Consumer Behavior when Zooming and Cropping Personal Photographs and its Implications for Digital Image Resolution

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Abstract

This paper discusses a pair of experiments in which groups of consumer photographers were given the opportunity to crop and zoom their pictures. In the first of these studies, a group of 33 customers were intercepted as they obtained their print orders from their photo-finisher. While reviewing their prints, the participants were asked which of their pictures they would like to zoom and crop. The users were then asked to use a collapsible template with a 2:3 aspect ratio to draw zoom and crop lines on the selected prints. These data were analyzed to determine the proportion of prints the users want to crop and the amount of cropping that was applied. In a second study the film of a group of 14 customers was intercepted, these pictures were scanned to a KODAK PHOTO CD Disc and the users were asked to use a computer-based tool to place a fixed 2:3 aspect ratio crop box in a subset of their photographs. This data was analyzed to determine the amount of cropping that was applied, as well as some guidelines for computer-based crop tools. This research shows that consumers wish to apply cropping to roughly 40 percent of their photographs. Some differences in the amount of cropping were observed between the two experiments.

Introduction

When designing an imaging system, it is important to consider the behaviors that are likely to be promoted by the system, and to establish image quality requirements that satisfy the needs of the intended audience. Traditional consumer photographic systems have been designed to promote a limited feature set in which the consumer photographer received a picture with one of a limited number of picture sizes. However, many technical barriers that existed to providing a rich feature set in traditional photography, no longer exist in hybrid or digital photography.

One of the desirable features provided by hybrid and digital photography is the ability to crop undesirable content from a picture in order to magnify or zoom the desired content of the picture to fill the entire photographic print. Within the traditional imaging system, zoom cameras have provided the consumer photographer greater control over capturing the desired content of a photograph. Even given this increased control, the photographer, or a person who views the photograph at a later point in time, often wishes to change the content of the photograph after it has been captured.

If this feature is to be promoted as a significant feature of a digital or hybrid system, it can have a dramatic effect upon the image quality requirements for a system. For example, if users are expected to crop a significant number of their photographs such that only half of the original picture content is retained, it may be necessary to double the required system resolution. Higher levels of crop and zoom may impose even more stringent requirements on system image quality parameters.

A goal of the research discussed in this paper was to understand users' desire to zoom and crop photographs so that these desires could be translated into image quality requirements. Two experiments were conducted. In the first experiment, participants were asked to indicate which pictures in their order they would like to zoom and crop and by how much. These edits were performed on a physical print. The second study attempted to understand how this behavior might be affected when individuals are asked to perform crop and zoom on a digital imaging system that included electronic preview.

Method for Experiment 1

The goal of this experiment was to fundamentally determine what people wanted to zoom and crop in their photographs, as well as, the number of photographs they believed they wanted to zoom and crop. Therefore, the fundamental method used was to allow individuals to review "proof" prints for their order and to draw a box on the print, indicating the portion of the print they wished to retain.

Participants

Thirty-three people took part in this study. Before participating in the study, each of the participants captured pictures on a roll of film. Although most of the participants were Kodak employees, they were selected to not be involved with photofinishing or digital product development. Participants were compensated with free development and printing services for participating in the study.

Apparatus

When asking the participants to indicate the portion of their picture they would like to crop and zoom; it was desirable to maintain a given print aspect ratio. Therefore, a tool was built out of clear Plexiglas. This tool could be resized to have a center aperture of any size smaller than 4×6 inches. When resized, the aspect ratio of the aperture had a constant 2:3 vertical:horizontal aspect ratio.

Procedure

Prior to the study session, the roll of film was developed and three sets of prints were made. One set of prints was used during the study, and two sets were returned to the participant as part of the incentive for participating in the study.

When the participants arrived to participate in the study, they were asked to view each of their pictures for composition. They were told that if the picture is exactly what they wanted, they could advance to the next print. If they felt they could improve the picture through cropping, they were asked to use the apparatus to indicate how they would crop the picture. This crop area was outlined on the print using a permanent marker. Participants were allowed to reorient the apparatus, as they liked. The only restrictions the participant had were to keep their desired crop region within the area of the print and to keep the template parallel to the edges of the print. This procedure was followed for each print in the participant's order. After completing the task for each print, participants were asked to indicate why they cropped or did not crop the photograph.

