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Communications

The Display of Photographic-Quality Images on the Web: A Comparison of Two Technologies

Chiang S. Jao, Daniel B. Hier, and Steven U. Brint

***Abstract*— Downloading medical images on the Web creates certain compromises. The tradeoff is between higher resolution and faster download times. As resolution increases, download times increase. High-resolution (photographic quality) electronic images can potentially play a key role in medical education and patient care. On the Internet, images are typically formatted as Graphics Interchange Format (GIF) or the Joint Photographic Experts Group (JPEG) files. However, these formats are associated with considerable data loss in both color depth and image resolution. Furthermore, these images are available in a single resolution and have no capability of allowing the user to adjust resolution as needed. Images in the photo compact disc (PCD) format have higher resolutions than GIF or JPEG, but suffer the disadvantage of large file sizes leading to long download times on the Web. Furthermore, native web browsers are not currently able to read PCD files. The FlashPix format (FPX) offers distinct advantages over the PCD, GIF, and JPEG formats for display of high-resolution images on the Web. A Java applet can be easily downloaded for viewing FPX images. FPX images are higher resolution than JPEG and GIF images. FPX images offer rich resolutions comparable to PCD images with shorter download times.**

***Index Terms*—FlashPix, Internet, Java applet, PhotoCD.**

I. Introduction

High-quality image archives will play an important role in both medicine care and medical education. Since 1992, Photo Compact Disc (PhotoCD, Eastman Kodak Company, Rochester, NY) has been the preferred method of storing and accessing 35-mm photography archives because of significant advantages [1]:

- Low-cost scans: scanning a 24-exposure roll of 35-mm film into a Kodak Digital Science PhotoCD Master disc costs under $25;
- Multiple resolution and high-quality capabilities: resolutions varies from 96×64, 192×128, 256×384, 768×512, 1536×1024, 3072×2048, up to 6144×4096 pixels;
- Consistent color display: implementing Kodak's proprietary scanning and color-management algorithms;
- High storage capacity: approximately 100 multiple-resolution images can be stored per compact disc.

PhotoCD can be used to archive and share high-quality medical images for either diagnostic or educational purposes [2], [3]. Images can be accessed by most graphical editing software, for example, Ulead's PhotoImpact (Ulead System Inc., Torrance, CA) as illustrated in Fig. 1. Loading images in the PhotoCD (PCD) format involves considerable processor as well as memory use.

The Internet has emerged as a superior medium to share medical images between healthcare providers worldwide. The PCD format is not standard on the Internet. Most images on the Internet are in either CompuServe's Graphics Interchange Format (GIF) or the Joint Photographic Experts Group (JPEG) format. GIF is not ideal to store high-resolution medical images because its maximum color depth is limited to 256 solid colors or gray scales. JPEG is used as a general-purpose digital image compression standard for continuous-tone still images [4]. The JPEG format retains all the color information in a red-green-blue (RGB) color model image. The JPEG uses a compression algorithm to reduce file size efficiently after it identifies and discards extra data unnecessary to the display of the image. The compressed JPEG file presents an edge effect with perceptible data loss [5].

TABLE I
FILE SIZE COMPARISON OF VARIOUS IMAGE FORMATS. (ALL SIZES ARE IN KILOBYTES)

File Format (Dimension, Resolution-in-pixels)	JPG	GIF	PCD	FPX (768x512)	FPX (192x128)
Series 1	77	260	4216	88	55
Series 2	55	211	4168	81	48
Series 3	60	219	3720	89	49
Series 4	58	224	4262	84	49

There are three solutions available to display photo-quality image archives on the Internet. The first is to use a PCD-aware Internet browser, such as the latest Mosaic for Windows downloaded from the National Center for Supercomputing Applications Web site.[1] The second is to use PCD on the Web that includes a Java PCD applet[2] on the Web page to be interpreted by Java-enabled Internet browsers (such as Netscape Navigator 3.0 and later versions and Microsoft Internet Explorer 3.0 and later versions). The third method utilizes FlashPix technology, an innovative product from Live Picture (Campbell, CA) in collaboration with Hewlett-Packard (Palo Alto, CA), Eastman Kodak, and Microsoft (Redmond, WA). FlashPix offers a better solution for work with large photographic quality images [6]. In this study, we compared the FlashPix technology to a built-in Java PCD applet for posting the high-resolution photographic-quality images on the World Wide Web (WWW). Both implementations display photographic images with similar on-line toolbars to adjust display features interactively. We conclude by discussing issues related to the use of FlashPix technology and predict its role in the medical image display.

