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Forensic Science Detection of Composite Photographs

Dissertation submitted in partial fulfillment for the Degree of Bachelor of Science in Forensic Science

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CERTIFICATE

This is to certify that the dissertation entitled

"Forensic Science Detection of Composite Photographs"

is the bonafide record of research work done by

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ABSTRACT

Photograph that is suspected to be forged one is occasionally encountered by the forensic practitioner for identification. This kind of examination is one of the most challenging problems in forensic photography. This identification is dependent on the existence of certain characteristics like inconsistencies in magnification, contrast and perspective. The study is intended to probe further into the salient features of photograph that can be used to identify a composite/forged photograph. The study is limited to composite/forged photograph produced by conventional montage techniques.

Photography experiments demonstrating the variation as a result of changes in focal length, aperture (f-stop number), object distance, lighting, shadow formations and film ISO film rating are performed. Important features that could be used in the identification of a composite/forged photograph were documented.

A questioned photograph has been produced with photomontage technique. This questioned photograph is forensically examined and identified as forged a one.

INTRODUCTION

Photography

Sir John Herschel first coined the word "Photography" in 1839. Coincidently, photographic process became public on the same year. The word is derived from the Greek words for light and writing (Leggat, 2001). "Photos" means light in Greek and "graphos" means writing in Greek. Essentially, "photography" means writing with light (Redsicker, 2001).

The production of photographs involves use of the camera and its relevant accessories like filters and other photographic materials and different photographic processes. Today, after many years of development, the process of photography and making prints had reached new heights. One particular contribution of great significance is by George Eastman who introduced the flexible film in 1884. Four years later, he introduced the box camera incorporating the roll film; and with his slogan "You press the button, we do the rest" he brought photography to the masses (Leggat, 2001).

In modern society, photography techniques are utilized as a convenient method to record visual information. The ultimate product of photography - the photograph is an important medium to convey visual information.

Forensic Photography

The role of photography in forensic science investigation is well known. Essentially it serves as a means to provide permanent and accurate record of crime scene and evidence. It is not to be expected that the scene of crime will be left undisturbed for an indefinite time. The position and condition of the details of the evidence must be made before they are altered in any way. In many situations, unless a photographic record is made, vital evidence may be lost. For legal as well as scientific purposes, it is desirable that a record of the original appearance be retained.

Special technique of photography can extend our range of vision. The human eye is sensitive to only a small portion of the electromagnetic spectrum. The eye cannot detect the infrared and ultraviolet regions, but the radiations affect certain photographic emulsions/materials. Hence photography by using these radiations will bring out details, which our eyes fail to see. The invisible radiation photography is utilized to discern of decipher the relatively unknown invisible in forensic science.

If ink lines and other things superimpose on important writing, it is possible to render the writing visible by means of infrared photograph. Similarly fraudulent documents can be distinguished by means of ultraviolet photography (ultraviolet fluorescence).

Certain characteristics of evidence (e.g. spermatozoa) are such that they are too small to be seen by the human eyes. Photography proves a valuable aid in the form of photomicrography.

In order to explain the case findings, the expert witness makes use of photographs to illustrate his points. Fingerprint comparisons are best shown with greatly enlarged photographs mounted side by side, the characteristics indicated by arrows. Similarly handwriting cases are most clearly demonstrated by means of enlargement of photographs of the true and disputed writings.

Some of the less popular areas are identification of the camera from film negative and establishment of whether a photograph is genuine or forged one. These require specialized knowledge in their solutions. For the present work, we are immediately concerned with the processes employed in the production of composite/forged photograph and its identification.

Composite/Forged Photograph

Photographs are ubiquitous in modern world that their existence is assumed as truthful recording of events. Many will not query the truthfulness of a photograph. The proliferation of digital imaging technology has raised concern of the society regarding the truthfulness of a photograph.

Less is known that even without the help of digital imaging, composite/forged photograph can be created. By utilizing knowledge of photography and dark room techniques, composite/forged photograph can be produced. A skillful forger with extensive knowledge on photography can produce a forged photograph that may even fool an expert.

Methods that can be used to produce composite/forged photograph are montage and multiple prints. Montage involves constructing pictures form portion of various prints, arranging them so they join or overlap (Langford, 1992). The term multiple printing means printing two or more images on to the same sheet of printing paper so that they form one scene (Langford, 1992).

