

Environmental Analysis through integration of Geographical Information and Machine Vision systems

by

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Abstract

A system for geo-referencing objects in general environmental scenes is presented. Specific attention is given to the application of change detection over time.

A commercial digital video camera is used for image acquisition and the requirements for using it for accurate photogrammetric measurements are thoroughly investigated. Methods are developed to compensate for pixel size and lens distortion.

Sources of the necessary geographical data for geo-referencing, as applied to Northern Ireland are analysed and their accuracy quantified with respect to each other. Appropriate data sources are combined to produce the most suitable and accurate data. An existing Geographical Information System (GIS) is further developed to improve its suitability for the necessary geographical analysis and processing.

The 3-D visualisation capabilities of a GIS have been extended to allow it to be used for image perspective transformation in non-flat scenes. The physical properties and known position of the camera are used to relate the geographical data to the camera image of the same scene.

A system design for accurately determining the camera position is developed, making use of GPS and inertial sensors for an initial approximation and a novel image feature-based technique to improve accuracy. Initial results are demonstrated to prove the potential of the method.

Methods of change detection and its pre-requisites (illumination and colour compensation) are demonstrated to be appropriate for the types of images and scenes under consideration.

Images and data from urban and rural scenes are used to demonstrate the effectiveness of the various aspects of the system. Suggestions for further work include further development of the system and application of several aspects of the work to other systems.

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List of Acronyms

- ASTER** Advanced Spaceborne Thermal Emission and Reflection Radiometer
- CIE** Commission Internationale de l’Eclairage (international colour standards body)
- DEM** Digital Elevation Model
- DTM** Digital Terrain Model
- DV** Digital Video
- GAMIT** GPS Analysis—Massachusetts Institute of Technology
- GIS** Geographical Information System
- GPS** Global Positioning System
- GRASS** Geographic Resources Analysis Support System
- IDW** Inverse Distance Weighting (interpolation method)
- MHT** Modified Hough Transform
- MSL** Mean Sea Level
- OSGM02** Ordnance Survey Geoid Model 2002
- OSNI** Ordnance Survey of Northern Ireland
- OSi** Ordnance Survey Ireland
- PAL** Phase Alternate Line (European television standard)
- RINEX** Receiver INdependent EXchange format (GPS data storage format)
- RMS** Root Mean Square
- RST** Regularised Spline with Tension (interpolation method)
- UTM** Universal Transverse Mercator (map projection ASTER data is supplied in)
- WGS84** World Geodetic System 1984 (geodetic datum and Earth ellipsoid model)

Publications

Parts of the work presented in this thesis have already been published elsewhere as follows:

Kelly, P. D. and Dodds, G., 2002. Image Processing and GIS Integration for Environmental Analysis. In: *Irish Signals and Systems Conference, Cork, June 2002*, pp. 121–126.

Kelly, P. D. and Dodds, G., 2003. Landmark Integration using GIS and Image Processing for Environmental Analysis with Outdoor Mobile Robots. In: *IEEE International Conference on Intelligent Robots and Systems, Las Vegas, Nevada, USA, October 2003*, vol. 3, pp. 2980–2985.