Dependent Measures

Among the dependent measures that were captured were the number of prints that individuals chose to zoom and crop. They also provided for wishing to zoom and crop some pictures, while not zooming and cropping other pictures. Finally, the percentage of the original print area that remained in their selected crop region was also recorded.

Results for Experiment 1

Participants indicated that they would like to apply some amount of cropping to 38% of all of the photographs they captured. When asked what they attempted to accomplish by zooming an image, the most popular comment (121 of 242) was to remove undesirable or irrelevant content from the photograph. The second most popular comment (109 of 242) was to isolate the primary subject. The third most popular comment (46 out of 242) was to zoom or enlarge subject matter. When asked why they did not wish to zoom or crop some of their photographs, some participants indicated that that picture was fine as it was captured and could not be improved through cropping (284 out of 512). However, 105 comments indicated that the picture was not worth cropping**.** Given this comment, it is possible that participants may not wish to print these pictures when using a hybrid or digital imaging system. Therefore, it might be hypothesized that the typical user may wish to crop and zoom approximately 52 percent of the photographs they will wish to retain and print when using a more flexible digital or hybrid imaging system.

Figure 1 shows a distribution of the percentage of the picture area that remained in the cropped photograph. The average area of the print remaining after cropping was 46 percent. Looking at Fig. 1, the remaining image area is approximately normally distributed with about 1% of the prints cropped to contain between 90 and 100% of the original and as much as 3% containing between 10 and 20% of the original print. Interestingly, no prints were cropped to an area smaller than 10% of the original print.

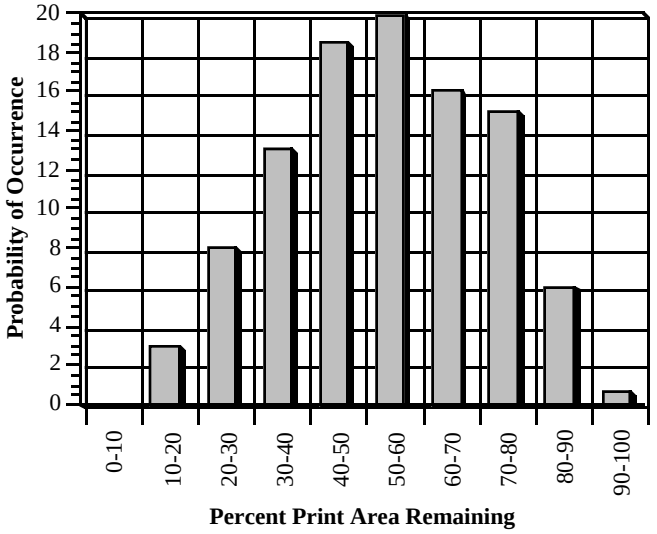

Figure 1. Distribution of the percentage of the picture area remaining in the cropped photograph.

Figure 2 shows the same data as Fig. 1, only plotted as a cumulative distribution. Interestingly, the majority of prints were cropped to between 1 and 2X. A 2X zoom is achieved when only 25% of the area of the photograph remains after cropping. Less than 5% of all photographs in this study were cropped to this level. About 43% of the cropped prints, however, retain less than half of their original area.

Method for Experiment 2

In this experiment, we attempted to understand whether the results obtained in the original experiment repre-

sented consumer behavior when they were asked to use a computer-based crop and zoom mechanism. It was also our goal to derive some guidelines for the design of this computer-based crop and zoom tool, including the desired size of the displayed image and the step size for the crop reticule.

Participants

Fourteen participants (2 female, 12 male) took part in this study. Each of the participants captured pictures on a roll of film before participating in the study. Although all of the participants were Kodak employees, they were selected to not be involved with photofinishing or digital product development. Although participants were not screened based upon their visual acuity, all participants had near and far visual acuity of 20/33 or better. The modal near and far visual acuity for the group was 20/22. Participants were compensated with free development and printing services for participating in the study.

