A Study on Utilization of Digital Photographs in the Construction Industry

Junshan Liu, MBC
Auburn University
Auburn, Alabama

Steven R. Jones, MBC
Ard Contracting, Inc.
Birmingham, Alabama

Digital photography is becoming an important technology used in the construction industry. Digital photographs taken from project sites can be used for a multitude of reasons by construction companies, including for communicating with all parties involved in the construction project; for documenting as-built information; for scheduling; for recording data for building maintenance and facility management; for legal issues, and for business development and marketing. However, there is not a system adopted by the construction industry as a standard of how to acquire, store, manage and retrieve digital photos so that they can be used in a comprehensive and cost efficient manner. This paper explains the authors' findings of capture and utilization of digital photographs in the construction industry that are obtained from a study that includes an online survey and ten interviews. This paper also presents a prototype "Digital Image Shooting Guide" as a recommended standard for construction field personnel to follow when taking digital photos. Furthermore, some basic terminology and techniques of digital photography that can be used in construction are introduced.

Keywords: Digital Photograph, Digital Images, Information Technology, Construction

Introduction

The construction industry is becoming more and more advanced every year in the way it uses information technology. One of the major new tools that are now being used widely by construction companies is digital photograph. The increasing affordability, portability and ease of use of high quality digital cameras and storage media are generating tremendous numbers of images (both good and bad) from construction sites (Liu & Hein, 2007). When asked about the amount of digital images taken by his company during an interview, the Chief Information Officer of a large commercial construction company in the Southeastern U.S. said: "In our 700GB server up to 60% of the space has been taken by images. That could get worse as the popularity of higher quality (resolution) digital cameras increases." Digital photographs can be used for a multitude of reasons by a construction company, including for communicating with all parties involved in a construction project; for documenting as-built information; for scheduling; for potential legal issues; for recording data for building maintenance and facilities management, and for business development and marketing. Digital photographs even reduce the amount of trips to the site by the parties involved by allowing them to see the job progress from their office. For example, a general contractor takes some photographs of a site condition that differs from the condition shown on the plans. The contractor then attaches those photographs to a Request for Information (RFI) to the architect for clarification. Once the architect receives the

photographs, the architect ought to be able to look through the series of photographs along with the question from the contractor and quickly understands the problem at hand. Then the architect could respond in a manner which keeps the job moving along at an efficient pace. Figure-1 shows a flow chart detailing this RFI process. However, in many cases, photographs taken and used by construction companies are unable to meet the needs because of poor photography skills or inappropriate use of the shooting device.
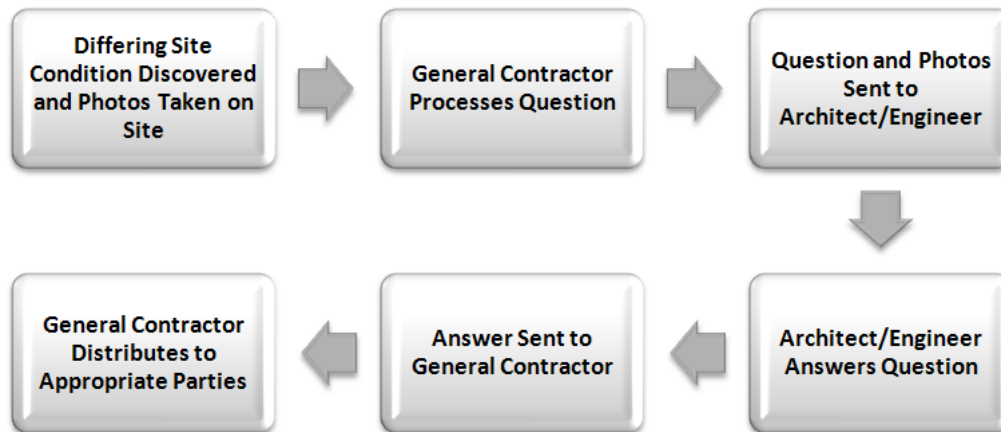

Figure 1: A RFI process in construction industry.

