ADVANCEMENTS IN DIGITAL IMAGING AND PHOTOGRAPHIC APPLICATIONS:
A FOCUS ON HUMAN EMOTION AND INTENT DRIVEN COMMUNICATION

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ABSTRACT

Photography is an art form, as well as a means of communication. It is gaining in popularity as imaging tools are becoming more prevalent, affordable, and user friendly. At the same time that more individuals are expressing interest in photography, little is being done to help them develop an understanding of how photography can be used for effective communication. In this thesis, I propose a computerized system for providing individuals with feedback useful for improving their understanding of how to visually communicate using the photographic medium.

In academia, an emerging area of interest amongst some researchers is human-emotion computability. Research in this area will pave the way for creating practical applications for teaching individuals how to communicate effectively through a photographic image. It will also provide a means for evaluating and offering feedback on the specific communicative effectiveness of images in near real time. Critical to developing such applications is the construction of a comprehensive dataset that can be used to train computers to provide relevant feedback.

Led by James Z. Wang, Professor of Information Sciences and Technology at The Pennsylvania State University, researchers from the College of Information Sciences and Technology and the Psychology Department, are constructing a dataset with the goal of understanding the relationship between visual stimuli and human emotions. Amongst other uses, such a dataset is expected to provide valuable information for building learning applications aimed at helping individuals take photographs that communicate effectively.
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Chapter 1

Introduction

Photography, like painting, drawing, or writing, is a form of communication. While some may be naturally talented photographers, the ability to repeatedly create an image that has depth and meaning and is particularly enticing, takes years of experience and practice. However, today, without the need for advanced technical knowledge, the average individual has the ability to communicate experiences quickly and effectively through the image, utilizing increasingly accessible camera technology. As reported by Tim Moynihan (2011) of PCWorld, “In 2012, cameras will become smaller, more powerful, and more specialized. Meanwhile, smartphone cameras will continue to improve at a blistering pace, approaching the imaging capabilities and features found in stand-alone cameras of a few years ago.” No doubt, this was the case in 2012. As we progress through 2013, “InfoTrends expects that cameras and phones will co-exist for the foreseeable future,” according to Ed Lee (2012), Group Director of InfoTrends’ Worldwide Consumer and Professional Imaging Services. Along with an increase in camera technologies, more
individuals are taking up photography as hobby, part-time job, and even profession. The United States Department of Labor’s Bureau of Labor Statistics (2012) reports, “Improvements in digital technology reduce barriers to entry into this profession and allow more individual consumers and businesses to produce, store, and access photographic images on their own.” Dave Good (2012) of Rangefinder points out, “[…] amateur and weekend shooters continue to go pro and compete with existing shops.” In fact, from 2010 to 2020, the number of self-employed photographers is expected to grow by 15 percent (Bureau of Labor Statistics, 2012). With an overall increase in the number of people taking pictures, it is expected that between 2013 and 2016, the number of images saved will grow from 1.6 to 3.0 trillion images (Lee, 2012).

**Importance of Intentional Communication**

With improvements in digital technology, decreasing costs of digital cameras, and an increasing number of photographers (both amateur and professional), one might assume that the number of compelling photographs will increase at a more rapid rate. However, even if every owner of a high-end camera such as a digital single lens reflex (DSLR) only developed technical proficiency in how his or her camera operates, the percentage of compelling photographs produced would remain stagnant. I make that claim based on the assumption that every individual who takes a picture has a purpose for doing so and to produce a ‘successful’ photograph takes more than technical knowhow. In other words, the individual has some intent, and understanding how to convey that desired intent is of crucial importance. For example, an individual may take
a picture of a scene because the moment playing out before their eyes is emotionally captivating. However, what many may fail to understand is how we go about making the necessary adjustments such that the image recorded conveys the intent sought. In its purest sense, the art of photography is about being able to communicate with images exclusively. Once the picture is taken, it should be able to stand on its own. Just a single, 2-D image, may be all an individual has to convey a story or event to the viewer. This idea of communicating with images is not unlike writing in that an individual who writes only has his or her words to use in communicating to the reader. Fortunately, in photography, like in writing, there are a number of techniques we can use to help us communicate our intended message. As David duChemin (2012), author of *Photographically Speaking* writes, “But if you identify that intent, it narrows your gaze and helps you choose the best lens, the best shutter speed or aperture, or suggests you shoot from a different, better perspective” (p. 8). In other words, once we are able to recognize our intent, it then comes time to use tools and utilize techniques to effectively communicate. This is where the challenge arises. Unfortunately, much of the current day educational material devoted to photography falls short on stressing the importance of intent, let alone, informing people of how to communicate based on intent.

**Current Educational Resources**
However, a solution to help photographers improve their craft could very well come in the form of an applied, in the field, independent learning system. Traditionally, someone seeking to learn photography has a few different options. Many colleges and universities across the country offer at least introductory courses in photography. Some schools even have entire curriculums centered around the photographic profession, such as the Brooks Institute of Photography in Santa Barbara, CA and the School of Visual Arts in New York City. Outside of school, it is probably not all that challenging to find photography classes being offered in one’s local area.

There are also countless numbers of books on the design and technical aspects of photography, many of which delve into specific photographic industries (i.e. wedding photography, wildlife photography, etc.). The amount of online photograph content in existence alone, and constantly being added, could keep someone ‘surfing the web’ for a lifetime. While all these resources can be immensely helpful, improving one’s photographs comes down to taking lots of pictures. The rest involves learning from our mistakes. One of the most effective ways this can occur is by receiving feedback on our photographs from experienced professionals or anyone who thoroughly understands and is able to communicate how an individual can specifically improve their photographic ability. However, as research in the field of computer-human interaction and human
emotion computability and predictability advances, widely available and increasingly helpful digital platforms/applications may exist, helping to facilitate the photographic learning process.