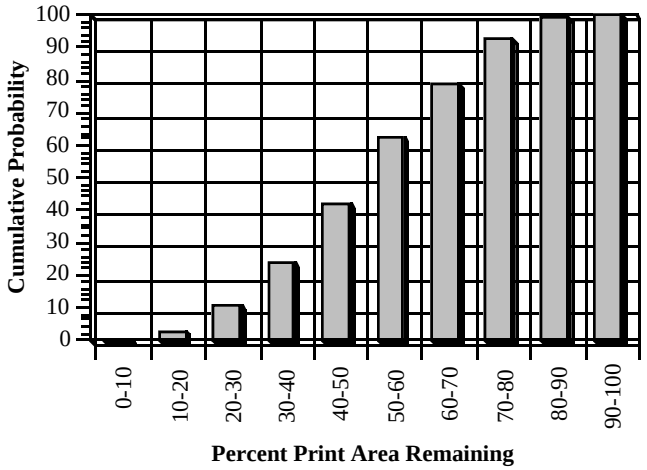

Figure 2. Cumulative distribution for the percentage of the picture area remaining in the cropped photograph.

Apparatus

All images were displayed on a 21-inch SuperMac display, driven by a Macintosh SuperMac Thunder IV video accelerator card. The display was operated in the millions of colors mode with an addressability of 1600 x 1200 pixels, providing a pixel pitch of 0.24 mm. The display was calibrated to provide a standard viewing condition.

Before each experiment, the participants' images were scanned to a Photo CD disc. A scriptable image manipulation program, IPLab, was used to manipulate each of the images.

The images were presented and data was collected using a custom C program. This C program allowed participants to view their images with a 20% gray surround. When the image was displayed, a white, one pixel wide, crop box appeared around the outside of the image. The participant could then zoom in on the center of the image simply by pressing the "I" key on the keyboard and zoom out to the border of the image pressing the "O" key. The box could be moved within the image region by using the left, right, up, and down arrow keys, which moved the crop box in the respective directions.

When the "I" or "O" key was pressed, the horizontal and vertical dimensions of the crop box were each reduced by 6.25 percent of the length of the horizontal and vertical dimensions of the original image. In doing this, the step size of the crop and zoom function was changed proportionally with the size of the image on the display and the aspect ratio of the image was maintained. The program also provided the participants a method of reducing the step size of the zoom and crop reticule if they felt they wanted additional control. After zooming and cropping each image, the software queried the user for two responses. The first was the difficulty in cropping and zooming, the second was a simple question in which the participant was asked if the image was large enough. The software recorded each of these responses, the final size and location of the cropped image with respect to the original, and information regarding the degree to which participants' reduced the step size of the crop reticule.

It should be noted that the image size was varied during the experiment to determine a minimum acceptable size for displaying an image to be cropped and zoomed. Within this study, the image resolutions included 64×98, 128×196, 256×384, 512×768. These image resolutions represented the resolution that might be provided during a scanner's prescan. The three lowest resolution images were also interpolated to the next largest size using bilinear interpolation. This provided for a total of seven image sizes at which the images were displayed.

Procedure

During this experiment, the participants were told that we were going to ask them to crop and zoom some of their photographs on a computer. They were asked to read some instructions. The experimenter then demonstrated the features of the software package using a picture the participants had never seen before. The experimenter then asked the participant to use the tool to crop and zoom this same picture. The participants were asked to use all of the crop and zoom functions of the software during this training session.

The participant was then shown a board that allowed them to simultaneously view all of the prints that were on their roll of film. Participants were asked to select prints from the board that they would like to crop and zoom. As they did this, the numbers of the prints were entered into the computer. These numbers were randomized and assigned to experimental conditions within the study. The first pictures selected by the participant were then displayed at a given resolution and size on the display. It should be noted that each participant in this study selected at least seven prints to crop and zoom from their print order.

The participant then cropped and zoomed this print and pressed a button on the screen using the mouse when they were satisfied with their cropping. They were then asked to provide a rating of difficulty for using the size of image that was displayed, and they were asked to indicate whether this print was large enough to crop the print, as they liked. This same procedure was completed for each of the seven images they selected.

Dependent Measures

The dependent measures in this study included the participants' difficulty rating, their indication of whether the image was large enough to zoom and crop, and their behavior while cropping. The difficulty rating asked participants to rate the ease of zooming and cropping the exact portion of the pictured they wanted. This rating was provided on a 9-point scale that was anchored at 1 with the adjective "Very Difficult" and at 9 with the adjective "Very Easy". They also responded positively or negatively to the question "was the image large enough?" Their behavior was characterized in terms of the print area remaining after cropping.

