INTERNET-BASED DISPLAY OF REMOTELY-ACQUIRED AMBIENT RADIATION DATA

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Abstract—**The World-Wide Web is a powerful medium for disseminating radiation information in a readily and universally retrievable manner. Ambient monitoring of radiation measurements at a New York City location (Jacobi Hospital, Bronx, NY 10461), with automated publication of the data on the Web, has been ongoing since 1998. Several times daily, specialized communications software automatically retrieves the data by modem to a central base computer from where it is uploaded to an Internet-accessible Web page. The data are then accessible by standard Internet Web browser at the address www.aw-el.com/nyc/. This automated acquisition and display system has run with uninterrupted operation and minimal operator intervention for over 3 years. As the Internet becomes a ubiquitous conduit for information transmittal, the Web can serve as an effective means of display for radiation data, with relevance to many health physics applications discussed herein.**
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Key words: Internet; monitors, radiation; radiation, environmental; instruments

INTRODUCTION

The Internet has rapidly evolved into a powerful and ubiquitous tool for information exchange and has revolutionized data collection and dissemination in many fields of commerce and recreation. We have considered its potential use in radiation-monitoring applications, including the display of remotely-acquired ambient radiation levels.

In this paper, we describe the ease of implementation, low cost, and potential benefits of an Internet-based system of radiation monitoring. As a demonstration project, we began the ambient monitoring of radiation data at a New York City location (Jacobi Hospital, Bronx, NY 10461) over 3 years ago, with automated publication of the data on the World-Wide Web (WWW). Data have been available for viewing by a standard Internet Web browser at the address **www.aw-el.com/nyc/.** In this paper, methods of data acquisition, communication and Internet display are described.

MATERIALS AND METHODS

Gamma radiation was counted using a commercially-available Geiger Müller (GM) tube-based detector (RM-60, Aware Electronics Corp., Wilmington, DE), which interfaces with an IBM-compatible personal computer by serial port (Figs. 1 and 2). This detector contains a halogen-quenched self-regenerating stainless steel GM tube with mica window, calibrated with ^{137}Cs by the manufacturer to an accuracy of within 5%. For convenience, the RM-60 was interfaced to a miniature IBM-compatible palmtop computer (1000CX, Hewlett-Packard Co., Corvallis, OR), which utilizes standard IBM-PC architecture and runs MS-DOS (Version 5.00, Microsoft Corporation, Redmond, WA). A rechargeable battery, integral to the palmtop computer, ensures uninterrupted data acquisition, even in the face of power disruptions. Standard software provided with the detector (AW-SRAD, Aware Electronics Corp., Wilmington, DE) was used to control acquisition, display and data storage, and operates in interrupt mode, with no data loss during disk-writes or serial communication. As configured, counts detected by the RM-60 were integrated over 1-min intervals and written to the two-megabyte hard-disk drive. A calibration factor of 1.05×10^8 cpm/(Gy h^{-1}) was used to convert count-rate to radiation exposure, based on the nominal sensitivity of the GM tube.

In previous work, Zuckier et al. (1998) have characterized the detector and computer assembly by a series of measurements to determine count-rate linearity, accuracy, and reliability of data transfer. The detector and computer system were shown to linearly accommodate count rates of up to 32,715 counts per minute, corresponding to an exposure rate of approximately 0.312 mGy h^{-1}.

The purpose of the present study was to demonstrate a method for automatic acquisition and posting of ambient radioactivity levels on the WWW. For this demonstration, we located the monitor in a convenient and easily reachable location with full knowledge that the data acquired were influenced by movement of patients and activity within the hospital. For the initial 6 mo of the

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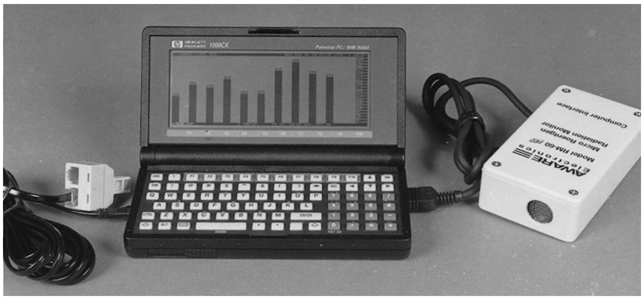

Fig. 1. Photograph of the RM-60 and palmtop computer containing a PCMCIA modem and rechargeable batteries.