Photographic Challenges

As David duChemin (2012) explains, his photographic process consists of making decisions and using the elements that exist within a scene, in order to most effectively convey his message (p. 16). The most challenging part of the process, the part that takes years of practice, trial and error, is the decision making part. This part of the process is challenging for many reasons. There are a plethora of decisions that need to be made, ranging from the camera settings dialed into the camera, to the appropriate time of day to photograph. Having a comprehensive understanding of the camera’s mechanical operation and photographic technique is critical. Additionally, one often has little time to make a well-composed photographs when out in the field. This is unlike other crafts, where the artist can solicit feedback from others (i.e. teachers, professionals, etc.) prior to completion of the artwork. With photography, once a picture is taken, not much more can be done with it aside from post processing. If you happen to have access to a professional photographer or someone skilled in the art, he or she can offer suggestions on how a photograph could have been improved. However, even if one went back to the location where the photograph was made, to experiment with the newly received advice, it is unlikely that the photographer will come upon the same scene in which to practice (of course this is largely dependent on the scenario). What needs to exist is a guidance
system whereby photographers can receive real-time feedback, allowing him or her to make corrections otherwise not possible (or at least not practical) at a later time. OSCAR provides one of the first major steps in this direction.
Chapter 2

Background on Photographic Applications

OSCAR: A Photographic Composition and Aesthetic Feedback Application

In the International Journal of Computer Vision, a paper entitled “OSCAR: On-Site Composition and Aesthetics Feedback through Exemplars for Photographers,” details the workings of a software application, which “has been designed to provide on-site composition and aesthetics feedback through retrieved examples,” as the title suggests (Yao et al., 2012). The application consists of three components. One looks at the content and composition and returns exemplar images based on those factors. Another component provides a confidence rating based on the quality of color combinations contained in the image. The third component predicts an aesthetic rating. Mobile devices, such as the iPhone and Lumia 1020, are best suited for use as part of the OSCAR system. The computing powers of such mobile devices are increasing, and most include built-in cameras that produce images of at least adequate image quality. The Lumia 1020 is a 41-megapixel smartphone. The OSCAR system is comprised of several parts, including the image archive, composition analyzer, color combinations feedback module, composition descriptor, and image retrieval.
module. All the images submitted to the system are labeled as “color images” or “monochromatic images” and stored in the image archive. Once an image is input, the composition analyzer will evaluate the image based on five categories: “textured”, “diagonal”, “horizontal”, “centered”, and “vertical.” Images that receive a high aesthetic rating and have similar composition and content to the input image are retrieved. The idea is that photographers would then be able to learn through examples. The color combination feedback module identifies the most aesthetically pleasing color combination from the input image and displays that to the viewer. Also derived is a score indicating the confidence of having high quality. If the image being evaluated is a color image, the Aesthetic Quality Inference Engine or AQUINE analyzes the image’s features including light, colorfulness, size, and aspect ratio. Features including contrast, details, shapes, and saliency are analyzed for monochromatic images. Both AQUINE and the monochromatic image program are used to determine aesthetic quality, which is represented to the viewer as a rating out of one hundred. For the retrieval module, the viewer can select SIMPLIcity (S) in order for exemplar images based on an evaluation of the input image’s texture, color, and shape features to be returned (Wang et al., 2001). Or, the viewer can select S+Composition (C) in order for the exemplar images returned to be further based on an evaluation of the input image’s composition. Or, finally, the viewer can select S+C+Aesthetics in order for the exemplar images returned to be based further on the information gathered by ACQUINE or the monochromatic image program (Wang et al., 2001).
Expanding on Advancements Made by OSCAR

The OSCAR application and similar applications that are sure to follow could prove very useful for many, particularly those handling large quantities of digital images. For instance, from a consumer perspective, such functionality as incorporated into OSCAR, could be integrated into photo management software, enabling new methods for organizing and querying images. Currently, the software also runs on mobile devices, allowing users to take a picture, run it through OSCAR, and instantly receive feedback on composition and aesthetics (Yao et al., 2012). I also see applications like OSCAR as part of a system for helping individuals interested in improving their visual communication skills. As explained in the OSCAR publication, “An effective way to learn photography is through observing master works and imitating” (Yao et al., 2012). Discussed towards the very end of the publication is future work expanding on OSCAR. For instance, a future version could provide feedback on placement of objects in a picture, based on principles of good composition (Yao et al., 2012). However, “observing master works” and receiving feedback on how to “improve” a photograph from a purely technical standpoint is unlikely to help a photographer convey their message in a more meaningful way. After all, the problem lies with the photographer facing the challenge of applying principles, he or she may not even truly understand, to unique circumstances in order to convey something. The situation the photographer may face is likely to be different from that whose photographs he or she may be viewing. As Wenyuan Yin et al. (2012) explain in their paper entitled, *Crowdsourced Learning to Photograph via Mobile Devices*, “Taking a high quality picture is a complex context-dependent process and many factors,
such as lighting, view angle, and view point, need to be considered.” Furthermore, viewing another individual’s photographs in the field is often impractical, as learning from others’ work often requires careful analysis. As discussed earlier, OSCAR utilizes ACQUINE. ACQUINE has actually been implemented into a mobile device, which goes by the name Nadia.

**Nadia: The Application of ACQUINE**

According to Charlie Sorrel (2010) of *Wired.com*, the user receives feedback prior to the picture being recorded. The user simply holds the camera up to whatever subject he or she is photographing. Nadia then returns an aesthetic rating as a percentage. The device itself is actually just a Nokia N73 cell phone, outfitted with a black, rectangular box. In order to obtain an aesthetic rating from the web application ACQUINE, Nadia needs to communicate with a nearby Mac via Bluetooth (Sorrel).