Application of such methods to produce legitimate evidence photograph or some work of art is acceptable. The abuse of such method to produce photograph that is fraudulent or fake in nature is unacceptable.

Although forged photograph can be produced, an intelligent forensic officer with sufficient tools and experience can detect even the best forged photographs. Forensic scientist equipped with sufficient experience and training in photography techniques, photographic processes and photographic materials can detect unnaturally occurring features in a questioned photograph. With the aids of tools such as hand lens and stereoscopic microscope, a forensic scientist will be able to reach an opinion concerning the truthfulness of a questioned photograph.

REVIEW OF LITERATURE

The following works describe the general technique of photography, production of montage and also the forensic examination of composite/forged photograph. Some of the pertinent literature is presented below.

There are several standard references that describe the various aspect of photography. O'Hara and Osterburg (1974) had given an excellent treatment of various photographic techniques employed in forensic science practice. Hedgecoe (1982) describes about camera and techniques of photography. He describes the evolution of camera from camera obscura to the present day sophisticated camera. Various components of a camera ranging from lens, shutter, aperture, viewfinder and film were discussed. He explained the basic idea, principle, advantages and disadvantages of Single Lens Reflex (SLR) camera.

Stroebel et al (1986) describes photographic materials such as photographic emulsions, films, and papers. They also explain in-depth about the black-and-white photographic development and color process.

Morton's textbook on photography covers many physics aspect of photography (Morton, 1994). This textbook provides information of photographic materials and processes, photographic optics, light sources for photography, photogrammetry, infrared recording, ultraviolet and fluorescence recording, close-up photography and photomacrography, photomicrography, photographic copying

and analysis using film. Jacobson et al (1988) describes the nature of light and explained the result of the interaction of the light with matter. They also describes topics about geometry of image formation such depth of field, depth of focus and perspective. Freeman (1980) dwelt on how focal length of a lens controls image size and also about various designs of the lens.

Langford (1992) suggests montage and multiple print as the methods of creative expression in the art of photography. Montage technique and multiple print techniques are explained in Langford's book. A montage is a construction of photographs arranged so that they join, overlap or blend with one another (Hedgecoe, 1982). The method of creating a montage or photomontage was outlined in Hedgecoe's book. Such techniques could be abused to forge a photograph that may have malicious intentions.

In the course of history, cases of photograph forgery are reported. Russ (2001) has expressed that the history of fakery in photographs is nearly as old as photography itself, and has been a source of concern and controversy just as long. He gave examples of photomontage (combining portions of different images) techniques usage that let Tom Hanks as Forrest Gump meet President Kennedy in a movie and during the Civil War to insert additional carnage into battle scenes or to place generals side by side in a portrait. The website "NEWSEUM: The Commissar Vanishes" had highlighted several instances of photograph forgery in the Soviet Union from 1929 to 1953 (NEWSEUM: The Commissar Vanishes) Forensic scientist of all age have been challenged to detect such forged photograph.

In a paper published in FBI Law Enforcement Bulletin (FBI Law Enforcement Bulletin, 1972) several characteristics of a photograph that can be used to detect a composite/forged photograph are mentioned. The characteristics include study of lighting on faces, difference in definition and difference grain pattern. A microscopic examination often reveals retouching marks not visible to the unaided eye.

Russ (2001) discusses some of the common errors that permit detection of forgeries in images. The errors are like inconsistency in size, inconsistency in orientation, inconsistency in contrast, inconsistency in lighting, technical or scientific inconsistency and occurrence of photograph in somewhere else.

Redsicker (2001) gives a number of suggestions for the identification of composite/forged photograph. He suggests that identification of salient features like shadow formation, relative magnification and perspective changes resulting from the use of different focal length lenses that can be used to identify a composite/forged photograph. Further more, he suggests that the consistency of facial and body outlines can be utilized to identify composite/forged photograph. Redsicker had also mentioned that careful scrutiny of the highlights and shadows in a photograph or negative can reveal attempts at deception.

