photo-consistency to identify problem areas
  - Surface regularisation by adjusting feature positions
  - Local adjustment to triangulation
  - Location and analysis of surface discontinuities
- Developed algorithms for first three above.

Other recent work topics have included:

- Performance assessments
- Systems study from user/integrator perspective by Remotec UK
- Preliminary study of use with thermal IR cameras.



*Structure-from-Motion processing provides passive sensing of 3D scene structure and camera path by processing a sequence of images from a moving camera system. The camera system can be monocular or stereo. Here stereo images are overlaid with tracked features, colour coded by range with contours indicating the estimated scene shape. The lower picture shows a virtual reconstruction from the viewpoint of a synthetic camera.*

*Roke's vision system has been integrated with experimental platforms to exercise the vision algorithms. The chassis of this vehicle has been loaned by Dstl.*

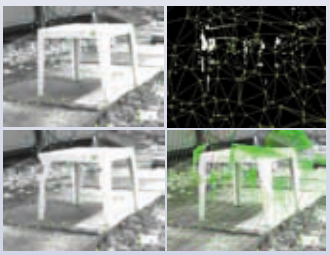


*Photo-consistency provides a means of verifying a surface representation. Here a true view of an object (top left) is compared with a synthetic view (bottom left). The synthetic view has been constructed by rendering the estimated scene surface with image pixel values from a different camera viewpoint. Differences between these images indicate errors in the surface. These are highlighted in the triangulation (top right) and offending regions are omitted from the contour plot (bottom right).*

### Where we are going

Pursue objective of more faithful 3D representation of scene surfaces.

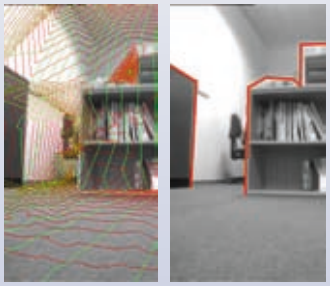
- Identified surface discontinuities as a key issue.

Further work to assess feasibility of exploiting thermal IR cameras with existing 3D processing algorithms.

- Build on recent pilot exercises
- Prospect of 24 hour passive operation.

*Local adjustments to triangulation can provide much improved estimates of scene structure. Here the output provided by the raw Delauney triangulation (top images) misinterprets the floor. Adjusting the triangulation of a single group of features provides a faithful representation of the floor (bottom images).*

*Cutlass experimental model, image courtesy of Remotec UK.*



*Future work aims to produce much improved surface representations. Previous work has been limited to relatively simple triangulation algorithms that do not accommodate scene discontinuities, such as occurring here.*

*Example of feature extraction of tracking on thermal IR imagery. Imagery from L-3 Communications website.*

### Find out more

See EMRS DTC conference paper "Stable Scene Surfaces from Computer Vision" by Chris Harris.

Contact: chris.harris@roke.co.uk or
richard.evans@roke.co.uk