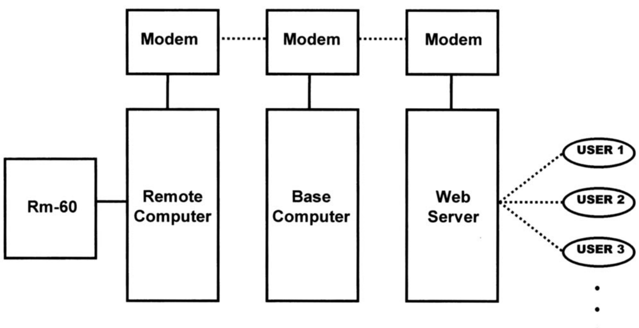

Fig. 2. Schematic representation of the acquisition, processing and display system. Dashed lines represent intermittent communications.

project, the RM-60 detector was sealed within a waterproof plastic bag and attached to the exterior wall of the hospital, approximately at ground level. Thereafter, for reasons of security and access, the detector was removed from the bag and relocated within the building, adjacent to the window. While it was realized that locating the detector adjacent to the Department of Nuclear Medicine was not suitable for measuring environmental radioactivity, this location was deemed sufficient to demonstrate the feasibility of the method under convenient conditions.

For purposes of remote-polling, the palmtop computer was connected to a dedicated telephone-line using a type II PCMCIA modem rated at a communication speed of 9600 baud (Fig. 2). A standard PC-compatible computer with modem, located in Delaware, served as the base station and was programmed to automatically phone the "remote" and retrieve the data at preset intervals during the day, typically every 4 h. Data transfer was accomplished using proprietary communications software (AW-FETCH, Aware Electronics, Corp., Wilmington, DE), which incorporated Cyclic Redundancy Check (CRC) error correction and password protection features to ensure reliability and security. Upon contact, the base computer compared its data file with that of the remote and uploaded all new data since last transmission. The base computer then invoked an automated program that generated predefined text and GIF graphic files (AW-GRAPH, Aware Electronics, Corp., Wilmington, DE), which were then sent by modem using a customized packet driver and File Transfer Protocol (FTP) program to the commercial Web-server. The packet driver was removed from memory, and the base PC restarted the entire loop at a predefined interval. Initially, as the small palmtop hard-disk drive began to fill, the data file was manually purged by command from the central computer. Subsequently, purging of the remote hard-disk drive and spawning of a new data file were incorporated into the data collection loop, so that no operator intervention was needed.

RESULTS

The described Internet-based radiation monitoring project first went on-line on 22 December 1998. Over the course of 3 y, minimal operator intervention has been required other than the manual purging of the remote hard-disk drive at 2-mo intervals, a task that now has been automated.

On the Web site, data are displayed depicting the most-recent 24 h, 7 d, and entire acquisition period since the last hard-disk drive purge (Fig. 3). By use of color coding of the curves, data can be portrayed with various time-bases, including counting rates averaged for longer times, which serves to decrease stochastic noise (Fig. 4). Previous data files are available for inspection or download, linked to a button appropriately titled "Archived Data" (Fig. 3). Additional links include methodologic and technical information, a tabulated version of the data ("Data Listing"), and educational sources.

DISCUSSION

The evolution of the Internet as a standard for data exchange offers new potential as a method for disseminating radiation data in a widely-accessible and distance-independent manner. Because availability of personal computers with Web-browsers and Internet access is widespread, data can be easily viewed from work or home, over a wide variety of hardware and software platforms.

One of the advantages of using a PC-based acquisition platform is flexibility, both in terms of hardware and software. For example, the hard-wired modem, described in this paper, can be replaced by a wireless modem for communication with the remote computer, thereby affording greater flexibility in location. The modular nature of the radiation detector also allows substitution by a variety of different detectors, including scintillation or GM-based probes of greater or lesser sensitivity. In the current study, the RM-60 GM tube was considered best-suited for measurement of the ambient radiation levels because of its ruggedness, dynamic range and economy.