An unusual case on the examination of a photograph involving Dr Kurt Waldheim (former President of Austria and former Secretary General of the United Nations) is reported in the literature (Crown, 1987). The evidence of interest here

is a photograph that was printed on Agfa-Brovira paper showing four men in German uniforms talking in front of an airplane at an airfield. The photograph was examined for evidence of photo montage, substitution, or retouching. The result has showed that shadows, facial and body outlines were proper. Further examination of details on the reverse side of the photograph had shown it to be consistent with the fact that the photograph was produced in the ordinary course of events in 1943. The photograph was concluded as a genuine photograph.

Among the several problems related to photography in forensic science, the examination of a questioned photograph is the most challenging. Such questioned photographs are encountered in cases of blackmailing, harassment and defamation. Much experience and specialized training are required to tackle such problems.

OBJECTIVE OF THE STUDY

The following are the objectives of this study:

1. To conduct experiments under controlled environment to produce photographs. The parameters of controlled environment are aperture size, shutter speed, focal length of lenses and film's ISO speed rating. Resultant photographs are systematically studied for naturally occurring features like magnification, depth, shadows, perspective effect, effect of film's grain size and others.

2. To produce a composite/forged photograph with photomontage techniques. The resultant photograph will be identified as forged one with the information gathered from the experiment.

3. To suggest a detailed examination procedure in identification of forged/composite photograph.

MATERIALS AND METHODS

Figure 1 shows flowchart depicting the work carried out.

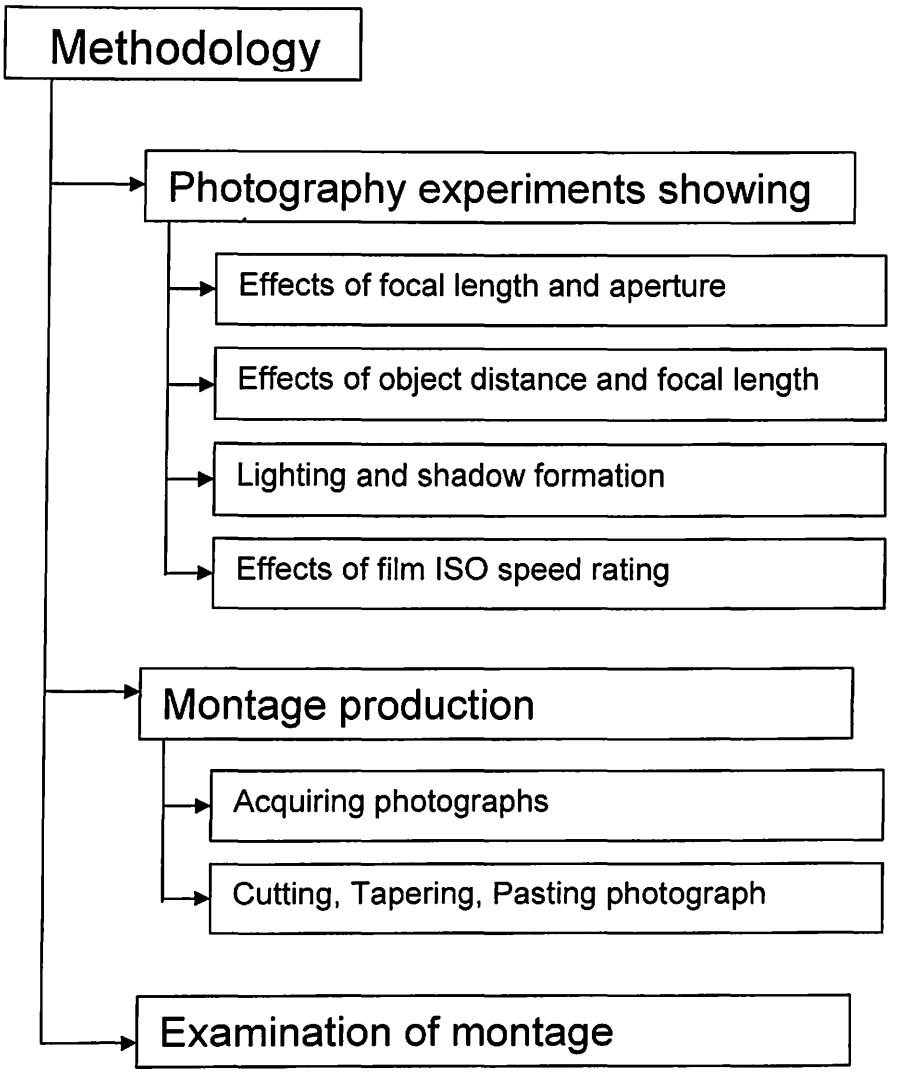

Figure 1: Methodology flowchart.