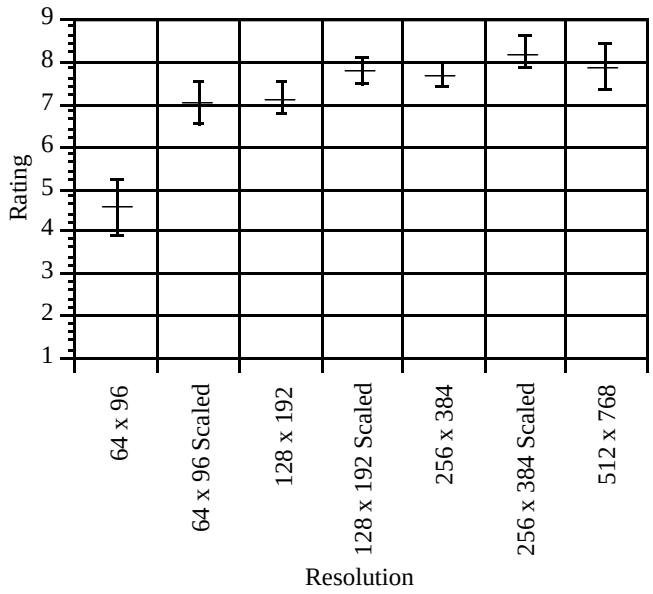

Figure 3. Difficulty rating obtained as a function of displayed image size. Error bars indicate plus and minus one standard error of the mean.

Results for Experiment 2

A single factor Analysis of Variance was conducted on the difficulty rating data. This ANOVA indicated that there was a significant effect of image size on the participants' ratings of difficulty ($F(6,72) = 13.151$, $p = 0.0001$). Figure 3 shows the trend that was obtained for this data. Looking at this figure, it is clear that the difficulty scale increase towards "Very Easy" as the resolution of the preview image increased. Student Newman-Keuls range tests indicated that the difficulty rating was significantly lower for the 64 × 96 pixel condition than for any other condition, the difficulty rating was significantly lower for 128 × 192 pixel condition and the condition where the 64 × 96 pixel image was scaled up to a 128 × 192 pixel image than for the conditions that appear farther to the right. Finally, the difficulty rating was lower for the 256 × 384 and 512 × 768 pixel conditions than for the condition where the 256 × 384 pixel image was scaled to 512 × 768. No other statistically significant differences existed at the 0.05 significance level.

Figure 4 shows the number of positive responses indicating that the displayed image was large enough to support the task of cropping and zooming the image. As can be seen, the number of positive responses increase with increasing image size until a base size image was displayed.

Despite the fact that participants did not prefer to use the smaller images to zoom and crop their images, there was no significant effect of image size on the crop amount they applied. In fact, the average crop amount was relatively uniform across the image size conditions. Further, when performing the task with the larger image sizes, no user ever utilized the ability to reduce the crop step size. Therefore, it would appear that the participants were able to complete the task with the smallest image and they never desired to optimize the crop amount to finer than the default 6.25 percent step size.

Figure 5 shows a distribution of the percentage of the picture area that remained in the cropped photograph. A very wide distribution of cropping was observed in this study. Seven percent of all photographs were cropped such that less than 10 percent of the total area of the original photograph remained. The average print area remaining in this study was 43 percent with a mode value between 30 and 40 percent.