Software programming, including batch commands, is also readily modified on a PC-based system. The frequency of communication between the remote and

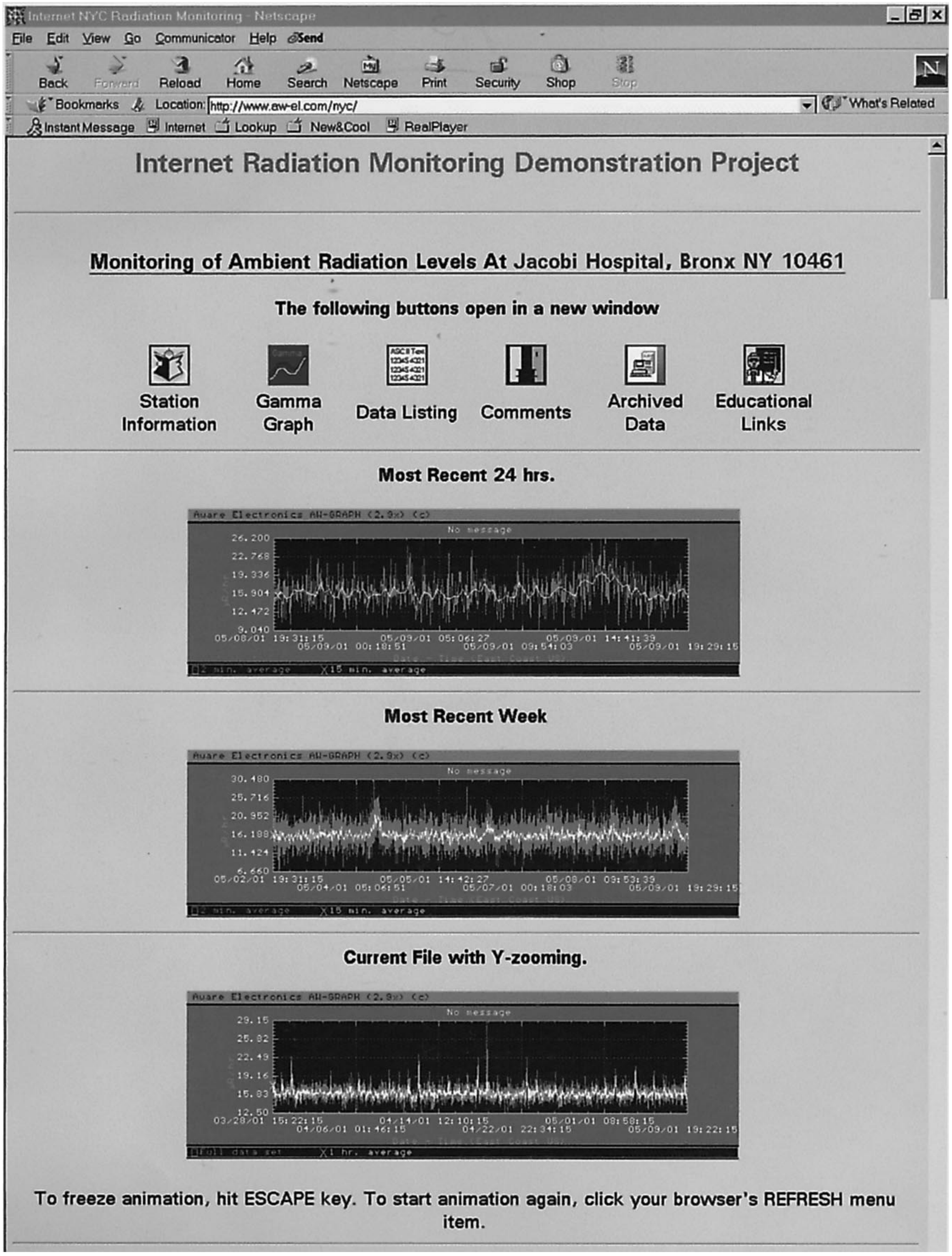

Fig. 3. Composite image representing the current page from the Web site **www.aw-el.com/nyc/.** The horizontal row of buttons near the top of the page provide links to station information, graphed and tabulated data, comments, archived data, and educational material. The third graph (current file) dynamically changes its Y-axis ("Y-zooming") through 3 scales, accentuating both the overall trend, as well as the higher-frequency fluctuations. Links to email addresses of relevant contacts are located further down the page, below the currently visible margin.