II. Method

The FlashPix technology breaks the screen resolution limit to improve the resolution of images on the Internet. The images in the FlashPix (FPX) format are stored as an array of 64-pixel square tiles. When a FlashPix-capable software program opens the FPX format, only selected tiles are loaded into system memory. This feature speeds up the loading of photographic images because of less memory requirement. A hierarchical infrastructure of resolutions is then stored in single images. The FlashPix technology enables applications to automatically pick the best resolution for a particular activity.

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[1] NCSA Windows Mosaic Home Page. Available WWW: http://www.ncsa.uiuc.edu/SDG/Software/WinMosaic/HomePage.html

[2] Kodak Photo CD on the Web, Eastman Kodak Company's Home Page. Available WWW: http://www.kodak.com

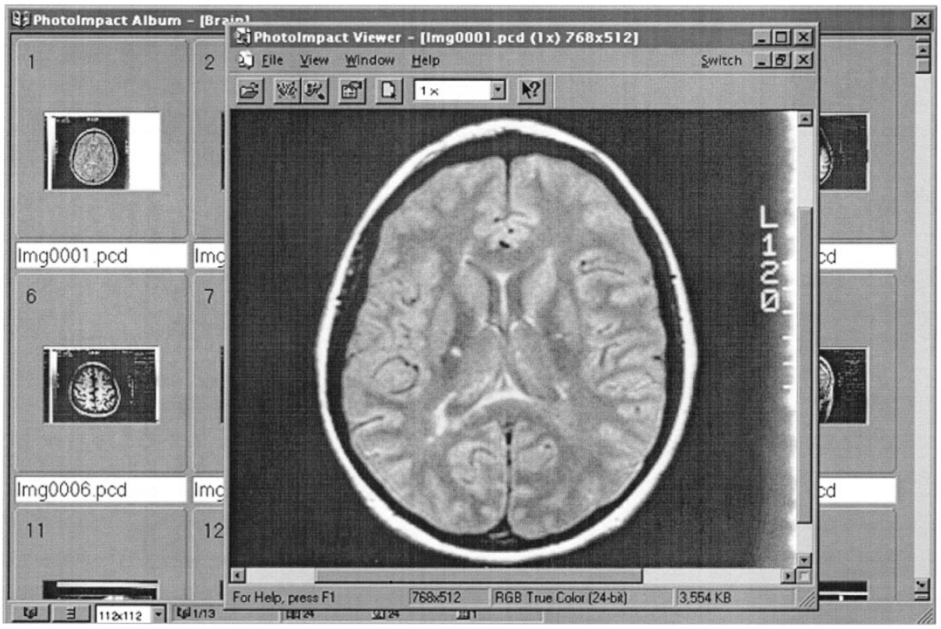

Fig. 1. The traditional image viewer on a set of high-quality medical image archives in a PCD.

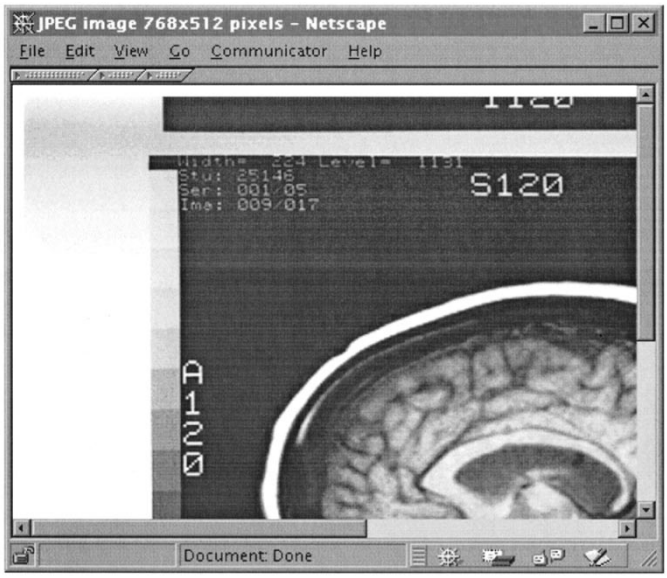

Fig. 2. An anatomical picture shows the inferior surface of the brain in the JPEG format on the Internet browser.

