Digital Camera Monitoring Technologies, Systems, and Products

Extended Abstract # 43

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INTRODUCTION

Photographs have been used to document air quality in national parks since the 1970s. The Clean Air Act as amended in 1977 included visibility monitoring and spurred the implementation of photographic air quality networks in the 1980s and 1990s. These networks, operated by federal, state and local agencies, captured images three times per day (9:00 am, 12:00 pm, 3:00 pm) on 35mm color slide film. The captured images represent a wide range of air quality conditions, including pristine, hazy, smoky conditions as well as unique meteorology events. The images portray a wide range of visibility conditions, document changes in visibility over time, and often show impacts of natural and manmade pollution. The quantity of 35mm slides, availability of film, degradation of the slides over time, and the advent of the Internet ultimately limited slide utility.

Digital cameras were originally developed in the 1980s and became affordable in the late 1990s. The application of photographic monitoring of visibility conditions was evolving to include near real-time presentation of captured images on public Web sites. The Web offered a way to add public outreach and education to the list of uses for captured images. Digital images offered more frequent image capture (15-minute), compact storage, unlimited image lifespan, and Web presentation. Digital cameras are more complex and require more support hardware than film-based camera systems, which were relatively simple, only requiring a camera, battery, and timer. Digital camera systems typically need a computer, power supply, sheltering, Internet connectivity, and other support hardware. Though early digital cameras did not provide quality and resolution equivalent to film-based images, modern cameras offer high quality optics, high resolution sensors, and features equivalent to those on film-based cameras. Digital cameras range in quality from very inexpensive Webcams to very expensive, professional grade SLRs. Digital cameras suitable for visibility fall into the mid- to upper-range models offered by manufacturers. This abstract describes the components used in digital camera systems used for visibility monitoring, the factors affecting the choice of those components, and examples of operational systems and public outreach Web sites.
DIGITAL CAMERA SYSTEMS

Digital Camera System Overview

Digital camera systems used for visibility monitoring and public outreach are composed of four basic components: 1) a digital camera and support hardware in environmental housing, 2) a camera control computer and support hardware in environmental housing, 3) a power source, and 4) Internet communications.

The choice of camera system parts depends on a variety of factors, including:

- Expected environmental conditions
- Mounting location and infrastructure
- Physical security and accessibility
- Power availability and cost
- Internet communications availability and cost

The choice of site depends on these factors, as well as the quality of the scene to be captured in the images. Selection of the site and scene typically includes evaluating the following criteria:

- Is the scene recognizable by the intended audience?
- Does the scene include features expected to be affected by varying visibility conditions?
- Is the scene directly east, west, or south, where the sun would affect many of the images?
- Is the site accessible for servicing and does it have the required infrastructure?
- What are the costs for using the site and for the infrastructure?

The following sections describe camera system components and how they are applied in various monitoring scenarios.

Digital Camera Choices

Digital cameras suitable for air quality monitoring include still and time-lapse models. Still cameras must include a high resolution (2 megapixel or higher) sensor, high quality optics, and be controllable via computer-based software. Examples of still digital cameras meeting these requirements are manufactured by Olympus (SP500 and E-series SLRs) and Canon (G-series and SLRs). Time-lapse cameras have similar requirements, though resolution is typically lower for reasonable image storage and video sequence performance. Examples of time-lapse digital cameras are manufactured by IQinVision (IQeye 705) and StarDot (NetCam). Digital still cameras are marketed to consumers and have a typical market life of less than one year and are available for about 2-3 years. Digital camera system must constantly evolve to accommodate the changing availability of cameras. Time-lapse cameras typically have a longer market lifespan and do not require the same level of software support.
Computer Choices

Camera systems require employing still digital cameras require a PC-compatible computer to configure the camera, acquire, manage and store the images, collect air quality data from collocated instrumentation, and handle Internet transfer of the images and data for Web site presentation. The choice of computer depends primarily on site specific environmental and space consideration, however, the computer must meet the following minimum specifications:

- 256 MB RAM
- 20 GB hard drive
- Windows XP professional or embedded
- Two USB 1.1/2.0 ports
- Network and/or serial/modem connectivity

These specifications are met by desktop, laptop, notebook, and industrial computers from many manufacturers. To ensure reliable long-term operation, a compact industrial computer resistant to shock, few or no moving parts, and wide temperature range operation is preferred. Examples of industrial computer manufacturers include Xenarc and Advantec.

Housing and Enclosure Choices

The camera, computer, and supporting hardware require protection from environmental conditions and accidental and deliberate human alteration. The simplest system configuration has the camera mounted on a shelf looking out a window, with the computer positioned nearby. Although simple, this configuration is atypical and not applicable at most sites. Typical camera and computer housing and enclosure options are shown in Figures 1 and 2.
Power Choices

The camera, computer, enclosure heaters and fans, communications devices, and support hardware require power supplies ranging from 3.5 to 24 volts. The power supply configuration typically consists of a primary power supply and additional supplies for individual components (camera, computer, etc.). The primary power supply is typically one of the following:

- 120 volt AC to 24 volt DC, 320 watt high efficiency switching power supply
- 24 volt DC solar panel array, sealed batteries and low voltage cutoff charge regulator

Solar-powered systems require analysis of the solar exposure at the site and the dynamic power consumption of the camera system. The camera system must be configured to manage power efficiently, including using computer standby/sleep mode, disabling camera power between image capture events, and turning off unnecessary components when not in use.

Internet Communications Choices

The camera system is capable of capturing images and storing them on its local hard drive. This basic functionality is sufficient for documenting visibility, however, providing images for Web site presentation requires Internet connectivity. Since the camera system uses a PC-compatible computer, a wide variety of Internet communication options are available, including:

- Dial-up modem via telephone land line
- Wireless digital cellular modem (CDMA, GSM, etc)
- Direct connection to local area network
- Cable modem or DSL service
- Broadband satellite service
- WiFi to local hotspot
- Wireless bridge to distant internet connection

Major considerations when choosing an Internet connection are availability, capacity (bandwidth), and cost. High resolution images can be large and use significant bandwidth.

Other Features

Other features typically offered by digital camera systems include specialized image processing software running on the computer, and specialized hardware extending the applicability of the system to new sites. Software features such as automatic panoramic image stitching, automatic time-lapse movie creation, and image watermarking and time stamping can be included on the computer to provide a more finished image product for transfer to the Web site. Hardware such as automatic pan/tilt heads and secondary cameras provide additional images from a single site. Fiber optic extenders allow the camera and computer to be separated by thousands of feet for deployment in challenging locations.
Web Site Outreach

Digital camera systems capture images useful for a variety of purposes, including public outreach and education on air quality Web sites. These sites typically present images depicting current conditions as well as examples of good and bad air quality. They also often include air quality and meteorological data to enhance the understanding of the message being presented by the site. Figures 3 and 4 show air quality Web sites using images and data to present their messages.

SUMMARY

Digital camera systems capture high quality images for air quality monitoring and Web site presentation. Their flexible configuration allows for deployment to a wide range of sites with a wide range of available power and communications infrastructure. The fast pace of change in digital camera and computer hardware means the specific components in digital camera systems will change frequently even as the general design remains stable.