Rapid Inventory Collection System (RICS)

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Introduction

The Rapid Inventory Collection System (RICS) was initially conceived as a roving vehicular video damage assessment platform which offered many potential time and cost saving benefits to Geoscience Australia (GA) in the efficient and effective assessment of building and infrastructure damage following natural disasters.

In particular, RICS:
- provides a quick "first-look" of the damage impact area when the first-on-scene personnel are assessing worst-hit regions
- compliments and augments the detailed field damage assessments (house-to-house, structure-to-structure) currently undertaken using hand-held PDAs
- allows for 100% coverage of building damage in a disaster-affected area
- collects data focusing on "population coverage" and undamaged structures allowing key engineering and geographic information systems (GIS) staff to focus on damaged structures
- allows the field damage assessment to be undertaken more efficiently and in a shorter period of time
- provides the option of analysing data off site when operating in the field in "poor weather conditions" and
- is useful for rapid building inventory assessment, validation & updating

To date, RICS has been mainly utilised for building inventory assessment in support of the development of the National Exposure Information System (NEXIS), a buildings database that GA is constructing for national scale infrastructure risk assessment.

Equipment (Hardware)

RICS consists of the following hardware components:
- extendable aluminium tripod with suction cup "feet" mounted on the roof of a motor vehicle. The aluminium mount allows cameras to be positioned approximately one metre above the car roof to allow photographs over roadside debris and vehicles (see Figure 2a)
- camera configuration consisting of two, three or four Prosilica GC2450 GigE 5 megapixel digital cameras (2448 by 2050 pixels)
- five port Gigabit Ethernet switch with jumbo frame support to network camera image streams (jumbo frames reduces the CPU load required to handle incoming data)
- Fujinon 16mm focal length lenses. It was found that the horizontal field of view provided by these lenses is too narrow in some cases (e.g. narrow streets in old neighbourhoods). We anticipate that 12.5mm focal length lenses (on order) would provide a better coverage of built areas
- Swann 1020 camera housings providing all weather protection

- Dell laptop with Intel Core 2 Duo Extreme 2.8 GHz CPU, 200 GB hard drive, and 3.5 GB of RAM
- Amtex 300W DC/AC sine-wave inverter
- Global Top Bluetooth GPS 5Hz update rate
- Pelican 1650 waterproof, crushproof and dustproof cases for hardware transportation

First generation RICS utilised a desktop PC with four SCSI hard disk drives and three Firewire Pixelink cameras. A Honda petrol generator was used to power the PC and monitor.

During the field trials of first generation RICS, we found the use of the PC and monitor to be cumbersome requiring significant time for set up with limited portability. The Pixelink cameras captured images containing distortion (skew) due to their use of *rolling shutter* technology. Firewire connectivity between cameras and PC also proved troublesome due to software and hardware incompatibilities. There were occupational health and safety issues with the petrol generator such as excessive noise and noxious fumes. The transportation of the generator on board aircraft (rapid deployment) would also be a challenge as it is heavy and contains flammable liquids.

To overcome the problems of first generation RICS, we resorted to a high end laptop, Prosilica cameras with *global shutters* and Gigabit Ethernet connectivity, powered by a 300W sine-wave inverter connected to the vehicles battery by heavy-duty cables. The laptop allows rapid setup while also adding to the portability of the system and provides greater comfort for the passenger. RICS requires a high end laptop because it compresses (in JPEG format) and saves images from up to four cameras at four frames per second which is computationally intensive. The software is also multi-threaded. RICS captures GPS data and adds the data to the SQLite database. Moreover, ESRI's ArcPad, used to generate a tracklog, may also run alongside RICS. As RICS is multithreaded, a multi-core system is necessary for optimal performance. We currently use a Dell dual-core laptop which has proven satisfactory utilising three cameras. We plan to stream and save images at a higher frame rate with four cameras utilising a new quad-core laptop (on order).

The Prosilica cameras employ global shutters, not rolling shutters, therefore image distortion is minimised. Gigabit Ethernet connectivity, common on all modern laptops, allows a more reliable data transfer and the use of multiple cameras through an Ethernet switch.

Software Components

RICS was implemented in C++ using Microsoft Visual C++ Express 2008. The software consists of 17 classes and makes use of a number of third party libraries and SDKs, including the Prosilica SDK, Boost C++ libraries, wxWidgets, SQLite and the MarshallSoft GPS component.

