CSIRO Land and Water

# An Integrated Automated Remote Digital Image Collection System


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**Cover photograph:**

Description: The digital imaging system installed on a hillslope monitoring station near Mingela, Queensland, Australia.

Photographer: Rex Keen

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# Executive Summary

Low cost automated digital image collection systems can be integrated into any environmental monitoring station that uses data logger technology. A prototype imaging unit, made from 'off the shelf' components has been successfully deployed at an MLA funded study site in North Queensland, Australia.

The primary role of the imaging system is to capture images of runoff events as data is logged and to collect a daily image of the study site, providing a record of how ground cover changes over time. It uses a 2 mega-pixel camera that is able to store around 500 images on a 256 MB Secure Digital media card. This equates to around 500 daily images or over 8 hours of photography at one minute intervals.

The unit is housed in a weather proof enclosure and is largely self contained, relying on existing systems only for power and triggering. By integrating into existing infrastructure, the cost of the parts for the prototype system was around AU$400 (March 2004).

The digital images that are collected can be correlated with associated datasets enhancing data analysis, interpretation and communication capabilities.

This paper details the system components, construction and application.

# Table of Contents

# 1 Introduction

Automated imaging systems are tools that can enhance research capabilities. Many of these systems have been designed for wildlife studies (Claridge *et al* 2004, Glen and Dickman 2003 and Otani 2001) with a reliance on mechanical or infrared triggers and 35mm cameras. Yasuda and Kawakami (2002) described an 'always on' streaming digital camera system that requires internet access. The primary role of these systems has been to collect information relating to species identification and abundance.

In the field of geomorphology, ground based digital imagery has generally been used for photogrammetry (Carbonneau *et al* 2003, Chandler *et al* 2003) and mapping purposes (Honda and Nagai 2002, Corripio *et al* 2004). The paper by Lawler (2005) discusses the benefits of high temporal resolution monitoring for understanding erosion and deposition processes.

CSIRO Land & Water has many automated environmental monitoring stations installed throughout North Queensland, Australia. These stations collect event data with a high temporal resolution. The stations are controlled using data loggers and operate on solar power. Some have telemetry systems for data relay.

A prototype imaging system has been installed at a study site on Virginia Park Station, near Charters Towers, Queensland. The monitoring system at this site was installed to measure the quality and quantity of runoff generated from a hill slope. It is comprised of a large flume, depth sensors, an automatic water sampler, a rain gauge and a Campbell Scientific CR10x logger.

This paper describes how an inexpensive digital camera can be integrated into existing monitoring systems, to automatically collect colour digital images that can be related to temporal or event based data.

# 2 Setup

## 2.1 Digital camera

A Kodak EasyShare CX6200 (figure 1) was used for the prototype system. This model was chosen due to its low cost of about AU$170 (March 2004). It has a 2 mega-pixel resolution and uses Secure Digital card media for storage. A 256 MB storage card is able to store around 500 images at medium quality (1632 x 1232 pixels).


**Figure 1 : Kodak CX6200**

## 2.2 Camera modifications

Two modifications were made to the camera which provided remote triggering and external power. These were made necessary due to the absence of features on this low cost model.

In order to remotely trigger the camera, wires were soldered to the positive and negative terminals of the shutter button. These wires were connected to an excitation port on a Campbell Scientific CR10x data logger that triggers the camera when it is activated. This modification could be made to an inexpensive remote control device so that no camera disassembly would be required.

To power the unit wires were soldered to the positive and negative terminals of the battery housing. Models that have a DC input would not require this modification to be made. Power for the camera is sourced from the 12 V output of the logger which passes through a 12 V-3.5 V linear voltage regulator (LM338T). Any 12 V power source that provides the required current to power the camera (2 A) could be used.

## 2.3 Enclosure

A modified B&R EC3215, powder coated enclosure with an IP55 protection rating was used to house the camera and other components (figure 2). This enclosure provides long lasting, water proof protection at a cost of around AU$110. A camera aperture was created by drilling a 30 mm hole into the side of the enclosure. This aperture was fitted with a watertight glass cover.