![Figure 4: Nadia camera showing a scene rating](image)
The Operation of ACQUINE

Having discussed a real-world application of ACQUINE, it is important to recognize how the Aesthetic Quality Inference Engine operates in order to understand to what extent it can assist in improving a photographer’s communication. While ACQUINE is first mentioned in “ACQUINE: Aesthetic Quality Inference Engine - Real-time Automatic Rating of Photo Aesthetics” (Datta & Wang, 2010), the research it is built upon is discussed in, “Studying Aesthetics in Photographic Images Using a Computational Approach” (Datta et al., 2006). The concept with which ACQUINE is designed is around the idea of aesthetics. As defined by the Oxford Advanced Learner’s Dictionary and also included in Datta et al., 2006 the word aesthetic is defined as: (1) “concerned with beauty and art and the understanding of beautiful things” (2) “made in an artistic way and beautiful to look at.” A reoccurring idea in both definitions is beauty. I do not believe that photographers always strive to communicate a sense of beauty through their photographs. While many enjoy photographs that are aesthetically pleasing, the purpose of art is to communicate, and how we communicate in a more compelling manner should be the focus. That said, ACQUINE is an important step in helping us to gain a better understanding of those characteristics that are considered aesthetically pleasing. Using 56 predictors based off of three criteria, ACQUINE is able to predict an aesthetic score for any input image. The three criteria with which the predictors where chosen include, “[…] (1) rules of thumb in photography, (2) common intuition, and (3) observed trends in ratings” (Datta et al., 2006). The following are the categories under which the predictors used to analyze an input image were chosen:
exposure of light and colorfulness, saturation and hue, the rule of thirds, familiarity measure, wavelet-based texture, size and aspect ratio, region composition, low depth of field indicators, and shape convexity.

A Crowdsourced Approach Using Mobile Devices

In a similar way that ACQUINE was adapted to run on a mobile device, the Nokia N73, Yin et al. proposed an approach of crowdsourced learning to photograph via a mobile device. The system takes into account “image content, context, and crowdsourced social media information” (Yin et al., 2012). In the publication entitled Crowdsourced Learning to Photograph via Mobile Devices three major contributions associated with the “crowdsourced learning approach to photograph via mobile devices” are presented. The system operates in the following manner. The ‘input view’ (i.e. the picture) and associated metadata including “the current geo-location and time as input […] are transmitted to [the] cloud media server and then three stages are performed: contextual image search, composition learning and photograph suggestion” (Yin et al., 2012). The purpose of the system is to suggest the optimal view enclosure. In other words, the system indicates what it believes to be the optimal framing in order for the mobile user to achieve the “best photo composition” (Yin et al., 2012). First:

“In [the] contextual image search stage, relevant images in terms of similarity on both contexts and content with the input view are obtained by crowdsourcing.
Images taken at the same geo-location and during the same time period are retrieved and further selected based on visual similarity with the input view.”

Second:

“Composition learning is carried out to discover photography knowledge in the input scene by utilizing the crowdsourced relevant photos. Discriminative features are selected and a composition regression model is learned to predict the composition aesthetics of images containing similar objects in the specific geo-location and time period.”

Third:

“With the regression model, the aesthetic score of different view enclosures at various scales of the input view can be predicted. To suggest the optimal view enclosure, we search the view rectangles in a hierarchical way and transmit the one with the highest aesthetic score to the end user for photograph suggestion.”

So, even though “[…] computer vision literature shows considerable interest in using sharpness and colorfulness as attributes of photograph aesthetics […]” as Todd S. Sachs et al. (2011) explain in their publication entitled “A Data-Driven Approach to Understanding Skill in Photographic Composition,” it has been shown that composition is far more important. While I do believe that such an argument is largely up for debate, the crowdsourced learning to photograph approach discussed in Yin et al. (2012), takes into consideration a crucial factor. “[…] A general composition model is not sufficient to model the professional composition knowledge since in different scenes containing various objects under a variety of contexts, professional photographers tend to compose
photos in different manners” (Yin et al., 2012) I agree that composition should not be generalized, as no two scenes are exactly the same and thus it would be inappropriate to assume that such scenes can be approached in the exact same manner. Any system intended to help individuals improve their photography needs to take into account the individual’s intent. As previously discussed, intent is crucial. And, since photography is a means of communication, then putting one and one together, anyone taking pictures should be intentionally trying to communicate. Consequently, a system intended to help individuals improve their photography should start and finish by addressing intentional communication.

An Alternative Solution

In Chapter 4, I propose a photographic system that is in some ways similar to what has been previously discussed. Like in Yin et al. (2012), I too would leverage the power of crowdsourcing. Similar to OSCAR, the system I propose would also be comprised of several parts, each of which would analyze a specific property of an image. OSCAR, Nadia (the application of ACQUINE), and the crowdsourced learning approach (Yin et al., 2012) can all help individuals improve their photography to a certain extent. The system I propose is intended to teach the communicative aspect of photography. It would help individuals learn how to visually communicate, while actually taking pictures. However, where the system is particularly distinct is in its operation as a whole, starting from its method of data collection. Also, rather than trying to determine whether
a photograph is simply “good” or “bad,” “aesthetically pleasing” or “non-aesthetically pleasing,” the system I propose would provide feedback on how effectively, or ineffectively, the image communicates what the photographer intended. It would also provide feedback on how the image can be constructed to communicate whatever is intended more effectively.

Photographers who have any desire to create photographs that will be shown to an audience should have some understanding of how human attention and association work. The dataset and the operation of the system would take into account both those concepts. The following chapter introduces principles of human attention and association.
Chapter 3

Background on Human Perception

We can start addressing the challenge of helping the average individual improve their ability to visually communicate by providing alternative and more effective systems for learning by leveraging advancements in technologies like OSCAR. Rather than placing the focus on generally accepted “rules,” photographers, particularly amateur photographers, need guidance on how to most effectively communicate once they are aware of their intent. Oftentimes, professional photographers will seek to establish something of a relationship with whomever or with whatever he or she is photographing. As Richard D. Zakia (2002), author of Perception & Imaging explains, “The relationship established between the photographer and what is being photographed is a critical one” (p. 192). Whether an animate or inanimate object, establishing a relationship can enable the photographer to communicate a deeper understanding then can be grasped at “face value.” Zakia (2002) further explains that at least three different approaches to establishing a relationship are possible.