How to acquire, store, manage and retrieve digital photographs so they can be used in a comprehensive and cost efficient manner in construction? In order to properly utilize them, appropriate procedure and method of collecting these digital photographs need to be established first. "The empirical value of photographic research requires the images to be obtained through a methodological process indexed to recognizable objects and spatial variables" (Gaber & Gaber, 2006). In other words, photographs would be most useful across the industries of architecture, engineering, and construction if they are taken according to a set system of standards so that the images collected are consistent and have the ability to be interpreted the same way by multiple parties.

A Study on Digital Photography and Its Use in Construction Industry

In order to understand how digital photographs are obtained, stored, managed and retrieved in the construction industry, the authors complete a mixed-method research study, which includes (1) a research on general terminology and techniques of digital photography, (2) a study on data that was collected through an online survey on the topics of "Digital Graphics in Construction" which was co-conducted by one of the authors, and (3) number of interviews with construction professionals regarding issues of digital photographs within their companies.

Basics of Digital Photography

Some basics of digital images and digital cameras need to be understood by construction personnel in order to better utilize digital photographs on a jobsite. Digital images are images that are produced electronically using digital cameras, scanners, or software programs. They are

electronic files that can be displayed from a computer monitor, printed on paper or stored as a file on media such as CD-ROM. There are several different formats used for saving digital images, including JPEG, TIF, GIF, or BMP. JPEG is the most widely used format by in construction. Digital image quality is a function of resolution, color bit depth, and compression and is measured by number of pixels. A pixel is the smallest addressable unit on a display screen or bitmapped image. For example, a typical image size is 640x480 pixels. This means that there are 640 pixels displayed in each row and 480 pixels in each column of the image, therefore this image's size would be 307,200 total pixels. Currently acceptable image resolution falls between 3 to 8 megapixels. A megapixel refers to one million pixels. The more mega pixels used to capture the image, the better the image quality, and the greater the file size. See Table 1 for further clarification on the above information.

Table-1

Digital Image Size Chart

Image File Size	Image Dimension (Pixels)	Resulting File Size	Equivalent 35mm Image Dimension
2 MP	1600 x 1200	0.9 MB	4x6"
3 MP	2048 x 1536	1.06 MB	5x7"
5 MP	2560 x 1920	1.28 MB	8x10"
7 MP	3072 x 2304	1.82 MB	11x17"

A digital camera is a still camera that captures and stores images in a digital form, and these images will be transferred eventually to the computer or a networked server. Just like 35mm cameras of the past, digital cameras also have zooms which are either optical or digital or both and allow the user to focus closer on distant objects. The reason that digital cameras have proven so popular in the construction industry as well as in many facets of the society comes down to two distinct advantages: (1) the ability of showing the final image right away which allows the users to be sure they have the shot they want; (2) the convenience of not having to take a whole roll of pictures before developing and using the images. However, at the same time, the ease of using digital cameras causes one of the major disadvantages: a large quantity of useless digital images could be easily generated because people are spending less time thinking about the content of the image and skipping the necessary techniques of capturing which has been one of the main concerns when using conventional cameras.

An Online Survey

In an effort to identify the applications of digital graphics including digital photographs in the construction industry, one of the authors launched a survey with one of his colleagues in Fall