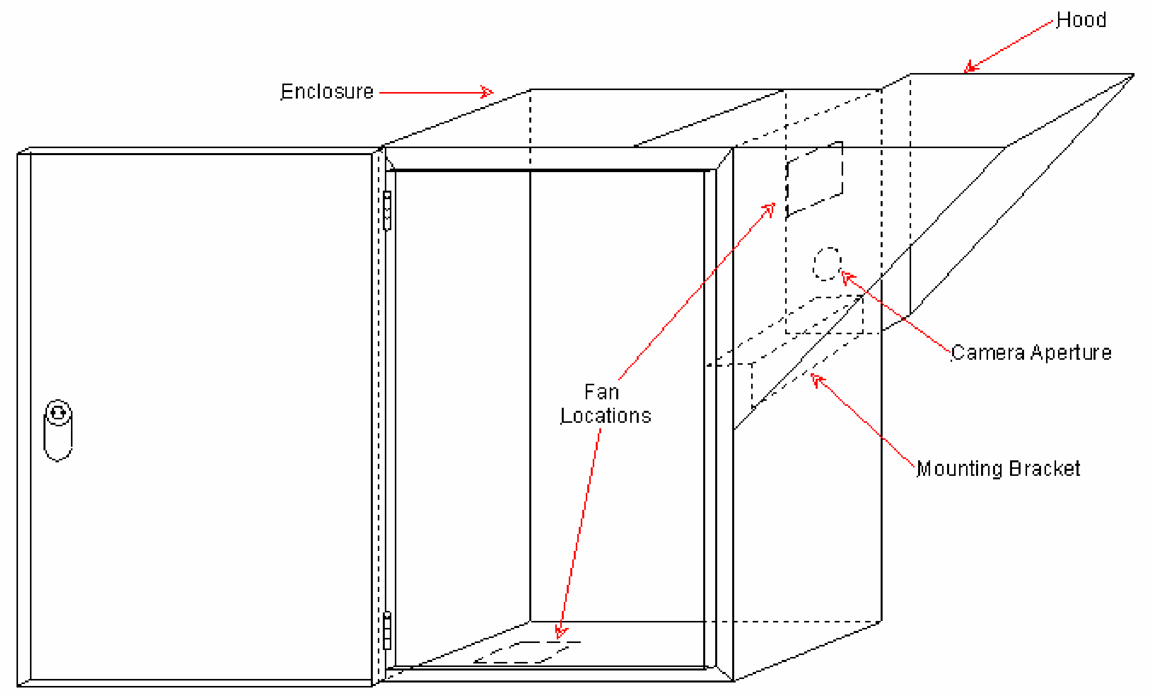


**Figure 2. Principal components of the camera housing.**

## 2.4 Rain and direct sunlight protection

A hood was attached to the enclosure to protect the glass on the camera aperture from raindrop interference and to prevent direct sunlight intrusion into the camera lens. The dimensions of the hood were calculated based on the focal length of the lens and the effective viewing angle to prevent interference with the images. A construction template is shown in Appendix 1.

## 2.5 Camera mounting

The camera was fixed to a mounting bracket using the tripod mount. The mounting bracket was fabricated from 50mm aluminium angle section which was fixed to the inside of the enclosure with stainless steel screws. The mount has an adapter made from ¼″ Whitworth threaded rod which attaches to camera tripod mount.

## 2.6 Ventilation

A ventilation system was required to prevent component damage caused by excessive temperatures. Ventilation is provided by two 12 V 50 mm computer fans which can be purchased from any electronic supply store. The fans are connected to the solar panel voltage regulator and therefore only operate during daylight hours. This stops the fans from drawing power from the station's batteries during the night. The air intake is located at the bottom of the enclosure where it is unlikely to be affected by moisture or dust build-up. The exhaust is located at the front of the enclosure, above the camera. This positioning enables the outgoing air to blow dust away from the glass covering of the camera aperture and also serves to deter nesting insects.

## 2.7 Insect deterrence

In tropical areas, structures that provide shelter from the environment are susceptible to infestation by nesting insects such as ants, wasps and spiders. Insect repellents including naphthalene and camphor were placed inside the enclosure. The vapours from these repellents are circulated by the ventilation system and prevent insects from nesting inside the enclosure and under the hood.

## 2.8 Logger program

The trigger switch of the camera is attached to an excitation port on the CR10x logger (Campbell Scientific 1997). To activate the camera, the logger program activates the excitation port (Instruction P4) for 10 milliseconds with 0 mV excitation. When an image is captured, a counter is incremented (Instruction P32). See appendix 2 for an example of logger code that will trigger the camera and increment a counter.

The monitoring station program was developed to respond to event triggers. Measurements are made and samples are collected at predetermined intervals during an event. An image is collected by adding a P4 and P32 instruction into the event processing code. The resulting log records a timestamp, any measurements taken and the photo number.

When there are no events, a daily image is collected at a predetermined time (currently 1230 hrs).

