Implementing Digital Image Photography in the Building Industry

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Digital photography provides a versatile technique to capture, view and manage images of site conditions and project progress. The graphical nature of communication in the building industry provides many opportunities for architecture and construction firms to benefit from this technology. This report presents a study performed to investigate the feasibility of replacing existing photographic services on design and construction projects with digital photography, and identifies strategies to encourage the implementation of this technology. Surveys and interviews were performed to assess the uses for and expenditures on photographic services by architecture and construction firms. Trial applications were also carried out to assess the actual costs, necessary time investment for training, and advantages of digital image technology in the building industry. Conclusions address the most feasible project types and techniques to successfully implement digital imaging tools.

Key Words: Digital Image, Photography, Internet

Introduction

This report summarizes the results of a pilot study performed at the University of Washington, in the Department of Construction Management. Advances in technology have varied effects on particular industries. The building industry, while traditionally slow to embrace new technologies, has evolved and become more receptive to innovation. Recent research (Abudayyeh 1995, Liu 1995, Liu 1996, and Songer 1995) has begun to explore the many applications of digital image technology in the building industry. This study was performed to investigate how architecture and construction firms can most effectively begin to take advantage of the emerging technology of digital photography. While numerous organizations have begun to experiment with digital cameras and computer images, many questions remain about how this technology can improve design and construction processes.

Digital Image Photography Defined

A whole new way of taking pictures, digital photography captures images electronically making them instantly available for computer processing and output. Consequently, the image is far more versatile than a traditional photograph, which requires extensive processing. Once downloaded to a computer, the image, like any other electronic document, may be printed, enhanced, filed in a database, or transmitted to remote locations. Computers play an integral role in digital photography, adding to the considerations relevant to this technology. These

considerations fall into four general categories: capturing, storing, managing, and sharing images.

Capturing Images

Images are gathered and stored inside a new breed of camera. Ranging in price from $300-$20,000, digital cameras vary greatly in capability and function. Significant variables are the resolution (number of pixels e.g. 640x1040), depth (number of colors), and storage capability (how many images can be stored in the camera's memory). While the quality of an image is highly dependent on the quality of the camera, low-end digital cameras ($500 - $1000) do provide sufficient detail and resolution for most general applications. An image that is captured by a digital camera is stored electronically in the camera's memory until downloaded to a computer.

Storing Images

Once loaded onto a computer, images can be saved onto hard drives, removable disks, or compact disks. Often larger than one megabyte in size, images will quickly absorb available memory, thus expandable forms of memory are essential tools for handling digital images. Managing stored images can also be a cumbersome task, and therefore is also an issue that must be addressed.

Management of Images

Once images are collected they must be stored in a manner that they may be accessed. For most commercial purposes, an image database is required, which can store images and detailed information about each image, including the date the image was captured, the subject matter, the project name, etc. Currently there are only a handful of packages that are capable of advanced database functions e.g. Quicksolve, and Lynx, however many are under development.

Sharing Images

One final issue that must be addressed is how images are transmitted or shared between different parties. Hard copies of images can be printed on a wide range of devices including laser and ink jet printers, with very good results. More advanced printers are also available which are capable of reproducing a high-resolution image at the same, or even greater, quality as a traditional photograph. Electronic options for sharing images include faxing images through a computer, attaching images to email messages, and accessing databases of images over a network, internet, or intranet.

Digital cameras have evolved to an important stage - they are actually easy to use. If accepted and integrated with design and construction processes, this technology has the potential to change the way architecture and construction firms communicate. Currently there are a significant number of firms in the building industry who are considering the use of digital cameras to replace or augment current photographic services. Few however, have begun to take fully take advantage of this technology. The goals of this research are to (1) demonstrate the

feasibility of architecture and construction firms successfully using this technology, and (2) begin to assess the potential impacts of digital image technology on the design and construction process.

Methodology

Surveys, interviews, and trial applications were used to investigate the feasibility of architecture and construction firms using digital photography and related technology. The strategy of this research was to show that existing expenditures on photographic services by architecture and construction firms are comparable to the costs of a digital image system, and thus encourage the use and experimentation with this technology in the industry.

Surveys were distributed to Seattle area design and construction firms that explored the existing use of photography on various types of projects and contracts. Surveys also requested existing expenditures made for photographic services in order to assess the feasibility of investing in digital image technology. Several open ended questions explored the current understanding of and interests in digital image technology.