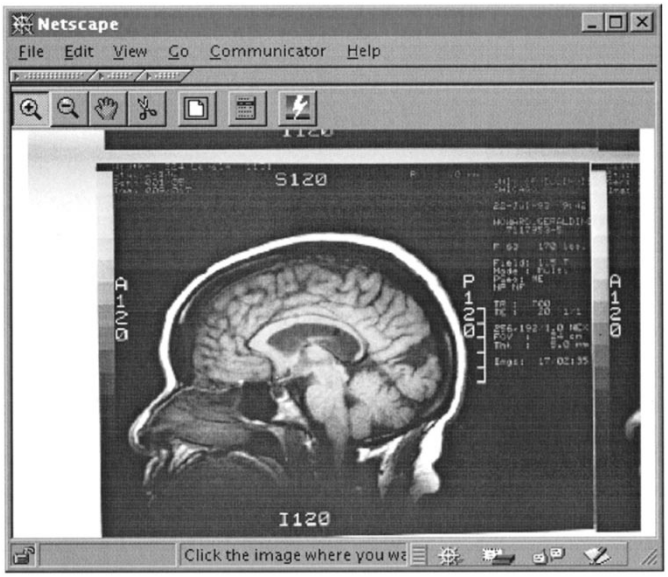

Fig. 3. A FlashPix plug-in enables the Netscape Navigator to view the inferior surface in the FlashPix-formatted image with consistent color quality. The built-in toolbar allows the user to interact with the image.

A free-downloadable Photoshop (Adobe System Inc., Mountain View, CA) plug-in is available on Live Picture Company's Web page.[3] It allows users to convert large photographic images into the FPX format. In our implementation, we saved all photographic images as 512 × 768-pixel high-resolution files on a Dell Inspiron 300 266 MHz computer. Another FlashPix plug-in for Internet browsers is available for both Windows 95/NT and Macintosh platforms. It displays high-resolution FlashPix images quickly over local area networks. The technology transfers data necessary for viewing the image in the current window. The plug-in creates a toolbar on the Internet browser when viewing any FlashPix-formatted image. This toolbar allows the user to manipulate displayed images. Manipulation includes the ability to zoom a two-dimensional (2-D) image at various resolution settings, to pan around the high-resolution image in a borderless viewer window within the Web page, to crop a selected portion of the image to be printed or saved to as individual image files.

PCD on the Web allows the users to interact with displayed images. Web authors can easily create pages to allow their audiences to zoom, pan, enlarge, crop, and rotate these on-line images. The captured images will show the image quality obtained with 35-mm pictures, providing more accurate color depth than previous formats. In order to interpret the PCD format on the Web, Kodak provides a set of Common Gateway Interface (CGI) programs that must be compiled and configured on the Web server. On the server side, it permits interactivity between a client and a host operating system through the Web via the HyperText Transfer Protocol (HTTP). A Java applet

[3]Live Picture Corporation's Home Page. Available WWW: http://www.livepicture.com

TABLE II
COMPARISON OF INTERNET IMPLEMENTATION FOR FOUR IMAGE FILE FORMATS

Image Format	PCD	FPX	GIF/JPEG
Functional Feature	With PCD applet	With FPX plug-in	No Applet/plug-in needed
Resolution Infrastructure	Hierarchical	Hierarchical	Fixed
Relative File Size	Largest	Medium/Small	Small
	(~4 MB)	(Compression-Dependent, ~100KB)	(Compression-Dependent, ~100KB)
Color Capacity	Rich	Medium	Low
Internet Capability	Built-in Java Applet	Software Plug-in	Graphical Standard
Internet Performance	Slow	Fast	Medium
Internet Zooming Control	Yes	Yes	No
Programming Effort	Significant	Minor	None
	(Server/Client Software)	(Plug-In Installation)	(Common Accessible Format)

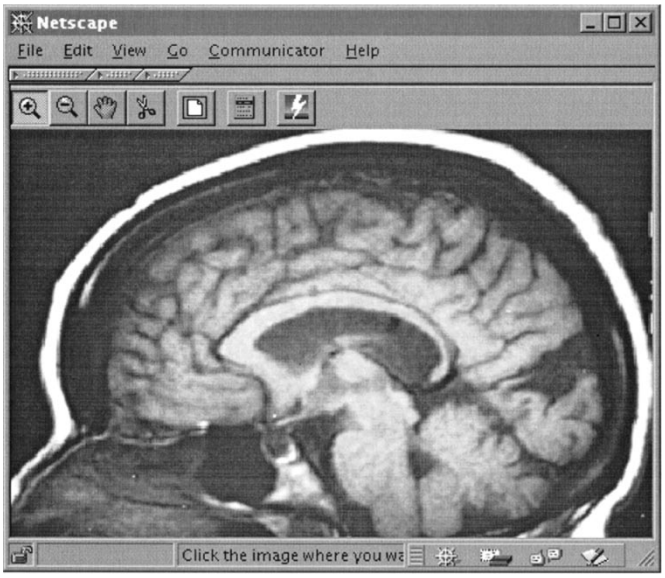

Fig. 4. A close look of selected area in Fig. 3. The zoom-in icon in the toolbar increases the photographic image resolution.