“The first is called projection; the photographer projects onto the object what he or she feels at the time. If the object is a tree and the photographer sees the tree as standing tall and proud, then the photographer attempts to capture that feeling. The next level is one of introjection. Here the photographer spends time looking at the tree and studying it in a quiet way, attempting to ‘listen’ to what the tree has
to reveal. The photographer then tries to photograph that quality of the tree. The third approach, confluence, is a highly meditative one in which the tree and the photographer become as one and the photograph reveals that intimate relationship” (pp. 192-93).

Having an understanding of what one is trying to achieve is important. It is also important that the photographer have an understanding of how human attention works in order that such information can be used to help achieve the desired communicative results.

An important point to stress is that of the figure-ground relationship. As Zakia (2002) explains, “Whenever we look at a heterogeneous visual field, that which we see as an object is called figure, and the figure is always seen against some background. The first step in perception is distinguishing figure from ground” (pp. 3-4). Do you see the silhouette of a saxophone player and face of a woman in Figure 5? It is interesting to note, as done by Zakia, that while the psychology field uses the phrase figure-ground, other disciplines use other phrases to describe that same concept. For example, the art disciplines tend to use the phrase positive-negative space, whereas engineering disciplines use the phrase signal-to-noise ratio (Zakia, 2002, p. 6). “Increasing the differences between figure and ground (negative and positive space, or signal and noise) increases the vividness of the corresponding perception,” Zakia (2002) explains (p. 6). For that reason, it is crucial that a photographer have an adequate
understanding of the relationship (i.e. knows what influences the selection of figure in a figure-ground relationship) and is able to apply such knowledge in reality. But, what characteristics of an image influence a viewer from distinguishing figure from ground? In order to answer that question, it makes sense to turn to Gestalt psychology. Gestalt psychology is used to explain how “[…] visual elements within a person’s visual field are either attracted to each other (grouped) or repelled (not grouped)” (Zakia, 2002, p. 28). The Gestalt laws that “[…] describe how grouping occurs within a context or field” include proximity, similarity, continuity, and closure (Zakia, 2002, p. 28). Zakia explains that the four Gestalt principles mentioned above “[…] are important to conceptualize, because if a photographer knows how a person most probably organizes or groups visual elements when looking at a picture, the elements can be arranged to favor or disfavor certain groupings” (Zakia, 2002, p. 29). Below is a brief explanation of each of the four Gestalt principles as discussed by Zakia (2002) in Perception and Imaging:

**Proximity**  “The closer two or more visual elements are, the greater the probability that they will be seen as a group or pattern” (p. 30).

**Similarity**  “Visual elements that are similar (in shape, size, color, movement, and so on) tend to be seen as related. When we see things that are related we naturally group them and therefore see them as patterns” (p. 38).

**Continuity**  “Visual elements that require the fewest numbers of interruptions will be grouped to form continuous straight or curved lines” (p. 48).

**Closure**  “Nearly complete familiar lines and shapes are more readily seen as complete (closed) than incomplete lines and shapes” (p. 56).
Zakia (2002) explains, “The overall rational for why people organize and group information the way they do is explained in part by the law of Pragnanz” (p. 61). According to Zakia (2002):

“This, it is thought, the meaning of the law of Pragnanz. We tend to organize our world so that we can cope with it. We search for stability, meaning, balance, security, and so on. We feel more comfortable when what we are looking at can be comprehended or experienced. If too much information is presented at one time, we either filter out some of it or simplify it by grouping or “chunking” it. If there is insufficient information, we add to it to form a closure and maintain meaning. We strive to reduce tension and stress to obtain stability and equilibrium” (p. 63).

Along with the Gestalt principles and the law of Pragnanz, an understanding of how people make sense of what they see when they view a photograph can also be valuable. In other words, it is important to be aware of associations. As Zakia (2002) explains:

“Another way to think of association is in terms of what Alfred Stieglitz and his followers called equivalents. In simple terms, it is the ability of one thing to bring to mind something else. A photograph can serve as an equivalent that triggers memory and elicits certain feelings and experiences” (p. 85).
While much research has provided insight into how humans interpret imagery (i.e. photographs), little if any has been done in the way of creating educational photographic applications leveraging the insight we have gained from such research.
Chapter 4

Photographic Intentional Communication System (PICS)

PICS Proposal

Initially, an ‘in the field’ learning system could take the form of a mobile application. Eventually, the system could be integrated into higher end cameras. The goal of the system would be to help individuals craft images in camera, truer to their intent. Rather than randomly packing features into such an application, it is important to understand how to design a system that can help enable effective learning. From the foundations of the system, questions of how learning occurs need to be answered and learning principles need to be applied if the application is to serve its purpose effectively. According to the authors of, How Learning Works, “Goal-directed practice\(^1\) coupled with targeted feedback\(^2\) is critical to learning” (Ambrose et al., 2010). As applied to the photography application, users could be evaluated on assignments centered on developing and conveying intent. Feedback specific to each individual’s efforts to visually communicate could be given at particular intervals during the assignment, as

\(^1\) “[…] An activity in which student engage their knowledge or skills (for example creating an argument, solving a problem, or writing a paper)” (Ambrose et al., 2010)

\(^2\) “[…] Information given to students about their performance that guides future behavior” (Ambrose et al., 2010)
well as afterwards. The photography application could be modeled after the *Cycle of Practice*, represented below.