Several survey respondents were contacted and interviewed in person to examine how digital image technology may be integrated into their work processes and services. Trial applications of digital photography were also performed to gain first-hand experience using digital imaging tools. Finally, three case studies were initiated in which digital technology has been used on building projects. Currently in progress, these case studies will focus on determining the potential benefits and improvements in project communication that result from using digital image technology.

Industry Survey

A survey of twenty-five architecture and twenty-five construction contractors assessed current areas of photographic use, and expenditures on photographic services on a per-project basis. Respondents were also asked to suggest what types of projects and contract types result in increased needs for photographic documentation. Lastly, the survey assessed current experiences with and further interests in incorporating digital photography into the design and construction process.

Survey Data and Analysis

Fifteen architecture and fifteen construction firms responded to the survey. Per project and annual project expenditures were categorized into six different areas of current photographic use: *Site Analysis, Monitoring Project Progress, Record Keeping, As-Built Record keeping, Marketing,* and *Other*. The respondents rated each category in terms of the frequency of use of traditional photography using a scale of 0-3, three being the most frequent. Estimates of expenditures on photography in each category were also provided. Current experiences with and future interests in digital photography were compiled in a short answer format. The data

collected was averaged and summarized for three areas of focus: Areas of Use, Current Expenditures on Photography, and Interest and Experience in Digital Image Photography.

Areas of use

The weighted responses (Sum of ranking where 1 = 3 pts, 2 = 2 pts, 3 = 1pt., 0 = 0 pts / total # of responses) for each category of use are illustrated in Figure 1. The architecture and construction firms responding indicated that there are extensive needs for photography in their organizations. While both types of firms use a large volume of *marketing* photos, architecture firms have greatest use for photographic documentation during initial *Site Analysis*. Construction firms rely more heavily on photographic documentation of *Project Progress*.
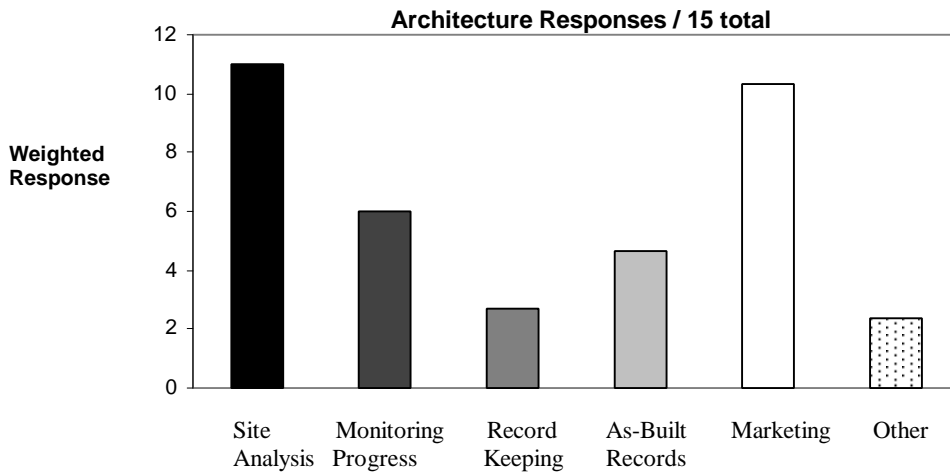
Architecture Responses / 15 total

Figure 1a. Primary use of photography by architecture firms
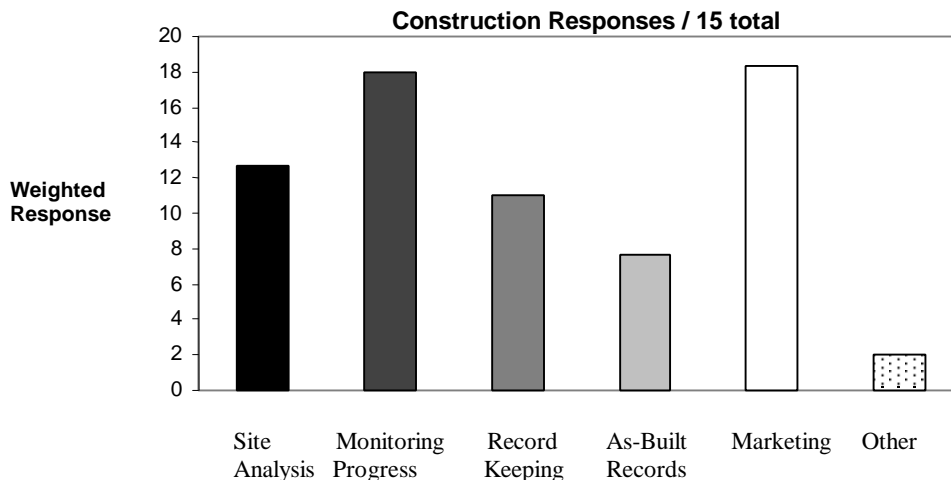
Construction Responses / 15 total

Figure 1b. Primary use of photography by construction firms.