A brief account of the flow chart in Figure 1 is as follows:

First, a collection of photographs was produced under varied conditions. The conditions included use of lenses of different focal lengths, changes in object distance, changes in lighting and the usage film with different ISO speed rating.

The resultant photographs were studied to identify naturally occurring features such as shadows, depth, magnification, contrast and others.

Second, a good photomontage was produced. Conventional methods of the forger were employed in producing this photomontage.

Finally, the photomontage was examined and identified.

Equipments

Camera

The camera employed to produce photographs for the study was Nikon 35 mm FM10 Single Lens Reflex (SLR) camera with focal plane shutter and Through The Lens (TTL) metering system. It has film speed range of ISO 25 to ISO 3200 by 1/3 step. The shutter of this camera is a vertically moving metal focal plane shutter with settings of B, 1 – 1/2000 sec. For focusing, the camera uses a split-image microprism type surrounded by matte field. Nikon FM10 exposure metering is a TTL center-weighted full aperture exposure measuring system. It covers the metering range of EV2 to EV19 (ISO 100. F2, 1 sec. – F16, 1/2000 sec.)

Lens

For the purpose of producing photographs for experiment and making copy print of montage, a zoom lens was used. The zooms lens used was Zoom-Nikkor. It has a focal length of 35 mm to 70 mm. The speed of the lens is f/3.5-4.8. The available aperture settings on the lens are f/22, f/16, f/11, f/8, f/5.6 and f/3.5.

Film

The negative films from Kodak, FujiFilm and Konica were used to produce the photographs. The speed of the film negatives used was ISO 100 and ISO 800.

Accessories

Several additional equipments were used during the research work. A tripod - *Monfrotto professional* was employed. The tripod has 3 axis of rotation for the camera mounted on it. The height of the camera can be adjusted as well with a convenient crank.

For the purpose of illuminating indoor studio settings, 2 fill lamps and 1 spot lamp were utilized. The two fill lamps are of the same brand BronColor CH-4123 made by Bron Elektronik AG. The spot lamp is a Visatec Solo 800.

For the preparation of photomontage, a pair of sharp scissors was used to cut photographs. Cutting blade was used for certain difficult edges. In order to taper the outline edges of a photograph, two types of sandpapers - 600 Cw Electrocoated Silicon Carbide Abrasive Paper and Glass paper Grain Size 120 No 0 – were used. Solvent free non-toxic glue made by UHU was used as adhesive to paste photographs during montage.

For copying the montage photograph, Nikon Repro-Copy Outfit PF-4 with side illumination was used. Four 60-Watt tungsten lamps were used as side illumination lamps. Two types of blue colored filter were used to filter off yellow tint from tungsten lamps. The two filters were HOYA 90A and Nikon B8.

Good magnifiers (X2 and X10) and Leica zoom stereomicroscope (X5 – X20) were used during the examination of composite/forged photographs.

Lens focal length and aperture size effects on photograph

This experiment was performed to study the effect of focal length on the photograph produced. In addition to that, the experiment was designed to study the effect of aperture size on the photographs produced as well.

The camera and subjects were set up as shown in the following Figure 2. Subjects were place at a constant position. Then a distance of 2.5 m was measured from the subjects. Camera was positioned at a constant distance of 2.5 from subjects. The distance provided the medium shot.