# 3 Results

The unit has successfully collected daily images since it was installed in April 2004. Event images have also been collected from three runoff events that occurred between Dec 2004 and Jan 2005. The unit has not required any maintenance or cleaning.

## 3.1 Daily Images

There was a 14 mm rainfall event that occurred on the 26 April 2004. Figures 3, 4 & 5 show the vegetation response to this rainfall event. The dominant grass species on this hill slope is *Bothriochloa pertusa*; a species known for its rapid response to the presence or absence of moisture. Figure 6 was taken at the end of the dry season, just before the first runoff was recorded on 10 December 2004 and highlights the reduction of ground cover.


Figure 3 Image taken during the 14 mm rainfall event. (Timestamp: mm/dd/yyyy)


Figure 4 Image taken 1 week after 14 mm rainfall event. (Timestamp: mm/dd/yyyy)


Figure 5 Image taken 2 weeks after 14 mm rainfall event. (Timestamp: mm/dd/yyyy)


Figure 6 Image taken at the end of the dry season. (Timestamp: dd/mm/yyyy)

## 3.2 Event Images

The flume and image system captured data and images from three runoff events that occurred on 10 December 2004 and 23-24 January 2005. Figures 7, 8 & 9 are images taken near the beginning, middle and end of the run off event that occurred on 24 January 2005. This event lasted for over 12 hours.


Figure 7 Beginning of runoff event 06:33 am. (Timestamp: dd/mm/yyyy)


Figure 8 Peak of runoff event 12:50 pm. (Timestamp: dd/mm/yyyy)


Figure 9 End of runoff event 06:33 pm. (Timestamp: dd/mm/yyyy)

# 4 Applications

Automated digital image collection presents an opportunity to correlate images directly with measured data. The images can then be used to enhance analytical, interpretational or communication abilities. Sequences of single images can be used to create animations that show entire events or changes over a period of time.

## 4.1 Analytical applications

A unit can be positioned to take a 'bird's eye' view of an area of interest. Image processing software can be used to determine changes in vegetation cover, leaf area index or any other spatial variable. This can be done as a time series and related to a specific treatment, management practice or environmental factors.

## 4.2 Interpretation benefits

Images can provide better process understanding than data alone. An image may be able to show when a sample inlet became fouled, a stream reaches bank-full or if an unexpected significant disturbance occurred over a study site. For example, there are a number of processes that are shown in images 7, 8 & 9 that could not be identified by the data alone.

- Figure 8 shows that the runoff from the right of the image is more clouded and coloured than the runoff from the main drainage line. The clouded water is runoff from a large scalded area.
- There is little mixing that occurs between these waters when the drainage line fills.
- The barer areas around the scald (right of image) produce runoff throughout the entire rainfall event.

## 4.3 Enhancing communication

It is easy to communicate results using pictures. For many people, an image that shows treatment responses or seasonal variations is easier to comprehend than a series of graphs or tables of data. Images can also be integrated into database systems where they may be downloaded with related datasets or displayed on web pages.

This also creates an opportunity to create animated images with a 'head up display' of data or graphs superimposed onto them. An example of this can be seen in figures 10, 11 & 12. These three images are taken from the runoff event that occurred on 23 January 2005. The hydrograph, cumulative total rainfall, rainfall intensity and total suspended sediment values are overlayed. The current position on the hydrograph is shown by the larger data point.