![Diagram](image)

*Figure 7: Cycle of Practice and Feedback (Ambrose, 2010, p. 126)*
Learning Theory Applied

The graphic can be explained as follows: practice leads to observed performance that, in turn, allows for targeted feedback, which guides further practice (Ambrose et al., 2010). All three elements of the cycle: practice, observed performance, and targeted feedback, should operate in accordance to achieving a common goal. In the most general sense, the goal of the photography application would be to help photographers craft photographs that convey their intentions more effectively. For example, let’s say a photographer wants to create two photographs of a teddy bear. In the first image, the photographer’s intent is to depict a teddy bear that is friendly. In the second image, the photographer’s intent is to depict a teddy bear that is scary. After inputting the desired intent into the application, it would then have the ability to help the photographer achieve his or her input intent.

PICS Design & Functionality

The Photographic Intentional Communication System (PICS) is made up of two sections, each composed of five modules (see Figure 2). The modules that make up section (I) are highlighted in orange. The modules that make up section (II) are highlighted in purple. It is also important to note that each module would utilize data stored in a central database (not illustrated). Certain modules rely on information generated from data processed by other modules.
Section (I), depicted in Figure 8 as the collection of orange modules comprises the mobile portion of the system. In order for a user to access the learning application, he or she would download the learning application onto their mobile device. From there, the user could upload an image and receive intent specific feedback in near real-time. Such feedback is based on information gathered from a crowdsourced library of evaluated and analyzed images, which is constructed in section (II). Section (II), depicted in Figure 8 as the collection of purple modules, accomplishes two main objectives. First, it provides the capabilities by which images can be categorized and features identified such that information valuable to understanding human perception and interpretation can be gained. Second, similar to section (I), section (II) would also output intent specific feedback in near real-time. Since a rating is recorded on how well the photographer’s explanation corresponds with the viewer’s explanation, users would also be presented with a number conveying the extent to which the photographer’s intent is consistent with
what is actually being communicated. However, unlike the mobile portion of the system, this portion of the system is not designed to operate as a structured learning program, utilizing the *Cycle of Practice* (Ambrose et al., 2010). In order for helpful suggestions that are relevant to the mobile user’s input intent to be output, as occurs in section (I), a large dataset from which an input image’s features can be compared needs to exist. Section (II) would provide the architecture from which such a dataset can be built. An explanation of the operation performed in each module is given below.
Figure 9: Explanation of each modules’ functionality in Section (I) and Section (II) of the PICS
The uploading and rating of photographs in section (II) would be a continual process. At some point, once a large enough dataset has been constructed, the system would be able to operate on its own, making reasonable judgments on the perceived intent being conveyed by an image without an absolute need for data acquired via human input. The mobile application, part of section (I), would be downloaded onto devices with Internet and camera capability. Going back to the friendly/scary teddy bear examples, once the photographer uploaded an image with their specific intent, the following suggestions may be provided to depict a teddy bear that is friendly:

1. *Position the light source above the camera with the light source pointed towards your subject forming a 45° angle between the light source, subject, and camera.*

2. *Illuminate the subject with a soft quality of light.*

3. *Remove any distracting elements from the background.*

Image 10: Friendly teddy bear
The following suggestions may be provided to depict a teddy bear that is scary:

(1) *Position the light source below the camera with the light source pointed towards your subject forming a 45° angle between the light source, subject, and camera.*

(2) *Illuminate the subject with a hard quality of light.*

(3) *Remove any distracting elements from the background.*

Image 11: Scary teddy bear

The user would be able to click on the suggestions in order to receive further clarification and read about why the suggestion was proposed. The photographer could then make the adjustments, retake the image, and again upload it via the mobile application for further analysis. Based on the Gestalt principles previously discussed, the application would also provide the user with insight into the areas of the photograph where the viewers’ attention would most likely be focused. A partially transparent color overlay could be used to indicate to the photographer the areas of the photograph where
the proximity, similarity, continuity, and closure principles have the greatest impact. Such an image assisting application would not only allow individuals to learn about techniques critical for more intentional visual communication, but it would also allow those individuals to practice the techniques immediately, receiving custom feedback aimed at helping them improve their visual communication abilities.

**Functionality Specific to Assessing Progress**

According to Ambrose et al. (2010), in order to effectively advance learning and performance, practice must (1) focus “on a specific goal or criterion for performance,” (2) target “an appropriate level of challenge relative to students” current performance, and (3) be “of sufficient quantity and frequency to meet the performance criteria.” As previously mentioned, the goal of the application would be to help individuals improve their ability to communicate visually. Feedback would come in the form of near ‘real-time’ suggestions. Movement of ‘progress’ along a progress bar could be used to help the user visualize short-term progress. As the user improves his or her visual communication abilities (i.e. less image attempts are necessary to achieve intent), the progress bar would fill. ‘Levels’ could be utilized to illustrate long-term progress. Once the progress bar is filled, the user would advance to a higher-level. In order to determine the appropriate level of challenge from which an individual can begin, a built-in evaluation could be given. This evaluation or knowledge assessment could be comprised of questions aimed at establishing the user’s experience. Another method of determining the level at which the user should begin could consist of having the user try and visually
communicate a series of intents, then automatically assigning a level based off that performance. Of course, the higher the level, the more challenging it is to fill the progress bar, as expectations are greater. It is also important that practice is of sufficient quantity and frequency if the individual is to improve. As an incentive to continually practice, the ‘progress’ along the progress bar would decrease as an individual’s skills begin to falter, likely a result of insufficient quantity and/or frequency of practice.