2006 to more than fifty companies that have major construction activities in the US Southeast (Zoomerang, 2006). More than half of these companies are large and had revenue over $100 Million in fiscal year 2005. This survey provided an understanding of exactly which digital visualization media and applications have found their way into construction offices and how they are being used. In order to obtain reliable information through the survey, a small group of fifty-four professionals known to be active users of IT applications within their companies was targeted. Most in the target group were in commercial/industrial construction, and many of them were IT directors. Through years of teaching, and continuous close ties to the construction industry, the authors of the online survey were able to call upon knowledgeable graduates and industry contacts to gain access to accurate information (Liu & Hein, 2007). The survey methodology involved: 1) A personal phone or email contact containing a link to the online survey to known users of graphic software in the region inviting them to take the survey. 2) Participants were asked to enlist the help of their colleagues to assist in getting all questions answered as accurately as possible. 3) A follow-up email was sent thanking the participant. 4) A post survey message was sent to participants containing a link that shared the survey results with all participants. The authors believe that the better than 63% response (34 out of 54) to the survey was a direct result of this personal approach to engaging participants in the study. Since this survey targeted and reached IT directors or knowledgeable users of information technology in construction companies (see Figure 2), the authors also believe the data and feedback regarding digital photography collected by this survey are valuable and significant.
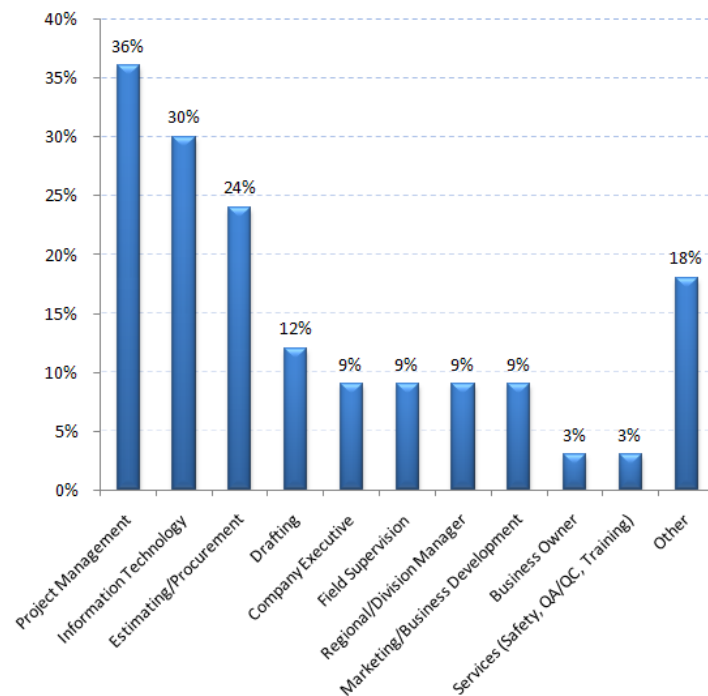

Figure 2: Distribution of the online survey respondents' positions.
Note: Since many of the respondents hold multiple positions within their companies and they were allowed to choose all answers that were applied when taking the online survey, the total number of positions was greater than the total number of respondents. For instance, one respondent selected 8 different positions in his answer.

Following explains some of the findings from the survey on utilization of digital photographs in the construction:

- The majority of respondents agree that digital images are very important to the construction industry and their companies use digital images for a variety of purposes (see figure 3).
- Microsoft Office Picture Manager, Adobe Photoshop, Adobe ImageReady, and Windows Paint are the most popular digital image programs used by construction companies.
- The digital image programs are mostly used by construction companies for three major types of activities: (1) manipulating images with fundamental editing features, (2) viewing, renaming, sorting images, and (3) annotating images with text, dimensions, and graphics.
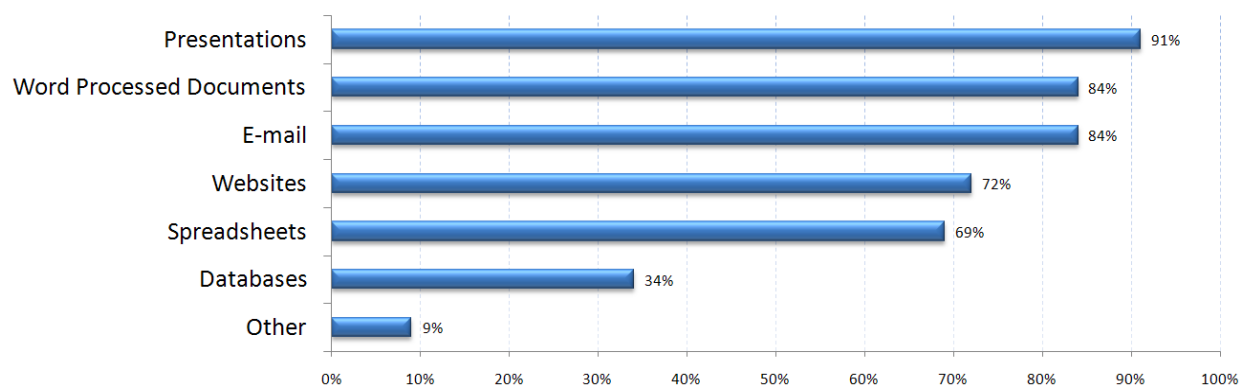

Figure 3: Uses of digital images by construction companies.