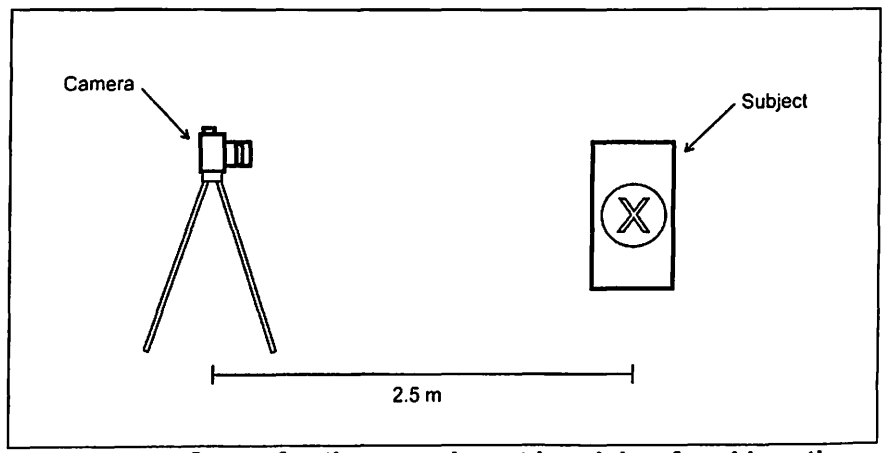

Figure 2: Setup for the experiment involving focal length and aperture size.

Subjects were focused with 70 mm focal length lens. A series of photographs exposure was carried out. Involving the changes in aperture size at 70 mm focal length lens. Shutter speed was set at a constant of 1/125 second. The aperture size (f-stop) used for exposure was f/16, f/11, f/8, f/5.6 and f/3.5. Corresponding frame number, focal length and aperture size were recorded.

The experiment was repeated with subjects focused with 50 mm and 35 mm focal length lens respectively. For every repetition, all other parameters remained similar to 70 mm focal length experiment. Corresponding frame number, focal length and aperture size were recorded.

Lastly, the whole experiment was repeated with other subjects.

Object distance and lens focal length effects on photograph

This experiment was designed to study the effect of object distance with lens focal length. The relationship between object distance, focal length and magnification was studied here.

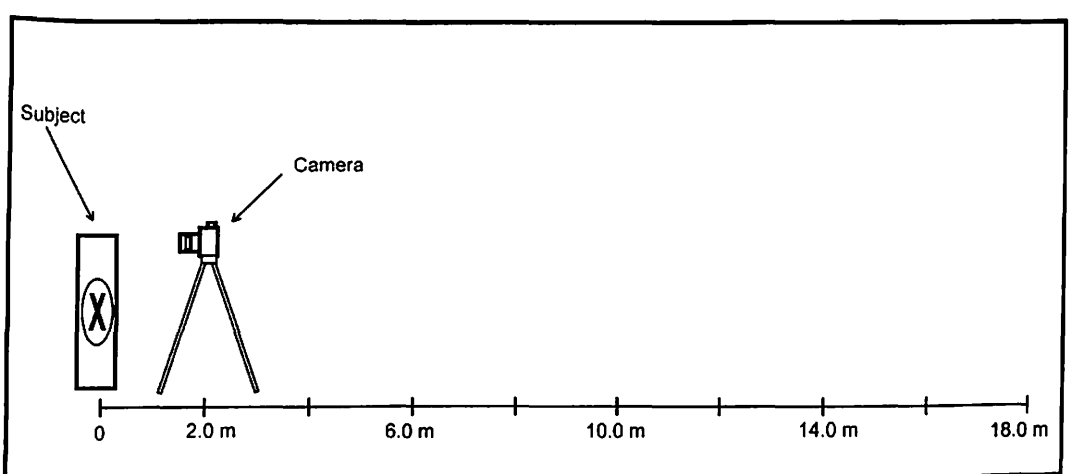

Figure 3: Setup for the experiment involving object distance and lens focal length.

The camera and subjects were set up as shown in the figure.

Subjects were placed at a constant position. Then a distance of 2.0 m was measured from the subjects. Camera was positioned at a constant distance of 2.0 m from subject. Then the subjects were focused with 50 mm, 70 mm and 35 mm focal length lens. Corresponding frame number, object distance, focal length, shutter speed and aperture size were recorded.

The experiment was repeated with camera positioned at 6.0 m, 10.0 m, 14.0 m and 18.0 m from the subjects respectively. For every repetition, all other parameters remained similar to the 2.0 m object distance experiment. Corresponding frame number, object distance, focal length, shutter speed and aperture size were recorded.

Lighting and shadow formation in photograph

This experiment was carried out to study the shadow production on subjects

For indoor scene, the subject was illuminated with 1 spot lamp and 2 fill lamps. The spot lamp was placed at several different locations to produce shadow. All the photographs were exposed on the correct exposure as indicated by the TTL metering system. Corresponding frame number, object distance, focal length, shutter speed and aperture size were recorded.