Respondents were also asked to compare their use of photography on different types of projects, e.g. New Construction, Renovation Projects, Tenant Improvement/Fit-out, Infrastructure, and

Other. Most (85%) agreed that all projects require photography in varied amounts depending on size and duration, however renovation work and new construction required many more photos for site analysis and project documentation than utility and highway construction. These photos were normally medium quality color photos taken by in-house employees.

Finally, comparisons of photographic use were made between projects with different contractual arrangements, e.g. Lump-sum, Negotiated, Design-build, Cost-Plus, and Other. While most firms indicated that there was no difference, several contractors pointed out that the higher the risk of litigation or disputes, the more photos are taken to document site conditions and project progress.

Current Expenditures

For each of the areas of use, expenditures were averaged for both types of firms responding. Architecture firms spend an average of $18,000.00/yr on photographic services, approximately $2,314.00 to support initial *Site Analysis*. Contracting firms spend an average $35,725.21/yr, on photographic services, approximately $13,000.00 to support monitoring *project progress*. Expenditures were also evaluated on an a per project basis to determine if it would be feasible to purchase and use a digital camera for site analysis or project documentation on a single project. Figure 2 illustrates the average per-project expenditures for photography by Architecture and Construction firms.
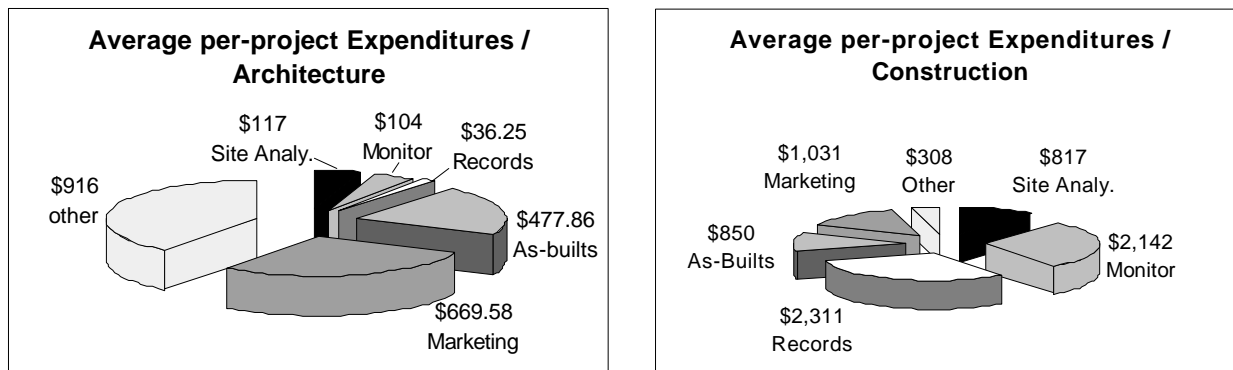

Figure 2. Average per-project expenditures on photographic services by architecture and construction firms.

While architecture firms spend the most money per project ($916 average) on high quality photos for marketing purposes, they are also spending close to $750 per project for site analysis, monitoring progress, and record keeping (services most easily replaced with digital images). Construction firms spend up to $5000 per project for site analysis, monitoring progress, and record keeping. Both of these figures were then compared to actual costs of an example digital image management system.

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The experiences of the respondents currently using digital photography have been positive. They have found added benefits in the speed in which images are available for use, compatibility with electronic media, and in the actual management of images. Two common problems experienced were the quantity of storage space and the management of large numbers of images.

Several existing field applications of digital image technology were examined to gain insight into the benefits and motivating factors experienced by users. Experiences of architects, contractors, and owners ranged from general experimentation to full fledged digital image management systems.

Architecture firms have begun using digital image technology to assist in the design process. In one case, digital photos were taken of an architectural model and used to make a presentation to a client in a remote location. Many images were displayed with a computer, and the need to transport the model to the client's office was eliminated. In another case, images were combined with CAD drafting overlays to produce construction documents for a renovation project. Discussion with several architecture firms reaffirmed that the highest use of photography outside marketing, was for site analysis at the onset of projects, particularly in renovation projects.