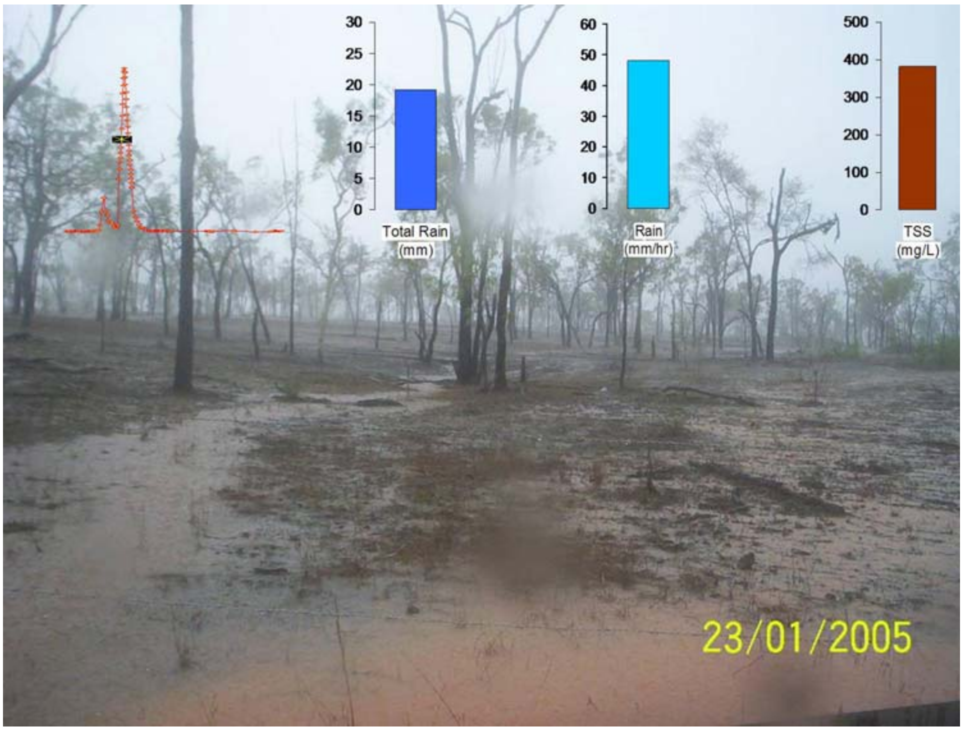


Figure 10 Sample point 11:40 am


Figure 11 Sample point 11:50 am

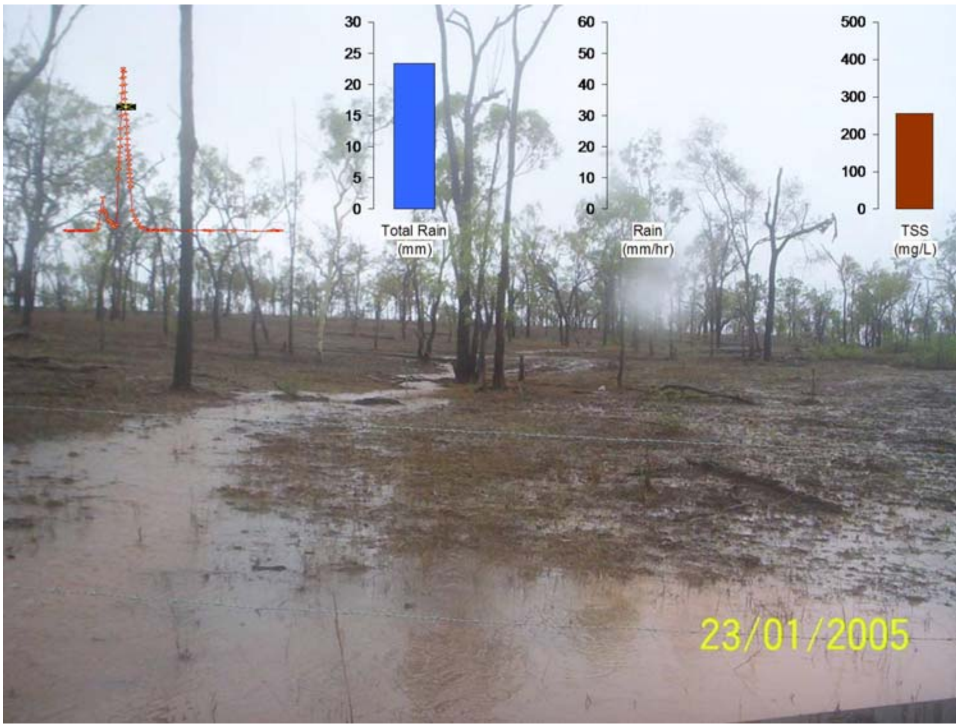


Figure 12 Sample point 11:55 am

# 5 Conclusions

The prototype system has performed to specification. There are several advantages that this system offers over other documented systems. These include low maintenance, low cost, simple integration into existing systems, readily available parts and the ability to correlate images directly with measured datasets.

As a prototype, this system has proven the effectiveness and robustness of using a consumer digital camera in a data logging systems. With further development this system could be improved by using a camera with a remote control and DC-in features, this would remove the requirement for camera modification. A digital video camera could be used instead of a still camera, although this will require a suitable power source.