base computer can be varied from minutes to days. Rather than having the base computer call to interrogate the remote, the software can also be configured to have the remote computer automatically send the data to the base at regular intervals, or when a specific count-rate has been exceeded. Use of such a "trigger" would be useful in radiation safety applications where a concurrent long-range page could be placed to alert the radiation-safety officer to check the updated Web page. An automated radiation-data posting system would represent a further development of Web-based data collection, as previously advocated by Woo (1999).

Another potential use of an Internet-based Geiger counter system would be in hospitals to monitor retained radioactivity prior to discharge of patients administered therapeutic radiopharmaceuticals as an extension of the telephone based system previously described by Zuckier et al. (1998). In that method, a modem was used to

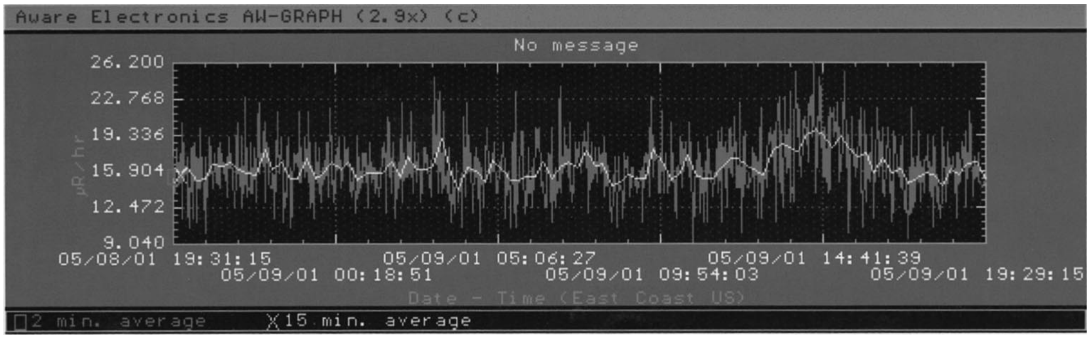

Fig. 4. Detailed view of a single-day GIF automatically generated by AW-GRAPH. Both 2- and 15-min averaged data appear, the latter less prone to stochastic noise. Based on the 15-min averaged data, the minimum detectable radiation dose at 3σ significance is estimated to be 3×10^{-8} Gy h^{-1} (Sorenson and Phelps 1980).

directly download information from the remote RM-60 and palmtop unit onto the physician's home or office computer. By contrast, posting of the data on the Internet would allow multiple individuals to view the information at any time, and from any site, thereby increasing convenience and flexibility. Methods of data encryption would have to be incorporated for file transfer, and a password-protection feature could be established to ensure patient confidentiality. A further usage in a hospital or research center would be to track potential contamination incidents by continuous monitoring of critical locations within the area of responsibility. A fixed record of minute-to-minute monitoring would be useful in reconstructing any such incidents.

An additional use for an Internet-based display would be for environmental monitoring of radioactivity. Not only can a single geographic monitoring site be displayed on the WWW, but data from vastly separated sites can be collated and displayed in such a manner. It is very conceivable that an international network of Geiger-counters could be established to map background radioactivity on a near real-time basis. If these remote computers were Internet enabled, the radiation data files could be periodically sent to the base computer by way of the Internet rather than by direct modem connection, without the expense of long-distance toll charges. Such a network would prove invaluable in the case of a major reactor accident, such as Chernobyl, allowing the shared data to be viewed worldwide. Internet connectivity has become very common and inexpensive, especially in the context of large academic or governmental organizations, and the cost of such a system would not be excessive.

In summary, we describe a method of remote monitoring of ambient radioactivity which has been implemented since December of 1998, with automated posting of data to an Internet-browser accessible WWW site. The Internet has great potential to become an effective and convenient means to disseminate large amounts of radiation data, with relevance to many health physics applications.

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