Construction firms use digital cameras to capture daily progress photos for historical record keeping purposes. The highest need for images is on renovation projects, where the need to show "before" and "after" conditions is often necessary. Images were stored on disks and archived for future reference, eliminated the need for cumbersome photo albums. Several design, engineering, and contracting firms have also begun to use advanced systems that are designed to catalog and transmitting images between remote locations.

Owners are driving another application of digital photography - the inclusion of images of construction projects on Internet Web pages to provide owners and project participants up-to-date progress photos of a project. Galleries of recent photos can be created using the most basic Hyper Text Markup Language (HTML) code. Real-time images can be captured by conventional video cameras, digitized by a computer, and downloaded automatically to web pages at predetermined intervals. This application could easily be adapted for time-lapse analysis of on-site operations. It has been envisioned that in the near future, project sites equipped with advanced teleconferencing systems will allow project participants in remote locations to participate in a real-time project walk-through using digital image technology.

By far the most extensive users of digital image technology are owners. Organizations like Boeing, Microsoft, the GSA, and the U.S. Postal Service have begun to transfer their project documentation from traditional photography to digital image format. In many cases, the use of digital image photography on a particular project was found to be driven by the owner.

Overall, the use of digital cameras by architecture and construction firms was found to be very limited. Actual applications that were observed were limited to basic tasks. Almost every firm contacted however, expressed a strong interest in this technology, and intentions to explore its

applications. In the future, the respondents envisioned using digital photography in the following ways:

- Improving the existing use of photography, especially for site analysis and project documentation
- Transmitting real-time progress images by Internet
- Bidding and documenting of existing damage to job sites before work begins
- Developing of manuals/presentations for methods and safety training
- Developing video presentations
- Making alternative working drawing methods using photos of details from previous projects
- Including actual photo images in renovation/remodel sets to show changes
- Documenting renovation projects and as-builts

Trial Application

An example digital image system was set up and tested by the research team. This application was performed to gain first-hand experience with several popular and readily available products. The application included researching available tools and acquiring and setting up the necessary hardware and software for a basic imaging system. Images of sample projects were then captured, viewed, and archived as they would be on trial design and construction projects. The products used for the application and the associated costs are provided below. It was assumed that an existing computer would be used to process images, thus the price total reflects the purchase of the digital image tools only.

Table 1

Software Tools

Product	Purpose	Cost
Kodak Digital Science 40 Camera	Capturing Images	$800
PhotoEnhancer Software	Transferring images to a computer	(included w/camera)
Computer with 133mhz processor	View and use images	(existing)
QuickSolve Image Database	Manage images	$600
Iomega Zip Drive (storage)	Share / Archive Images	$200
Netscape Software	Add images to Web pages	(existing)
PowerPoint Presentation software	Present images at meetings	(existing)
	Total	$**1600**

The above tools were used to capture and manage sample images. These images were then used for a number of practical purposes including:

1. Capturing images from a site investigation and cataloging in a database,
2. Superimposing images of an architectural model onto images of a prospective site,
3. Viewing images on a high-resolution screen to analyze site conditions in detail,
4. Including images on a sample project specific web page, and
5. Presenting a project proposal with images in a PowerPoint presentation

Results

The tools selected for this application were very easy to use and readily available. Images were most clearly viewable on a computer monitor, and printed on a laser printer. Images were also very easily added to project reports, PowerPoint presentations, and web pages for dissemination to project players. Figures 3-6 illustrate several photos taken with the Kodak DC40 Camera and a variety of architectural and construction applications.

Figure 3. Progress image of the Henry Art Gallery Expansion at the University of Washington Campus, Seattle, WA.

Figure 4. Close-up images of building details can be placed on Internet sites and viewed instantly by project players in remote locations.

Figure 5a. Before-Site analysis image of a prospective building location.

Figure 5b. After-Image of architectural model combined with image of prospective site to assess impact of project on setting.

Figure 6. Images taken from neighboring buildings at regular intervals provide an excellent record of project progress.

The image database allowed large numbers of images to be stored, sorted and retrieved effectively by using key words and captions created by the users. The Zip drive allowed up to 80 full size and 300 compressed images to be stored on one 100Mb disk, which is essential with a large number of images.

One drawback of this system was that images were recorded in a format that allowed them to be edited or altered. This is considered to potentially make them inadmissible as evidence should they ever be needed to resolve a dispute. Several methods are available however, to store images in a format in which they can not be changed. These include writing the images to a compact disc (physically burns image onto disk), and proprietary systems (Lynx) that prohibit alteration of images once they are downloaded from a camera.

The training required to learn the tools in this application could easily be accomplished in a day. It was estimated that a project engineer on site would require approximately 1 hour per day to annotate and archive 25 images taken on a daily project walk-through. This time would be added to the time needed to complete daily project logs and progress reports.