Interviews

Ten phone interviews to construction professionals in a semi-structured format were conducted in conjunction with the online survey. In order to obtain accurate data for this research, when selecting interviewees, the authors decided to choose the construction professionals who are a user or knowledgeable on the area of digital photography. The ten interviewees were selected through authors' industry contacts and recommendations by other people in the same companies. Among these ten interviewees (from nine different construction companies), two are company Chief Information Officers, two are project managers, two are executives/VPs, one is the owner, one is working on pre-construction, one is in graphic design/marketing department, and one is in business development. The interviews ranged in length from 5-20 minutes. Most questions used in the interviews were taken from the online survey and made better suited for finding information directly on digital photography. For example, one of the original survey questions was "In general how important do you think graphics currently are in visualizing and communicating issues, problems, and solutions in your construction company?" In the interview a similar question was asked, "In general, how important do you think using digital images taken on the jobsite is for visualizing and communicating issues, problems, and solutions in your company?" which was asked in a manner that better fits the objective of the study. Also, the

questions used in the interviews are open-ended and conversational responses are encouraged, which allows the person being interviewed to answer freely and without the confines of a "pre-determined list" of responses. See Appendix B for the guide and questions used in the interviews.

Following lists the major findings from these ten interviews:

- Nine out of ten people being interviewed believe that digital photography is either important or somewhat important in construction for visualizing and communicating issues, problems, and solutions.
- The main reasons for a contractor to take photos from project sites include:
  - To document the project progress, safety and unforeseen conditions,
  - To enhance the communication with all parties involved in the project,
  - Risk management,
  - To help prepare for OAC meetings,
  - To record as-built information,
  - To record data for building maintenance and facility management,
  - Business development and marketing uses, such as for designing advertising fliers and for updating company's website.
- None of the companies being interviewed have a standard for field personnel to follow when taking digital images on jobsite or a training program on this topic.
- All companies but one being interviewed use various types of digital cameras to take project photos.
- All companies but one being interviewed do not have a preference on features or settings of the digital camera that are used on jobsite.
- Most field image files are stored on the company's network drive.
- Saving the image files under the name of the particular project in which they are taken is the only method used by all the construction companies for storage and management of their field photos.
- Microsoft Picture Manager is the most common software used by construction companies for sorting, viewing and retrieving field photos. Adobe Photoshop is used by some companies to edit the photos to meet the needs of business development or marketing.

A variety of responses were received on what the most important issue is when capturing and using digital photography for construction, a Chief Information Officer of a large construction company stated "Storing the images is the biggest (issue). Photos once took up approximately 60% of our server space, and it will only get worse as higher resolution cameras continue to come out."

Another finding from the interviews regarding the use of digital image editing programs is that construction companies do not allow any kind of manipulation on the field photos except resizing which is very helpful when sending an image over email. Other editing actions such as cropping and brightening of the image ruin the image's value as an eligible document when possibly used in later legal action.

A Prototype "Digital Image Shooting Guide" for Construction

One of the major problems of utilization of digital photographs is that in today's construction industry there is no set system of standards for how to acquire digital photographs in order to properly convey questions or information. In fact, a large percentage of digital photographs used in construction are taken by a field person (such as a superintendent or a field engineer) with no formal training in how to explain an idea through the use of a digital camera. Therefore, a "Digital Image Shooting Guide" would help construction field personnel define how to accomplish their goal in taking photographs on jobsites.

According to Collier and Collier (1986), "A whole view is the product of a breadth of samples that allows us to comprehend the whole through systematic analysis of those carefully selected parts." Digital photos taken by the construction industry first need to include the date and time when the picture was taken. This can easily be accomplished by setting the date/time stamp on the digital camera itself. Also, photographs within the construction industry need to contain three basic parts to convey the "whole" of the information: context, detail, and scale.

1. Context can be obtained by using of panorama or wide angle shot.
2. Detail can be shown by taking a close-up of the condition in question.
3. Scale can be shown by including some everyday items in the photograph.