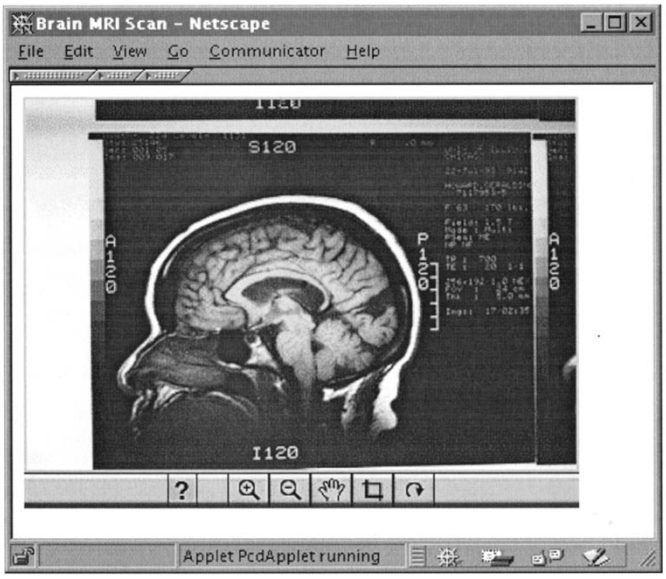

Fig. 5. A built-in Java PCD applet enables the Internet browser to view the same image in a PCD format. A similar toolbar on the bottom of the image performs similar functions as those in Fig. 3.

is then added to the Web page as a Hypertext Markup Language (HTML) tag on the client side. The tag defines the PCD viewer protocol and its location. It also specifies the dimension of the window that the applet execution will use. A full path of image source in the PCD format is required for the display. These applet tags add a similar toolbar in the Web page as that created by the FlashPix technology.

III. RESULTS

A FlashPix image retains as highest resolution at which the original photographic image was created. A FlashPix-based application decreases original file size by reducing the number of pixels and creates lower resolutions as necessary. A 4.2-MB photographic image in PCD format can be converted to an uncompressed FlashPix file that is about one tenth its original size. A FlashPix image can be downloaded quickly over a direct Internet connection, whereas the download of a comparably sized JPEG or GIF file takes longer. Table I illustrates a quantitative analysis of file downsizing by FlashPix technology compared to other file formats are with same 768×512-pixel resolution image. Lower file resolution reduces the file size significantly.

While the common view of an oversized brain image in the JPEG format is controlled by the scrollbar to adjust its displayed area in the viewing window (refer to Fig. 2), a corresponding FlashPix format is easily controlled by clicking any embedded icon in the toolbar (refer to Fig. 3). The zooming icon on the toolbar enables the user to change the image to the desired resolution setting (refer to Fig. 4). This feature saves data transmission time on the Internet while displaying only the selected area. The reader can click the hand icon and use the mouse cursor to move the image in a panoptic effect instead of scrolling the displayed window. The scissors icon allows the reader to crop, save, or print a specified region.

The Java PCD applet creates a similar control toolbar on the Internet browser (refer to Fig. 5). One additional feature is the ability to rotate the displayed image 90° clockwise. However, the loading of a Java PCD applet is slow. Furthermore, the slow data transmission of a large PCD file makes for long image loading times. In addition,

more programming effort is required for PCD implementation than for FlashPix implementation. Table II provides a comparison of these two approaches.

IV. Conclusion

Using FlashPix technology, a photographic image can be converted to a format well suited for display and retrieval on the Web. Smaller low-resolution images in GIF or JPEG format can be created as an on-line preview album that is linked to FPX images. This method reduces the long loading times associated with viewing high-resolution images on the Web. It allows the delivery of high-resolution photographic images to Internet browsers with a FlashPix plug-in at about the same speed as lower resolution GIF or JPEG images. The users can zoom in the images on a region of interest for greater details, a feature that is lacking in the GIF and JPG formats.

The Java PCD applet allows the downloading of PCD formatted images without any file conversion. However, the complicated installation of CGI software on the Web server makes it difficult for novices to create Web-based applications. Because of its consistent functions over platforms, the Java applet is the dominant trend for the next generation of applications on the Internet. To enhance processing speed, Java requires code optimization, powerful computers, and faster data transmission protocols. In the meantime, a PCD file size needs to be reduced in order to speed up the download time.

The FlashPix technology provides a highly efficient means to transfer high-resolution medical images across networks. After installing a software plug-in tool into Internet browsers, it improves data transmission rate for high-resolution images. It allows Web authors greater flexibility in the types of large high-quality images to be included in on-line catalogs and albums. The FlashPix technology enhances medical education by making available high-resolution images that were previously available only in JPEG and GIF formats.

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