Prosilica's GigE Vision SDK allows users to programatically control and capture images from Prosilica's GigE Vision gigabit Ethernet cameras operating in a Windows environment.
Boost C++ libraries are a collection of peer-reviewed, open-source libraries that extend the functionalities of C++ and STL (Standard Template Library). Extensive use of the Boost lexical_cast, shared_ptr and shared_array libraries were made in the code.

wxWidgets was used to create the Graphical User Interface (GUI). wxWidgets is an open-source, cross platform GUI toolkit for creating C++ GUI applications. Threading and online help tools are provided by wxWidgets and both tools were used in RICS.

SQLite is an open-source SQL database engine contained in a C library. Unlike most other SQL engines, SQLite is not a standalone engine, and is thus linked in and becomes an integral part of an application. This reduces latency and its design is well suited to use in RICS.

The MarshallSoft GPS component is used to receive and decode standard NMEA* 183 sentences from a GPS receiver connected to a RS232 serial port. The GPS component is a commercial Win32 DLL and uses the Win32 API for serial port input.

The RICS Graphical User Interface (GUI) was designed to be user-friendly, consistent, and intuitive. The main window consists of three sections (see Figure 1). Streamed images are displayed in the top section. The middle section displays the collected GPS data, specifically time (GMT), latitude, longitude, bearing, number of satellites, fix quality, and speed. Based on user feedback, the speed, in kilometres per hour, is printed prominently in a larger font. The bottom section is a notepad, where users can type notes during a field trip. If a user wishes, the current time, latitude and longitude can be added to the end of each line, therefore the notes are time and geo-referenced. The note pad text is saved as a CSV (comma separated value) file, and can therefore be opened in a database or spreadsheet program.

Camera and network properties, such as exposure time, white balance, frame rate, and Ethernet packet size can be set in RICS. The COM port of the attached GPS device can be set manually if known, or if unknown, can be searched for automatically. The online help manual, in CHM (Microsoft Compiled HTML Help) format, can be launched from RICS. RICS does not currently have a tool to view the tracklog. To view the tracklog, ESRI's ArcPad can be launched from RICS, which runs as a separate process to RICS. Since both ArcPad and RICS share the data collected by a GPS device a COM port splitter is employed to allow both processes to share the same COM port.

RICS can be operated in two different modes: Display Mode and Session Mode. In Display Mode, images are streamed and simply displayed; the streamed images are not saved and a database is not created. Display Mode should be used to focus the cameras and to set the correct camera properties before a session is created. In Session Mode, each session of field work is assigned a unique name, and streamed images are saved and a SQLite database created. Each camera has its own database table and every saved image has a corresponding entry in the database table.

Discussion

Figure 1 shows RICS in Session Mode; the captured images and GPS data are displayed and entries are made in the notepad display area. ArcPad, showing the tracklog, runs side by side with RICS. In order to discover and eliminate bugs, and to test RICS in a "live situation", extensive field testing has been undertaken.

