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Cold Regions Research & Engineering Laboratory

Ice Engineering

U.S. Army Engineer Research and Development Center, Hanover, New Hampshire

Monitoring Corps Projects with Web Cameras

Many Corps projects need monitoring and inspection at regular intervals, if not continuously, to track progress, to assess evolving conditions, or to anticipate undesirable events. Examples of possible uses include observation of riverbank erosion, construction sites, demonstration sites, and machine operation, as well as hydro-meteorological documentation of field sites, monitoring of endangered species, and—especially now—increased security.

Physical monitoring can drain personnel and equipment resources, especially if the site is remote, and important events may be missed because of unfortunate timing. Photographs documenting site conditions are often requested by more than one person or agency. In some instances, a remote camera image may be preferred over a personal site visit, e.g., when monitoring endangered species. The Internet provides a convenient way to access images from Web cameras.

How Web cameras work

The basic setup for a Web camera is a digital camera and telephone modem or cell phone, positioned to obtain images of the site being monitored (Fig. 1). Many commercial sources offer off-the-shelf cameras of many sizes and lens configurations, with transmission and retrieval options. Cameras can be color, black and white, low light, or infrared. With proper site connections and equipment, pan–tilt–zoom cameras can be programmed to automatically or manually acquire wide-angle overview images, pan in different directions, and zoom in for detailed images. Web camera images can be stored on a hard disk in an on-site computer for later retrieval, a convenient option for remote sites.

Figure 1. Web camera setup.

Images can be transmitted via modem over regular telephone lines, by cellular phone, by radio to one or more remote computers, or transmitted directly via the Internet. Wireless Internet technology allows cameras to be sited a few miles (line of sight) from the Internet and still maintain an Internet connection. Image transmission rate, which depends on available equipment, can range from once per day to as high as one image every fifteen minutes for a standard system, and up to 30 frames per second for direct transmission via the Internet.

Once the camera is set up, the rate of image transmission can be changed remotely from the home station. For some applications, internal relays within the camera can also be set to trigger image transmission when a particular event takes place. For example, a camera obtaining images at one-hour intervals can be set to obtain and send an image when a float switch is tripped by rising water levels, or in response to background sounds or other stimuli. Another possibility is to trigger the camera to turn on lights, wait 60 seconds for full illumination, take an image, send it, turn off the lights, and wait for the next scheduled or tripped image. When images are received, they can be displayed for viewing, archived, or placed on a Web site. Images can also be "stacked" or assembled into animations to simulate time-lapsed observations. For all of these applications, the necessary electrical power may be supplied through power lines, batteries, or solar panels.

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Security cameras

Web cameras provide a convenient, efficient means of monitoring remote sites. Using the Internet, systems including cameras, electronic image storage, and image retrieval capabilities can be monitored at great distances.

Security systems can allow multiple zones to be monitored and displayed through a Web browser. Each zone can have multiple cameras for backup. Each zone can be available for general monitoring at preset intervals, but personnel on site can have override capabilities to obtain images at any time.

At any predetermined time, the system can be set to allow motion sensors to monitor the site. If motion is detected, images can be sent to remote computers for storage and display on Web pages. Rates greater than or equal to one per second provide better coverage for this application than cameras on a time-lapse tape recorder with a typical speed of one frame every four seconds. These security systems can be created from existing analog systems or they may be developed with new digital equipment.

Examples of ERDC Web camera applications

Laboratory uses

Often people from many institutions are involved in a series of experiments. Economic constraints may limit their physical presence at test sites, but they can still participate interactively using Web cameras. The pan–tilt–zoom capabilities allow control of visual observations. For example, a joint project between CRREL, the Ohio DOT, and the University of Maine included long-term testing of new bridge decks made of composite materials (Fig. 2). A Web camera system transmitting visual images to a Web page allowed everyone involved to monitor the tests in real time and then store images for later review.

Figure 2. Composite material bridge deck tests.

In another project, a Web camera has been used to non-destructively monitor growth rates of roots in the CRREL greenhouse. The camera was placed in front of the root bag (a clear one-quart plastic bag) containing water and growth media. The light required for plant growth was sufficient to illuminate the bag for Web camera images. The camera transmits one image per day of each sample. The stored images depict root growth in time-lapse mode. The images can be digitized or otherwise measured to provide data for further analysis.

Field sites

During the period of ice growth on a river, it may be sufficient to obtain an image once every four hours to observe ice formation, growth, and decay. Ice cover breakup can occur as a result of thermal deterioration, a slow process, or because of mechanical ice cover breakup, which can result in the formation of ice jams that can cause sudden, major increases in water levels. Thus, at times when the ice cover is expected to break up, it may be necessary to take an image every 15 minutes or more often to obtain information on the progression and timing of the breakup. CRREL helped to design and construct an experimental ice control structure (ICS) on the Lamoille River in Hardwick, Vermont. The site is fully instrumented to monitor ice conditions and ICS performance. Web cameras are an important part of the monitoring system (Fig. 3).

Web cameras have also been used to monitor bank scour that occurs as a result of ice action or freeze–thaw. During low flow, one image per day may be sufficient, but it is desirable to increase the rate to one image every hour during periods of high flow. As part of a joint effort by CRREL and Montana DOT, a Web camera at a remote site on the upper Missouri River in Montana provided images of the progress and extent of scour. The volume of bank scour can be estimated from the images via the time stamp, which allows correlation of scour with other measured physical properties. The time interval between image transmissions can be monitored and remotely changed for each camera.

Figure 3. Images of the Hardwick Ice Control Structure showing different ice cover conditions.

Another CRREL project required the monitoring of ice conditions and ship traffic in Sault Ste. Marie, Michigan. For this project, existing cameras at the locks there were slightly realigned to provide the necessary views, and image storage and transmission equipment was connected to the cameras. This equipment is connected to the Internet at the project office and sends images to Web pages every 120 seconds (Fig. 4). Review of the stacked images allows evaluation of project operation under different conditions.

Web cameras are also useful for monitoring threatened and endangered species (TES) and their habitat. The Omaha District approached CRREL looking for a creative method to monitor the bird nesting area on a remote island downstream from Gavin Point Dam. A single solar-powered camera using a cell phone was used to remotely monitor the nesting sites of Interior Least Terns and Piping Plovers (two TES that nest in South Dakota) within a few feet of the shore. The use of Web cameras in this situation allowed the dam operators to remotely observe the wave action and water level at these nesting sites without disturbing the nesting grounds.

Summary

CRREL has installed digital cameras at over twenty monitoring sites throughout the United States and within our laboratory. The flow of images from these sites has greatly complemented periodic field measurements and traditional data acquisition. Because of its specific mission, CRREL uses Web cameras for monitoring research projects both in laboratory settings and at field sites, or in support of Corps Districts. Application of the Webcam concept is practically unlimited. It can range from observing road, river, or airport traffic, to construction project monitoring, to security purposes. Web camera images could also be used for "ground truthing" of satellite remote sensing observations.

Since the technology is rapidly evolving in this area, it is likely that improvements being made to all of the currently used equipment will increase and expand the area of application of Web cameras.

The Web sites from Sault Ste. Marie, Michigan, have elicited tremendous public interest, with more than 30,000 hits in just one week. Such public interest in the Web cameras could be a secondary benefit to the Corps.

Figure 4. Summer and winter images at the Sault Ste. Marie locks.

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