**Design and Functionality Specific to the Mobile Application Portion of System**

The application would be invaluable to individuals wanting to receive feedback right on scene. However, it is critical to remember that the application would purely be intended to serve as a guide. Users should not depend on it for conveying the one and only ‘ruling’ on the success of an image. It should only be viewed as a single source of feedback, helping users learn and apply known techniques useful for conveying specific intents. Ambrose et al. make the point that feedback should not necessarily be instantaneous since immediacy could result in people “[…] missing the opportunity to practice recognizing and repairing their own errors” (Ambrose et al., 2010). In order to minimize the likelihood of users failing to gain and/or improve a critical eye for evaluating images, and simply relying on an automated system to think for them, the application could operate under constraints. For example, such a constraint might work as follows: once an individual comes upon a scene he or she wants to photograph, the individual will have to input their intent. And, only after recording a fixed number of images—say 7—will the individual then be able to choose a single image from the set on
which feedback is desired because he or she believes the chosen image most effectively conveys their desired intent. As users advance to higher levels, the number of images required before a single image can be selected and analyzed could decrease. Ideally, as individuals develop an eye for effectively translating the 3-D world onto a 2-D screen, the number of frames required before an effective image is taken should decrease. To reiterate, “It is best to find a type and frequency of feedback that allows students to reap the benefits of feedback while staying actively engaged in monitoring their own learning—in other words, feedback that does not undermine students’ progress in becoming independent, self-regulated learners” (Ambrose et al., 2010). Many in the photography community will argue that one of the best ways to learn photography is by looking at the work of others and critically analyzing it. Ambrose et al. explains that showing what target performance looks like along with highlighting weak features can help students get more engaged (Ambrose et al., 2010). However, rather than just showing images considered either strong or weak, it is important to include an explanation of why, particularly for beginning photographers who are just starting to learn techniques useful for communicating specific intents. Additionally, rather than showing examples of exemplary images categorized by genre, for instance, the images could be chosen as a result of communicating something identical or similar to what the user is trying to communicate.
Functionality Specific to Web-based Portion of System

In addition to functioning as the location where images and their associated intents can be uploaded, ratings assigned, and analysis offered, the web-based system could also be designed as a place where individuals may simply receive feedback on any of their images. In other words, like the mobile application, a user would be able to receive feedback on how well he or she visually communicated, as well as suggestions for improving intent. However, as previously mentioned, unlike the mobile application, it would not be specifically geared towards learning.

Benefits of the Web-based Portion’s Functionality

Simply having the capability to determine how well an image communicates what a photographer intended would be invaluable. A former student of Garry Winogrand, an influential street photographer in the mid-20th century recounted, “[Winogrand] often added that photographers mistake the emotion they feel while taking the picture as judgment that the photograph is good” (O.C., 2007). When photographers do not take the time to ‘step-back’ from their images and emotionally disconnect from a scene, the photographer may be unable to recognize that an image does not communicate to viewers as the photographer intended. After all, by the very nature of the photographer’s situation, a degree of biasness towards the interpretation of the photograph is present. When a photographer looks back at his/her own work, he or she may be able to recall past stimuli, such as sounds or physical feelings, and associate those with the scene previously photographed. A viewer is not privileged to such information when trying to
comprehend a photograph. Not only would the system have the capability of providing a non-biased evaluation, it would also be able to provide a quick evaluation, narrowing down a potentially large quantity of images. While such a system could prove quite useful within the photographic community, as well as amongst individuals in other fields where imagery is heavily relied upon, the initial challenge involves collecting relevant data, as previously mentioned.
Chapter 5
Method of Data Collection

State of the Art in Consumer Imaging

In 2012, Lytro, a California based startup, introduced a consumer camera with technology that has great potential to impact the photography field. For well over a decade, digital cameras have provided consumers numerous luxuries including the ability to change exposure, crop, and make a number of other adjustments, all with relative ease after a picture is taken. However, even on high-end cameras, if the focus is off, a picture tends to lose much of its aesthetic value and may become unusable and in some cases the content of the image may be unrecognizable. With the advent of light-field technology, the Lytro camera enables the user to focus on any area of an image even after it is taken.

Taking pictures that can be refocused after the fact requires that the Lytro camera record much more information upfront than traditional digital cameras record. As Mark Harris (2012) explains in an article on Spectrum.ieee.org:

“Instead of merely recording the sum of all the light rays falling on each photosite, a light-field camera aims to measure the intensity and direction of every incoming ray. With that information, you can generate not just one but every possible image of whatever is within the camera’s field of view at that moment.”

At this point, the Lytro camera is in its infancy stage. The camera itself has only three controls including an on-off switch, a shutter button, and a zoom function. A couple of
its greatest limitations at this point are its 1.2 megapixel image resolution and inability to take video. While light-field technology has potential to significantly impact the consumer-imaging field, the decreasing cost of storage space has revolutionized how images and information in general is stored and distributed.

**Current Photo Sharing Websites - Capabilities and Shortcomings**

With respect to imagery, websites like Flickr, Pinterest, 500px, Deviantart, and others all provide virtually anyone with Internet access the ability to share images with the public. But, as a consumer interested in accessing and viewing imagery, where does one start? After all, content is continuously being uploaded to the Internet and finding imagery specific to your interest(s) can be a daunting task. To some extent, the websites previously listed provide users with the ability to filter content from continually expanding libraries. For instance, users can input key terms into a browser window in order to perform a search, hopefully resulting in the return of relevant content. Unfortunately, many of these websites only return content that is ‘tagged’ with the word(s) that the user used to search. And, content is often tagged only by the content uploader or other users. Many services including 500px also provide users the ability to select categories such as ‘animals’ or ‘landscapes’. This enables users to narrow their search to some extent, however, the contents of categorizes can often be further specified for ease of search.
Need for Greater Search Functionality

As light-field technology and other imaging advancements make creating good quality pictures easier and are integrated into mobile devices, the number of pictures people upload to photo sharing websites is likely to increase. Without more advanced ways of making sense of libraries of content, it could be challenging for end-users to retrieve desired content from websites such as Flickr, Pinterest, 500px, Deviantart, and others. In fact, let us say a user wants to locate a series of images that evoke the feeling of joy. If that user were to input ‘joy’ into the photo sharing site’s search browser, only a small percentage of returned content is likely to evoke the desired emotion. Some of the images may include the word joy. Some of the images may be of people experiencing joy. Basically, images tagged with the keyword ‘joy’ are returned regardless of whether or the not the images actually evoke any feeling of joy. Currently it is very challenging to locate images that fit specific criteria.