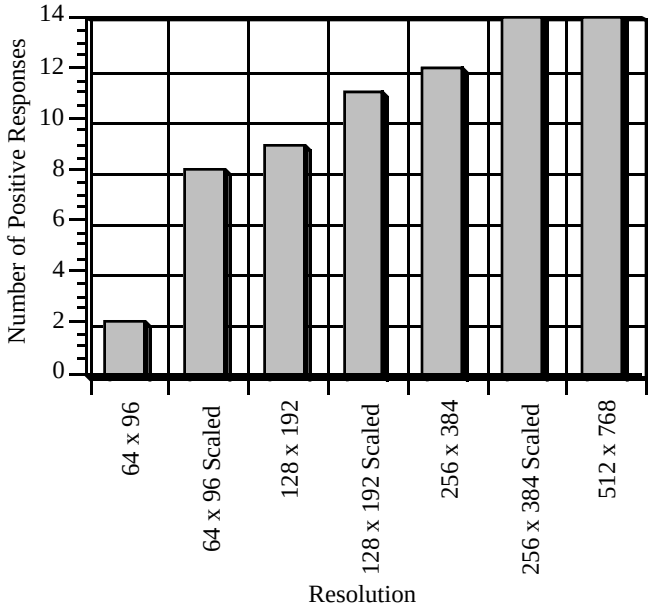

Figure 4. Number of positive responses to the image size.

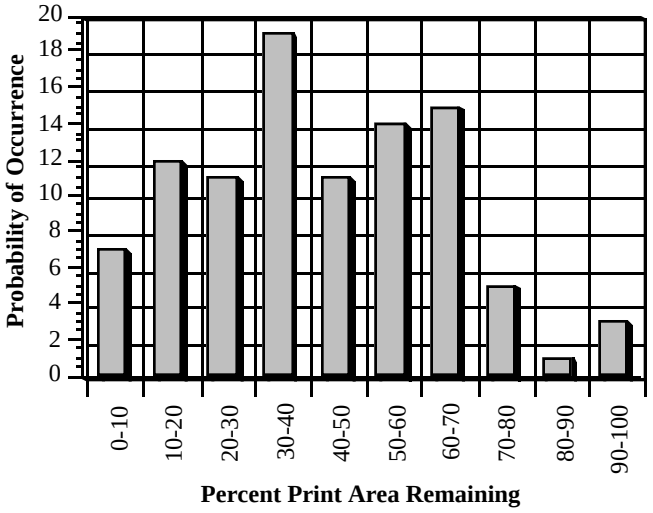

Figure 5. Distribution of the percentage of the picture area remaining in the cropped photograph.

Figure 6 shows the cumulative distribution for the print area remaining in this study. As can be seen in this graph, as much as 30 percent of the images in this study were cropped and zoomed to 2X (25% of their original area). In excess of 20 percent of the photographs contained less than 20 percent of the area of the original print.

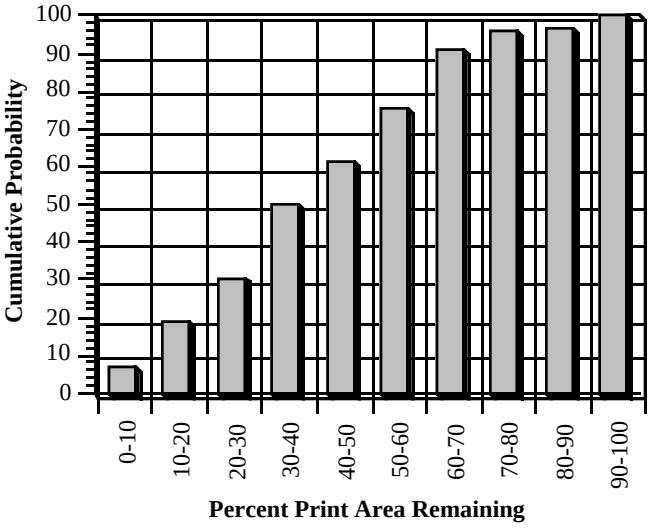

Figure 6. Cumulative distribution for the percentage of the picture area remaining in the cropped photograph.

Discussion

In general, each of the studies discussed in this paper demonstrated the amount of cropping consumers would like to inflict on their original photographs. In general, the participants in the first study appear to be less aggressive in cropping their photographs when using a physical cropping tool, than the participants in the second study who were asked to use a computer to crop their photographs. The initial response to this difference would be to state that consumers may have been more aggressive when using the computer, because they were more willing to take risks or because participants in the first study did not wish to admit to the experimenter that they had framed their original photograph so poorly.

It should be noted, however, that the extreme crop amounts observed in the second experiment were predominantly exercised by three participants. One of these participants cropped photographs of airplanes taken overhead at an airshow, a second appeared to desire portraits of people in photographs extracted from pictures taken at a reasonably far distance in their yard, and the third consumer attempted to zoom in on wild animals that had been captured at a far distance. The fact that these three individuals found photographs they wished to crop by an amount that was sometimes far in excess of 2X would appear to indicate that these photographs do exist in the consumer population. Perhaps photographs such as these were not present in the population of photographs used in the first study because of the time of year in which the study was conducted.