* Standard ASCII protocol used by GPS receivers to transmit data

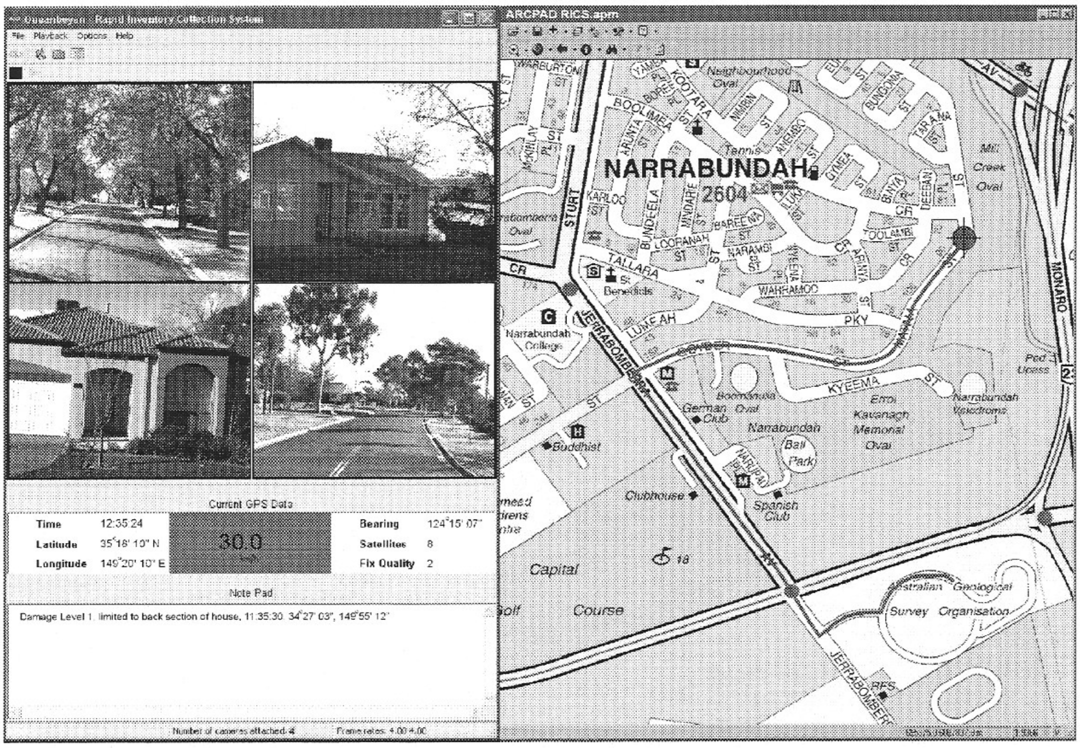
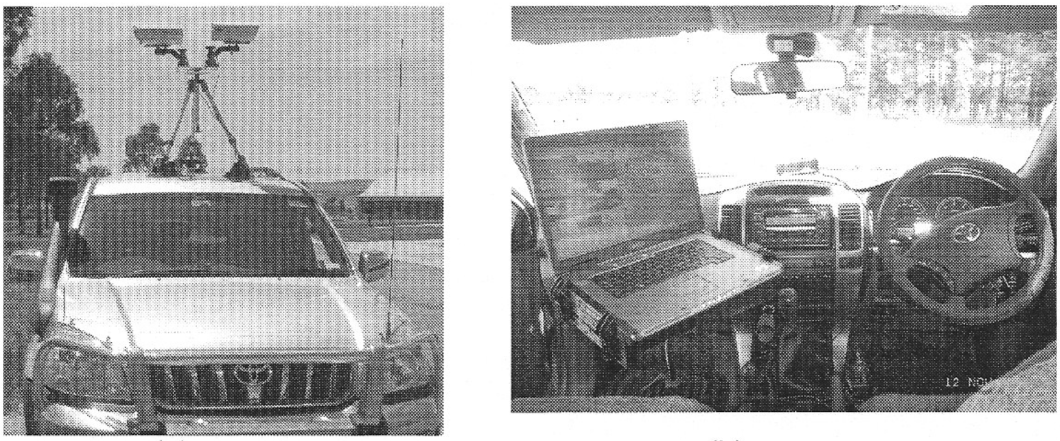


Figure 1: RICS and ArcPad (showing the tracklog)

Figure 2(a) shows the cameras mounted on a 4WD vehicle and Figure 2(b) shows the laptop set-up inside the vehicle using the TREK mount system and RAM tray. Note that this arrangement also allows a front-seat passenger to sit comfortably and operate RICS.



(a) (b)

Figure 2: (a) Cameras mounted on a 4WD vehicle. (b) Laptop set-up inside a vehicle.

RICS will continue to be used to enhance the commercial and industrial components of NEXIS buildings database. We also plan to use RICS to validate the Australian Bureau of Statistics (ABS) residential buildings assessment that is used by NEXIS in some Australian regions. We are prepared (on standby) to use RICS for a major natural hazard impact analysis (Australian region) involving both infrastructure and natural environment damage/impact assessment. Outside Australia, we are seeking collaboration to utilise RICS in neighbouring nations such as New Zealand, New Guinea and the major South Pacific countries.

Future Directions

Continuing development and refinement of RICS is planned. The following issues are currently part of the development plan:

- In order to make RICS an independent and stand alone package, the tracklog functionality will be incorporated into RICS. Currently ArcPad is employed to display the tracklog in a parallel session
- Internal car cabin commentary will also be recorded to obtain comments from the driver (and passenger if available). All *wav* file data will be geospatially located via the GPS stream and time synchronised so that recordings can be played back (frame by frame if necessary) to assess structures
- Trial 360° panorama images using either fisheye 2.4mm focal length lenses or Theia ultra wide angle non-distorting lenses for CBD image capture similar to Google StreetView, will allow high rise buildings to be captured and viewed
- Streamlining the database upload into the GIS environment will be implemented to allow for accelerated image display and improved data-processing back in the office (currently using ESRI's ArcMap software and python scripting)

Acknowledgements

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