Research Efforts

Under the guidance of Pennsylvania State University Professor, Dr. James Z. Wang, graduate students, Xin Lu and Baris Kandemir, are creating a dataset geared towards understanding the relationships between visual stimuli (i.e. images) and human emotions. Assisting with the research project are undergraduate students, Michael Costa and I. Part of gaining an understanding of the relationship between visual stimuli and human emotions means being able to quantify those factors in such a way that computers can ‘understand’ and ‘learn’. An end goal, for example, would be that an individual
could upload an image to a software program that could evaluate the image, correctly tagging the image with accurate emotional terminology that describe, for example, how an individual may feel when viewing the image and/or the emotion that individuals within an image are expressing. Such operation, which computers have the potential to perform quicker than humans, would be based on a significant dataset of previously labeled content. We are in the early stages of constructing such a dataset.

**Semantical Meaning and Our Research Interest**

Generally, the meaning that exists between visual stimuli and human emotions can be described as “semantical meaning – the relation of signs to their significates” (Osgood et al., 1957, p. 3). As Charles E. Osgood (1957) argued in *Measurement of Meaning*, “Whenever some stimulus other than the significate is contiguous with the significate, it will acquire an increment of association with some portion of the total behavior elicited by the significate as a representational mediation process” (p. 6). Osgood (1957) further explain, “[…] Words represent things because they produce in human organisms some replica of the actual behavior toward these things, as a mediation process” (p. 7). What we are interested in studying is “the mechanism that ties particular signs to particular significates rather than others” (Osgood et al., 1957, p. 7). In summary, Osgood (1957) explains:

“A pattern of stimulation which is not the significate is a sign of that significate if it evokes in the organism a mediating process, this process (a) being some fractional part of the total behavior elected by the significate and (b) producing
responses which would not occur without the previous contiguity of non-significate and significate patterns of stimulation” (p. 7).

More specifically, we are interested in quantifying the relationship between color images and human emotions in order that computers can learn to interpret images from a human perspective. The critical tool we utilize to collect fundamental participant data is the Self-Assessment Manikin or SAM, a series of semantic scales. Osgood explains, “Each semantic scale, defined by a pair of polar (opposite-in-meaning) adjectives, is assumed to represent a straight line function that passes through the origin of this space, and a sample of such scales then represents a multidimensional space” (p. 25). The result of utilizing such scales is semantic differentiation: “[…] the successive allocation of a concept to a point in the multidimensional semantic space by selection from among a set of given scaled semantic alternatives” (Osgood et al., 1957, p. 25).

Semantic Scale

Using the semantic scale, SAM, ratings are taken based the 3-dimensions of valence, arousal, and dominance. Initially, using factor analysis, Charles E. Osgood was able to identify three judgment factors: evaluative, potency, and activity that account for a significant portion of the variance among descriptive scales (i.e. good-bad) (Osgood et al., 1957). Building on this, Albert Mehrabian, a social psychologist “suggested that these three judgment factors are related to three fundamental emotional responses […]” (Lang, 1980, p. 122). In An Approach to Environmental Psychology, Mehrabian & Russell explain, “These studies defined arousal (the activity factor that was obtained from
studies with this method) and pleasure (the evaluation factor) as basic responses to stimuli, and also suggested a third dimension (potency)” (Mehrabian & Russell, 1974, p. 16).

**Structure of Study**

The scales we use to account for each dimension are happy-unhappy (*valence*), excited-calm (*arousal*), and submissive-dominant (*dominance*). Along with collecting data associated with degrees of valence, arousal, and dominance, we are also interested in simply identifying what general emotions study participants associate with a given image.

In order to collect such data, we will present participants with a short list of emotions based on a paper entitled, “Emotional Category Data on Images From the International Affective Picture System” (Mikels et al., 2005). The emotion terms we chose to list include: Amusement, Anger, Awe, Contentment, Disgust, Excitement, Fear, and Sadness. We also provide participants the opportunity to enter one or more emotions.
not provided in our list, into a blank textbox. The last thing we ask participants to provide is a rating on how much they like or dislike an image. The scale provided allows participants to select one of seven options, which range from “dislike extremely” to “like extremely” (Sudre et al., 2012).

**Distinguishing Factors of Our Study**

There are a number of key factors that distinguish our study from that presented in Lang’s IAPS instruction manual. For instance, all of our data will be collected electronically. Rather than using a static SAM instrument, we chose to implement a dynamic SAM instrument. Like the SAM instrument utilized in the IAPS study, our dynamic SAM instrument is based on a 9-point rating scale. The appearance of dynamic SAM can easily be manipulated by sliding a solid bubble along a bar. The expressions of dynamic SAM change fluidly, contributing to a more intuitive rating experience for participants. Another distinguishing factor is that the bulk of data we collect will come from users of Amazon’s Mechanical Turk, “an online labor market where requestors post jobs and workers choose which jobs to do for pay” (Mason & Suri, 2012). In a publication entitled “Conducting Behavioral Research on Amazon’s Mechanical Turk,” an in-depth and comprehensive examination...
of the platform is given. They explain some of the main benefits of Mechanical Turk include: “(1) subject pool access, (2) subject pool diversity, (3) low cost” (Mason & Suri, 2012).
Chapter 6

Conclusion

As computing power has increased over the past decade, a variety of advancements have been made in fields such as computer-human interaction and computational image analysis. Programs now exist that will tell us, more or less, what images from a series are most aesthetically pleasing, as well as how we ‘should’ be composing a photograph. With these and other related advancements, one may ask the question, Will computers replace photographers and/or the need to carry a camera? In other words, will computers be able to intelligently compose a photograph and account for all other aspects that would be of interest to a professional photographer or other individual?