Based on the results of these two studies, it would appear that perhaps a longer term, more comprehensive study of consumer behavior when cropping and zooming photographs may need to be undertaken to fully understand consumer behavior. However, the best estimate now might be obtained by combining these two experiments and weighting the data by the number of photographs represented in each study. This combined cumulative distribution is shown in Fig. 7.

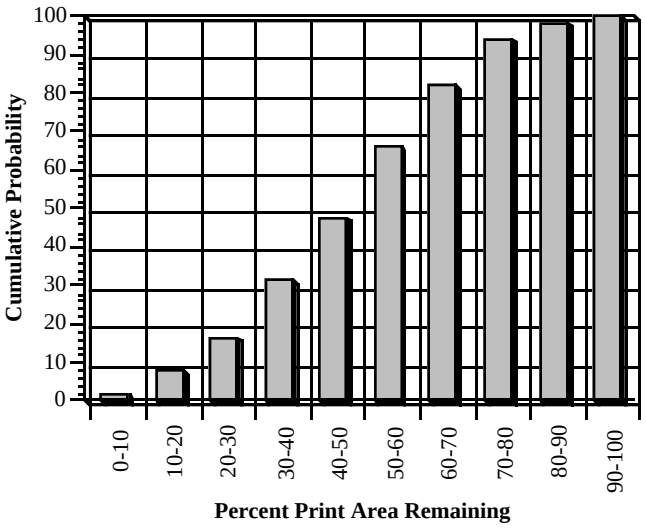

Figure 7. Cumulative distribution of print area remaining obtained by combining the data from the two studies.

As can be seen from this figure, roughly 2 percent of all photographs can be expected to be cropped to contain less than 10 percent of their original area and roughly 9 percent can be expected to be cropped to less than 20 percent of their original area.

Once this distribution is specified, one can use the results from other studies to predict the resolution required of digital imaging systems. Ohno, Takakura, and Kato[1] recommended that a digital camera have a printing resolution of 300 pixels per inch. Assuming that this number is correct, that the users will crop approximately half of their pictures and that they will utilize the crop amounts specified in Fig. 7, one may determine the digital camera resolution necessary to provide a satisfactory quality print for various percentages of the prints that are made. Table 1 displays this information for three print percentages.

Table 1. Estimated digital camera resolution required to provide a satisfactory 4 × 6 inch print. This data is indexed by the percentage of prints that are likely to be satisfactory after crop and zoom is applied.

Percentage of satisfactory prints	Resolution (pixels per inch)	Required Digital Camera Resolution
50	300	1200 × 1800
75	300	2400 × 3600
90	300	4000 × 6000

As shown in Fig. 1, roughly 50 percent of all printable pictures will not require any amount of crop and zoom. Therefore, if a digital camera resolution of 300 pixels per inch is required, satisfactory prints can be created from these uncropped pictures using a camera with roughly 1200 × 1800 pixels. However, to include 75 percent of all photographs the users will require the ability to crop approximately 50 percent of the print area away. This increases the required digital camera resolution to 2400 × 3600 pixels. Further, to include 90 percent of all cropped pictures, the user will need the ability to discard 70 percent of the area of their photograph. This translates to a digital camera resolution of 4000 × 6000 pixels.

Conclusions

It was demonstrated that users are likely to request that approximately 50 percent of all printable photographic prints undergo some level of crop and zoom. This requirement can place additional requirements on the resolution of a digital imaging system. In fact, 25 percent of all photographs can be expected to be cropped to less than half their original area if easy crop and zoom tools are provided. This alone can require the necessary resolution of the imaging system to be doubled.

Acknowledgments

The initial study discussed in this paper was developed and conducted by David Mitropoulos-Rundus. The authors would like to recognize him for his valuable contribution.

References

1. Ohno, S., Takakura, M., and Kato, N., Image Quality of Digital Photography Prints-2: Dependence of Print Quality on Pixel Number of Input Camera, Proceedings of the 1988 PICS Conference, pp. 51-55 (1998).