Lessons Learned

The following practical lessons learned through the trial application and case studies are provided as a practical guide for setting up and implementing a basic digital image photography system.

Capturing Images

Most affordable cameras ($350-$1000) provide sufficient image resolution and depth for most applications needed. In short, they are most suited for capturing *large quantities of medium-high quality images*. High quality photos for marketing presentations and brochures are more affordable with traditional photography. However digital images can be easily incorporated into multimedia presentations for rapid generation of proposals. Highly desirable features to look for in a camera are (1) the ability to store at least 50 images, to minimize the need to download images, (2) easy-to-use cross platform software to perform the transfer of images to a computer, and (3) an adjustable zoom lens.

Storing Images

One of the most significant issues to resolve is how to store the large number of images that accumulate. The most economical choice for users of digital photography are removable disk e.g. Iomega Zip (100Mb) or Jazz (1Gb) drives. These new systems offer speedy access and can also provide a means to exchange images between parties. It is also possible to compress images from their original size (1000K) to much smaller (26K) sizes. Several file formats are available on most machines, however JPEG and GIFF images are generally recommended. If it is necessary to store images in an unalterable format, a CD ROM writer may be used to save images. Commercial software packages are also available to compress and save images so that they can not be altered.

Managing Images

There are several digital image databases on the market, all fairly new and unproven. The most established, QuickSolve, was developed in conjunction with Kodak and provides a fairly affective tool to store images and a variety of other documents such as presentations, text files etc, along with up to 50 fields of detailed information about each document. Other, less expensive programs provide photo-album type image managers with far fewer programmable database features.

Sharing Images

While a wide variety of techniques were found to share images, only three are practical and reliable. The first, over a network has the disadvantage of requiring an infrastructure of network cables and software. The second, via removable disks has the advantage of being fairly simple and inexpensive. It is clear, however that the most versatile method for people in remote locations to share and view common images is through web sites and the Internet. At least one advanced system (Lynx) is currently available to help manage and share secure images of

construction projects. While it is relatively expensive, many owners are currently using it to document project progress and resolve conflicts that occur in the field.

In summary, the products used in the trial application were easy to work with, and produced useful results. The cost of the necessary tools ($1600) was also found to be well within the range of typical expenditures on photographic services for a single project ($914 - $5000). The advantages of easily accessible site analysis photos to architects combined with the simplicity of combining images with design information make this technology of great interest to the architecture profession. Documenting large numbers of progress photos also proved to be quite feasible and attractive to construction contractors.

Conclusions and Recommendations

The goal of this study was to assess the feasibility, and best applications for using digital photography in the building design and construction process. It is evident that the graphical nature of communication in the design and construction process can be immediately enhanced by the capability to capture and exchange images of site conditions and work progress. By evaluating existing use and expenditures for photographic services, as well as the affordability of digital cameras, it was found that most medium to large firms could easily begin replacing traditional photographic services for site analysis and project documentation with digital photography. This initial change would allow the advanced features of this technology to be explored, largely driven by client needs and marketing initiatives.

Renovation projects, above all, have the highest need for photographic records for both architecture and construction firms. For the most part however, the need for photos is driven by two factors: project location and potential litigation, regardless of project type or contract arrangement.

It is feasible and in most cases cost effective for architecture and construction firms to begin using digital image technology. In many cases, the benefits are already being experienced by firms who have purchased digital cameras and begun using them on site. One important trend to note is that more owners are beginning to expect high quality and timely progress reporting provided by digital image photography. Eventually this service will be required of architects and contractors, and should therefore be offered during marketing proposals.

Three factors will continue to encourage architecture and construction firms to use digital photography. First, specific needs and requests of clients to provide digital photography services on a project will increase. Second, digital image photography can replace traditional photographic services at some savings and in many cases, with improved management and versatility of images. Third, digital image technology improves the communication of site conditions and work-in-progress between design and construction firms.

A recommended strategy to encourage experimentation with this technology is to replace existing use of traditional photography for site analysis and project documentation with digital

photography. In time, as the need arises, the use of the technology can be expanded to some of the more advanced functions discussed above

Future Research

It is evident that the use of digital photography will continue to grow in the building industry. As a result, more avenues to take advantage of this technology will surface. Questions being asked by architects and contractors are not whether or not to use this technology, but how to best put it to use to improve design and construction processes. In response to this question, further case studies will be performed to determine how the ability to share current images of the site and construction progress can be used to and improve project communication and the productivity of designers and project managers.

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