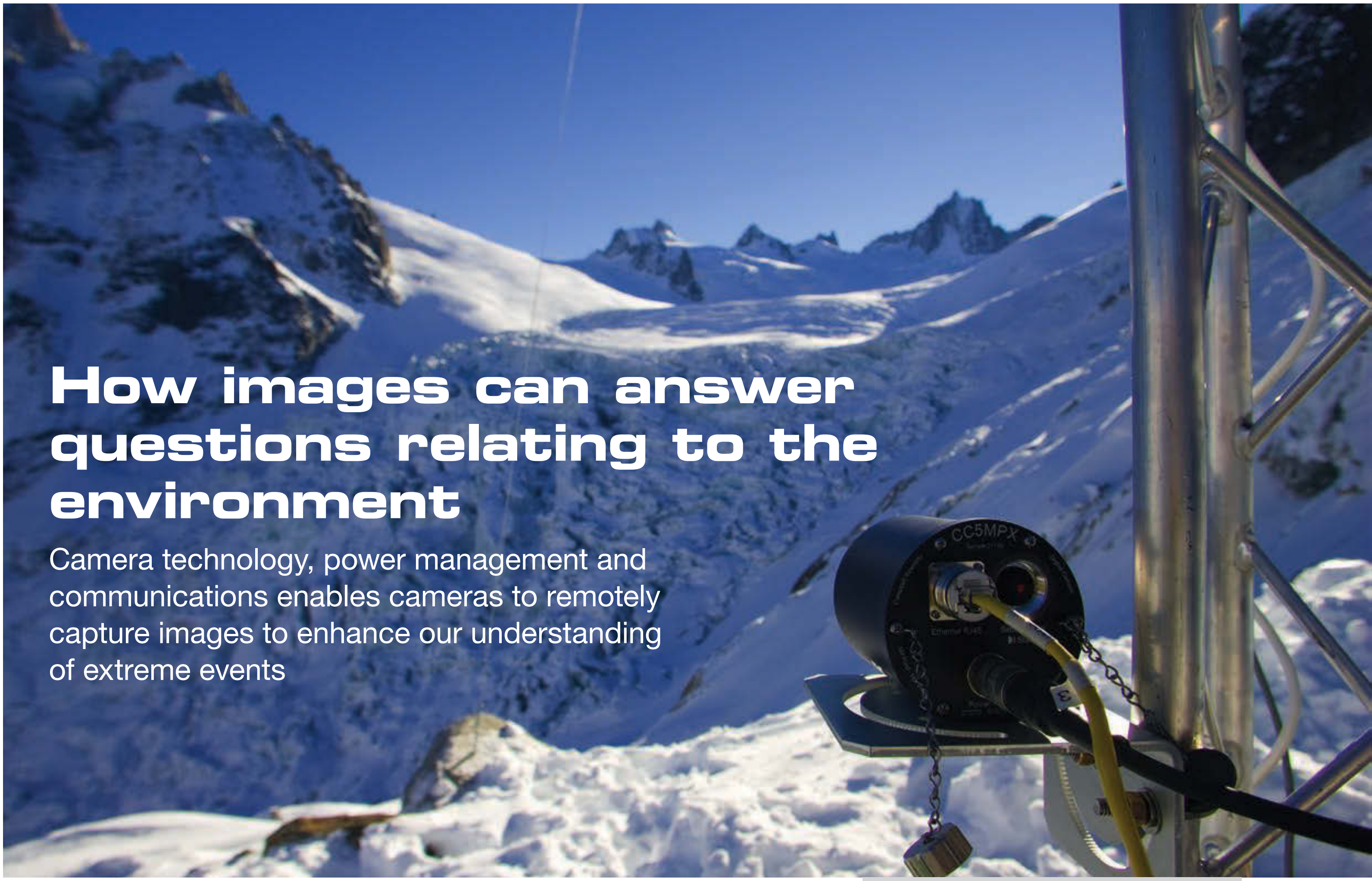
by Alexia Lane

EYE ON THE WORLD



How images can answer questions relating to the environment

Camera technology, power management and communications enables cameras to remotely capture images to enhance our understanding of extreme events

Glacier du Géant with descending séracs
Photo: Gaiasens Technologies Sarl

When the Indiana Department of Transportation (INDOT) received an increased number of bridge impact reports on the Virginia Avenue Bridge over the I-65 near Indianapolis, it contemplated a major bridge restructuring program to correct the under-clearance. The reduced distance between the pavement overlay and underside of the bridge was the inadvertent result of a previous project.