Normally, these three basic parts can be covered by a set of images that illustrate one or two parts on each. However, in some cases, all these three parts can be addressed by one single photo when appropriate photography techniques are utilized with a well-prepared shooting plan. Figures 4, 5 and 6 are an example of using three photos taken from a construction site to help ask a question regarding rebar clearance.

Figure 4: An example of an image showing context.

Figure 5: An example of an image showing detail.

Figure 6: An example of an image showing scale.

Based on the research on digital photography and data gathered from the online survey and interviews, the authors developed a prototype "Digital Image Shooting Guide" for construction. See Appendix-A for the shooting guide. The authors have successfully tested this shooting guide through few field studies and introduced it to their students in an ACCE construction management program.

Conclusion and Future Studies

Through the study, one conclusion on utilization of digital photographs in construction industry has been made by the authors. The fact is that digital photography is a widely used tool in the construction industry and plays a major role in communication, documenting project process and as-built information, recording data for building maintenance and facility management, legal issues, and business development and marketing. However, with this conclusion comes the reality that unlike other important technologies, there is no set system of standards or training done to properly inform construction field personnel on how to use digital photography in an efficient and cost effective manner. Therefore, a prototype Digital Image Shooting Guide for Construction has been developed by the authors. This shooting guide contains three basic parts - context, detail and scale to convey the "whole" of the information using photos.

For future studies there are many paths a researcher could take in furthering the look into digital photography in the construction industry. The most prevalent and practical research should be concentrated on further development of more shooting guides. As shown above, digital photography is used for multiple purposes within the construction industry. Therefore, a separate image shooting guide could be developed for a certain type of activities in construction. For example, a guide could be developed explaining how to educate the subcontractors in recording their as-built information. Traditionally construction has been an industry slow to change, but now that digital photography has taken a strong foothold the industry needs to keep moving towards more efficient and effective ways to use this new technology.

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Appendix A

A Prototype Digital Image Shooting Guide for Construction

1. Identify the issue that needs to be communicated through images
2. Set Digital Camera to appropriate resolution (3MP)
3. Make sure date stamp is turned on and set to correct date
4. Shooting Tips:
   1) Frame the shot by adjusting your distance from the subject, or by using camera zoom
   2) Make sure all the settings of the camera are appropriate
   3) Try to avoid aiming camera into bright sunlight
   4) Hold the camera steady
   5) Hold the image capture button gently for one to two seconds to allow the camera to automatically obtain proper focus and light reading.
   6) Review captured image in camera review mode to make sure you have a good shot.
   7) If subject is over exposed or underexposed adjust the lighting (as with Flash) and reshoot.
   8) Make note of specific place in the building where issue is located.
5. Take a set of pictures which communicate the following
   1) CONTEXT- Overview of subject as it relates to other objects.
   2) DETAIL - Close-up of the issue or problem
   3) SCALE - Use a common object to reference the size or magnitude of the problem or issue

Context:	Detail:	Scale:
This shot shows a window unit with the problem corner.	The problem is the widow frame is not square with the wall.	This shot indicates the degree out of square.

6. Once shots have been obtained save images to a computer
   1) Name Images including Date-Location-Issue: Ex. 060807-121-window (Middle Picture Above)

7. Attach images to appropriate document (e.g. Memo, RFI Log, email) with a short text description of the problem at hand.

Appendix B

Interview Guide

Person Being Interviewed:

Date:

Questions:

1. In general, how important do you think using digital images taken on the jobsite is for visualizing and communicating issues, problems, and solutions in your company?

2. Why do you take digital images for your company's projects?

3. Is there a standard in your company that needs to be followed when field person taking pictures on construction sites? If so, what is it?

4. What is the most important issue(s) that you will be concerned when taking photos for construction?

5. How are the image files stored and managed?

6. Which of the following digital image editing/management program(s) are used in your company?

7. What do you use these image editing/management program(s) for?

8. In what other major software applications do you import or insert images?

9. How often do you need to retrieve old images?

10. What position in your company utilizes digital photography the most?

11. How important do you think utilizing digital images will be in your company in the next 5-10 years?

12. What type of preparation or training in photography techniques or skills do your employees have?

13. What type of camera does your company use?