Film ISO speed rating effects on photograph

This experiment was carried out to study the effect of grain size in different film's ISO speed rating.

This experiment was carried out with the procedures described in the *Lens focal length and aperture size effects on photograph* experiment. All other parameters remained similar with only changes in film's ISO speed rating. The film's ISO speed rating films used in this experiment were ISO 100 and ISO 800 respectively. Corresponding frame number, focal length, shutter speed and aperture size were recorded.

Montage Production

The following table introduces the terms used in the manuscript while discussing the montage production process:

Photograph	Description
Background	This is the base for other photographs to be inserted
Insert	Photograph(s) to be pasted/inserted onto the *background*
Montage	The resultant composite/forged photograph after employing montage technique with *background* and *insert*
Copy Print	Copy made from the *montage* photograph

Table 1: Terms used in the montage process.

For producing a montage, first, a series of photographs from different sources were chosen. From such photographs, appropriate picture/subject were selected to serve as *background* and *insert*.

The *insert* photograph was then cut out carefully with a scissors in order to isolate it from other subjects. While cutting with a scissors, the scissors was held at an angle to produce a tapered edge. Blade was also held at an angle while cutting to produce a tapered edge.

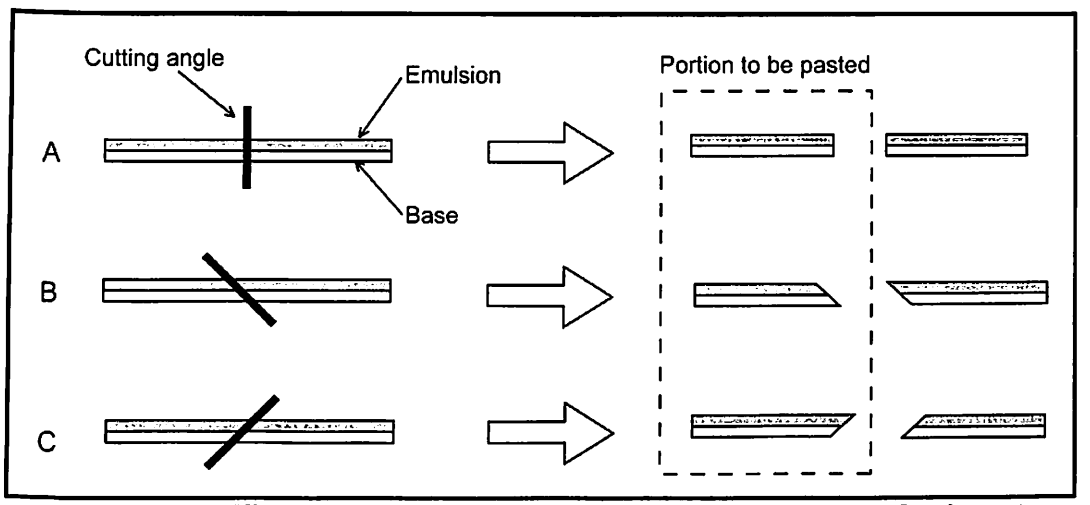

Figure 4: The figure shows the various cutting processes for *Insert*. Among the methods A, B and C, C is the most preferred as it results in good edge outline.