The problem was that the proposed rehabilitation would be costly, and some doubted that the number of reported impacts was enough to justify the cost and the traffic interference. INDOT suspected there were more events than were being reported, but what was needed was data. How many impacts? What type? How significant? Was this really a problem?

To address the need for data, INDOT teamed up with an engineering group at Purdue University, Indiana, to develop a web-based monitoring interface. The objective was to monitor impact events at the Virginia Avenue Bridge. In order to capture still images (site metadata) and video (impact event), they used a high-resolution Campbell Scientific CC5MPX digital network camera.

The system operated autonomously, providing real-time notification of impact events through email and text messaging, accompanied by high-definition video of impact events.

The results were impressive. From the images and video collected, INDOT's suspicions of under-reporting of impact events were confirmed. The images and video were numerous, influential and made public through various media. As a result, INDOT was able to convince stakeholders, including the public, that repair of the under-clearance was indeed necessary. For INDOT and the public, images held the answers to their questions.

Camera use

The employment of cameras as independent monitoring devices, capturing real-time data

Chamonix Valley, France

on changes to infrastructure and the environment represents a sound, cost-effective, user-friendly asset and risk management tool. Due to technological advances in cameras, the collection of real-time data in the form of high-resolution still images and/or video (with GPS capability) is now possible.

Cameras can be set up nearly anywhere and connected to a datalogger and solar power supply to capture data in the form of images. Image acquisition can be triggered through various mechanisms, including internal timers, motion detection, web page control, or an external device such as an accelerometer or strain gauge, via a datalogger. In the case of INDOT, an accelerometer is connected to a datalogger initiated image and video capture. Images can then be stored on a secure digital (SD) card, saved in datalogger memory, sent to a PC via email, or transmitted to an FTP server. In short, today's cameras can be fully web-enabled. With this array of activation, storage and low-power capabilities, cameras are suitable for a wide variety of data-gathering applications.

Stemming from increased demand for independently operating cameras in remote locations, cameras such as the CC5MPX, are built with advanced power saving or standalone modes to function in remote, battery-powered applications. Reduced power consumption by no way implies reduced quality of image or video capture. In the case of the CC5MPX, high-resolution still images (JPEGs) can be up to 5MP in high-definition 720P video. Environmentally sealed, robust enclosures protect the camera from moisture, high humidity and other conditions.

Event image capture

Event-triggered image capture can be used to provide decision makers with visual confirmation of an event. The Virginia Avenue Bridge monitoring project is an example of an event-triggered image-capturing application. In this case, the datalogger was programmed so that the CC5MPX camera would provide pre-trigger video buffering. As such, the camera was constantly filming and temporarily storing a desired length of video in a memory buffer. When no external trigger (i.e. impact event) was received by the datalogger, the buffer was dumped.

If an external trigger was received, the camera recorded the buffer followed by the predetermined length of video footage, which ensured that the entire impact event was recorded. South Split Greatest Hits, a video compilation of truck impacts on the Virginia Ave bridge near Indianapolis can be seen at http://www.youtube.com/watch?v=HoisCDmpSsU

Flood forecasting

Another example of an event-triggered application is flood forecasting, where a series of precipitation and water level sensors, such as radar level sensors and pressure transducers, and cameras mounted on bridges or in riparian areas, are programmed to capture images of the water body when the sensors indicate specified thresholds. Images of the water body inform the authorities in charge of flood forecasting that water levels are rising, enabling them to track these changes remotely, in real time.

Virginia Avenue bridge impact event

These images ultimately inform authorities when there is a need to evacuate communities downstream, ensuring public safety during a flood. Additionally, cameras installed along rivers known for ice jams at break-up can be programmed to capture images and video of the ice breaking up, which serves as a warning for potential jamming and subsequent flooding.