# Appendix 1: Hood Template and Construction

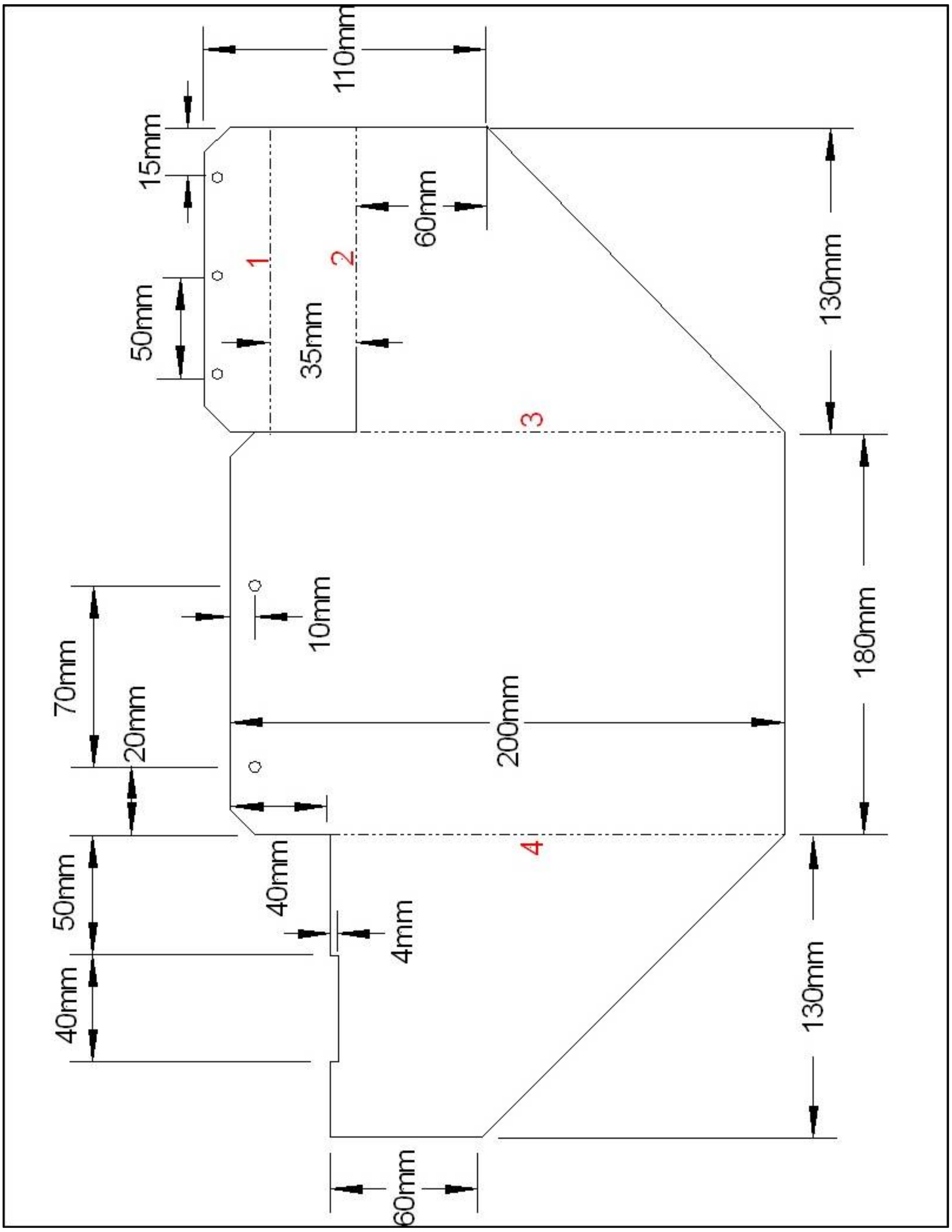


Figure 13 Template for hood construction

**Hood Folding Instructions:**

With the finished cut-out oriented as per figure 13

- Fold Up 90 degrees at line 1
- Fold Down 90 degrees at line 2
- Fold Down 90 degrees at both lines 3 and 4

# Appendix 2: Sample code for Campbell Scientific CR10x logger.

```
;***** Increment counter & trigger camera *****
64:  If Flag/Port (P91)
 1: 18       Do if Flag 8 is High
 2: 30       Then Do

    65:  Z=Z+1 (P32)
     1: 49       Z Loc [ PhotoNum    ]

    66:  Excite-Delay (SE) (P4)
     1: 1        Reps
     2: 00        Range Option
     3: 8        SE Channel
     4: 2        Excite all reps w/Exchan 2
     5: 10        Delay (units 0.01 sec)
     6: 0000     mV Excitation
     7: 50        Loc [ TakePhoto ]
     8: 1.0       Mult
     9: 0.0       Offset

67:  End (P95)
```

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