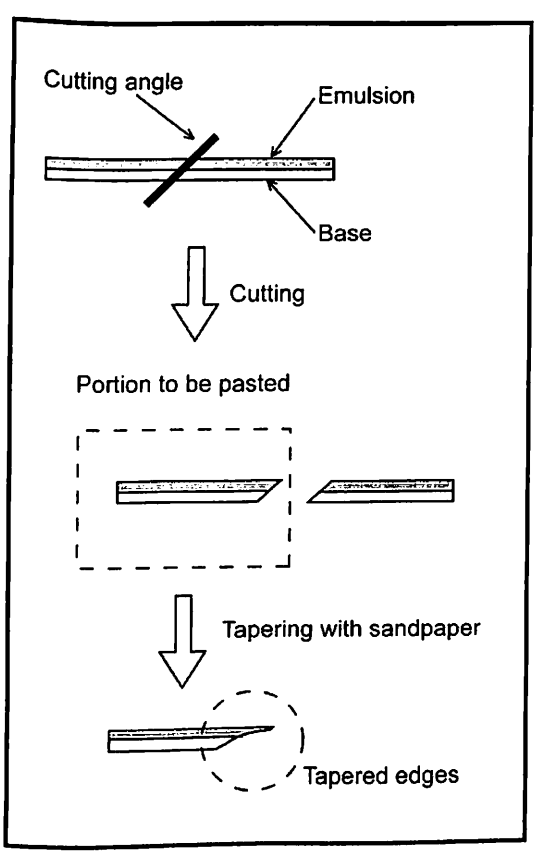

Figure 5: The figure shows the cutting of the insert photograph at an angle and tapering the cut edges with sandpaper. Thus, the edges become sufficiently thin to reduce the shadow cast while pasted on the photograph.

Then, the edge outline of *insert* was tapered carefully with sandpaper. Finally the Insert was pasted on the *background* with adhesive glue. The resultant photograph of *insert* pasted on *background* was referred as *montage.*

The *montage* was then copied on a copy stand. The four illumination lamps were positioned opposite of each other around the four corner of the *montage*. All four side illumination lamps were adjusted so that an incident angle of 45° was produced on the surface of *montage*. The above illumination arrangement was necessary to avoid the shadows cast by the *insert*. The camera was attached with the two types of blue filter. The height of the camera was adjusted to allow the *montage* to fill the frame of the camera with minimum cropping. *Copy print* was then made.

Copy print was examined under magnification (X2 – X20). The truthfulness of the *Copy print* was assessed with the following features: lighting, shadow, magnification, focus, outline edges and technical or scientific inconsistency.

RESULTS AND DISCUSSION

Result and discussion for Photography experiments and montage production

The results and discussion of all the photography experiments and montage production described under *materials and methods* may be summed up as follows:

Lens focal length and aperture size effects on photograph

Small differences in the aperture setting have no perceptible depth effects on the photographs produced. However, objects that are very far from the focal plane blurred relatively more than objects near the focal plane.

Figure 6: Photograph showing a subject taken with 70 mm focal length, 1/125 second, f/8.

Figure 7: Photograph showing a subject taken with 50 mm focal length, 1/125 second, f/8.

Figure 8: Photograph showing a subject taken with 35 mm focal length, 1/125 second, f/8.

Difference of depth in photographs can be seen in the photographs (Figure 6-8) taken with the fixed shutter speed and fixed aperture but differs in focal

length. Photographs taken with longer focal length gave a perception of background and subjects sharing the same plane (Figure 6). Photographs taken with short focal length differentiated well between background and subjects (Figure 8). In other words, the depth of field is deeper in the latter case. The effect of depth of field is more obvious in longer focal length photographs series (aperture changes from f/16 to f/3.5 and fixed shutter speed) compared to shorter focal length photographs series. In 70 mm focal length photographs, only about 2 f-stop differences from f/16 are needed to render the effect of depth of field visible. Whereas in 50 mm focal length photographs, about 3 f-stop differences from f/16 is needed to render the effect of depth of field visible. Lastly, in 35 focal length photographs, the effect of depth of field is difficult to achieve even in the whole range of f/16 to f/3.5. However the relative magnification of objects had varied and it formed a significant factor for comparison of montage.

While using different focal length lenses and exposing at various apertures, the depth of focus seems independent of focal length of the lens for objects around the focal plane.

With fixed focal length and only variations in aperture (from f/16 to f/3.5), higher focal length lens tends to be less affected by over exposure situation. In photographs series taken with 70 mm focal length lens involving changes of aperture from f/16 to f/3.5, the effect of over exposure is less observable. Whereas in photographs series taken with 35 mm focal lens involving changes of aperture from f/16 to f.35, the effect of over exposure is readily observable.

Object distance and lens focal length effects on photograph

As object distance increases, more viewing area is visible. As object distances increase, subjects appear to be smaller in size in the photograph. Therefore, as object distance increases, relative magnification decreases.

When the object distance increases, the perspective effect is noticeably more. Figure 9, 10 and 11 shows respectively the perspective effect at fixed focal length but variation in object distance.

Figure 9: Photograph showing a subject taken with 50 mm focal length and object distance 2.0 m.