Marine environment

Images are also extremely useful for time-based studies; time lapsed videos provide interesting visualizations of changes over time, often in difficult places to study. One example is from Duke University, where a group of researchers developed Wormcam to record events at the sediment-water interface in marine environments. Real-time images of the numerous microscopic bioturbation events at the sediment-water interface are captured *in situ*.

> "Video compilations allow robust insight into processes at the sediment-water interface"

These video compilations allow robust insight into processes at the sediment-water interface, which provides an understanding into these intricate, microscopic events.

The videos are used in further research initiatives and education in schools from primary to university.

Glacial recording

Cameras can be installed above the snow pack to record changes over long periods of time at high altitudes and in harsh environmental conditions. Understandably, these cameras must be rugged. With an operating temperature range of -40°C to +60°C, the CC5MPX is one example. It also possesses a lens defroster to ensure clarity of image. There are several CC5MPX cameras monitoring glacier health in light of climate change around the world, including Gaiasens Technologies' Station du Refuge du Requin, which monitors snow and ice in Chamonix-Mont-Blanc, France.

Additionally, there are various research and government efforts to monitor forest health by observing changes to canopy cover in forests over time. Cameras can use various lenses to enhance their flexibility; to best capture images of the entire forest canopy, fisheye lenses are generally used to capture 180° hemispherical images and video.

Another time-based application includes gathering video of changing ice cover, which is directly linked to evaporation of a water body and weather prediction. At several sites in Lake Superior, Canada, cameras capture images and video of the ice cover and site metadata. This information is used to inform scientists about weather trending and the coast guard about the passability of shipping lanes.

Several applications use cameras to provide visual confirmation of current weather conditions, supplementary to numerical weather data. Due to advances in image acquisition devices, road and highway conditions are available in real-time to motorists and transportation authorities. The combination of surface sensors and sophisticated cameras provides information on the surface state as well as visual confirmation of numerical data. This information also helps advise decision makers on whether to deploy appropriate maintenance teams (plowing, sanding and salting) to improve the condition.

Remote airport technology

Unmanned airports in the northern hemisphere communicate daily images of runways to inform pilots and airport authorities of up-to-date landing conditions. These images are integral to ensuring the safety of pilots and their crews, ensuring they do not attempt to land in unsafe conditions. If data on current on-the-ground weather conditions demonstrates that it is unsafe to land, the plane does not embark on its journey unnecessarily. Hence, access to these images serves as a cost-saving measure. Flights into remote areas are known to be costly, with chartering fees ranging from C$1,500 to C$3,000 per hour. The cost of installing one camera and the necessary accessories is therefore far less than one chartered flight! In Lake Michigan, USA, real-time high-definition videos from a camera set up on a buoy three miles offshore are aired on a local news station to provide viewers with supplementary, visual information on current conditions. This is mostly used during the summer, when the onshore area experiences heavy recreational use, to provide accurate marine forecasts of windspeeds, wave height and water temperatures.

An oyster toad fish (Opsanus tau) peering into a Wormcam

A mud crab in its burrow

A penaeid shrimp preying on a worm

Avalanche monitoring

Avalanche monitoring authorities are also using cameras for a visual of snow conditions. The cameras are situated in known avalanche corridors, where they communicate real-time images to authorities responsible for ensuring the safety of populations in the area, whether residents or recreational users. The images captured provide visual confirmation of snow height and changes to the snowpack.

Cameras are used in various unique ways to help gather scientific data. In addition to studies such as Wormcam, cameras have been mounted to helicopter bases to conduct recent plant phenomics studies. As the helicopters fly over vast fields of crops, cameras capture images and data used by scientists to understand parameters, such as plant canopy temperature. This data is used in conjunction with other field data to inform researchers about various aspects of plant genetics, with the aim of improving crop yield.

Considering the versatility of cameras and the influence of the images and videos they produce, it is clear how powerful they are as asset- and risk-management tools, and for research. The images and video gathered can be used to inform decision makers about impending safety issues, including flooding, avalanches and road conditions. Data in the form of images is also being gathered and studied to enhance understanding of phenomena in places that were previously inaccessible to visualization. It is the unbounded opportunity to see something that has never been seen that will continue to drive our limitless collection of image data. ■

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