I believe computers will be able to create photographs independent of human input—photographs humans still value. Today, computers do have the ability to make decisions, accounting for one more variables. It is only a matter of time before computers are able to determine from a scene what “should” be photographed and exactly when to trigger the shutter button. However, the more roles an individual must play until “arriving” at a photograph, the less likely a computer is to adequately replace a human. For instance, for many professional photographers, there are a variety of steps that lead up to the final photograph such as making physical adjustments to the lighting setup, eliciting the desired reaction from the subject, or knowing how to rearrange any number of elements in a photo studio or on location. For the foreseeable future, computers will
only be able to supplement the work of photographers. That said, it is not hard to imagine a personalized, coffee mug sized hovering robot, following a family around on vacation—constantly evaluating scenes and situations—telling the family when to stop and pose for a photograph.
Appendix A

Study Procedure

Our study is partially modeled off Peter J. Lang’s publication, “International Affective Picture System (IAPS): Affective rating of Pictures and Instruction Manual.”

See below for study participant instructions.

Overview:

Thank you for taking the time to participate in our study intended to further understanding on the relationship between visual stimuli and human emotions. In this study, we are interested in collecting data on how you respond to a series of color images. In total, we would like you to evaluate 200-250 images or as many as possible in 1-hour.

Before we begin, please take 5-10 minutes to read through these instructions intended to help you successfully complete this study.

Once you click the “Start” button, a page with the words: “The survey will begin in 5 seconds” will display. Use this time to ensure that you are ready for the task. After those 5 seconds, you will be presented with an image. You will have 6 seconds to observe the image before it disappears. Afterwards, a page with 3 sections will display. Please take 13-15 seconds to fill out the 3 sections. It may take a bit more time to complete the 3 sections at first until you get used to the format.

Section (I) consists of three scales:

1 for Valence (degree of feeling happy vs. unhappy),

1 for Arousal (degree of feeling excited vs. calm), and
I for Dominance (degree of feeling **submissive vs. dominant**)

Note: Use all three scales to evaluate each image.

Section (II) is where you select one or more *Emotions* if applicable.

Section (III) is where you rate how much you *Like* or *Dislike* an image.

Please fill out all 3 Sections based on the image you viewed. If you need to refer back to the image, click “Reshow Image” in the upper left part of the screen. Click “Hide” to return to the 3 Sections. Once you have filled out all 3 Sections for an image, please move on to the next image by clicking the “Next” button at the bottom of the screen.

**Section (I):**

For the first section, please adjust each of the dynamic SAM figures, which illustrate varying degrees of *Valence*, *Arousal*, and *Dominance* respectively, by sliding the solid bubble along each of the bars. As you move the solid bubble along any one of the bars, observe how the expression of the associated SAM figure changes. Please indicate how you ACTUALLY FELT WHILE YOU OBSERVED THE IMAGE by adjusting the solid bubble, so that the expression of the SAM figure closely resembles how you ACTUALLY FELT WHILE YOU OBSERVED THE IMAGE. Please make one judgment per the *Valence* scale, the *Arousal* scale, and the *Dominance* scale.

All three scales are arranged such that each extreme is located at either of the ends. On the *Valence* scale, moving the solid bubble to the far left indicates completely **Happy** where as moving the solid bubble to the far right indicates completely **Unhappy**. On the *Arousal* scale, the same is true in order to indicate completely **Excited** and completely **Calm**. The same is also true on the *Dominance* scale, in order to indicate
completely **Submissive** and completely **Dominant**. You may or may not feel an extreme (i.e. completely Happy) about any image or every image which is why you can make a rating anywhere along all three scales.

**Section (II):**

For the second section, please click the checkbox next to the words, *“Click here if you felt any emotion(s) while viewing the image.”* If you did not feel an emotion after viewing the image, do not click the checkbox. Please move to section three.

Assuming you click the checkbox, a collection of words will appear. Select the checkbox(s) next to the one or more emotions you ACTUALLY FELT WHILE YOU OBSERVED THE IMAGE. If the emotions you felt do not exist in the list provided, click the checkbox next to “Other” and enter the emotion(s) you felt.

**Section (III):**

For the third section, please rate how much you **Like** or **Dislike** the image by clicking in the bubble underneath the phrase that tells how much you like or dislike the image. If you find that you neither like nor dislike the image, click in the bubble underneath the words “**Neither like nor dislike**”.

**Concluding Remarks:**

Throughout the entire process there are no right or wrong answers.

Once ratings for every image have been input, a button with the words “Finish” will display. Please click “Finish”.

**Review:**

Step 1 Click the “Start” button, after 5 seconds you will be presented with an image.

Step 2 View the image that displays for 6 seconds.
Step 3 Next, a page with 3 sections will display.

For Section (I), please make a rating on each scale (Valence, Arousal, and Dominance), based on how you ACTUALLY FELT WHILE YOU OBSERVED THE IMAGE.

Complete Section (II) only if you felt emotions by selecting one or more of the Emotions you felt and/or by entering the emotion(s) you felt into "Other."

For Section (III) rate how much you Like or Dislike the image. Click “Next” in the lower right hand corner when you have finished all 3 Sections.

Step 4 Repeat “Step 2” and “Step 3” until a button with the words “Finish” is displayed.

Step 5 Click the “Finish” button.
REFERENCES


Cycle of Practice and Feedback. Illustration showing the cycle of practice. Recreated from How Learning Works: Seven Research-Based Principles for Smart Teaching (p. 126), by S. A. Ambrose, et al., 2010, Wiley.


ACADEMIC VITA

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