Analysis of the Effects of Front and Back Lights in Chroma Key Effects During Implementation in Virtual TV Studio

Branimir S. Jaksic, Boris Gara, Mile B. Petrovic, Petar Lj. Spalevic and Ivana M. Milosevic

***Abstract*—**In this paper, the analysis of the effects of front and back light in chroma key effect in the realization of a virtual TV studio, is explored. The analysis was done for the case with variable and the case with fixed values for the front and the back light. The tolerance range of colors is set with the software package Adobe After Effects adn it is set for the different values and combinations of lights. The results are presented graphically. Based on these results, we can determine which combination of light and volume gives high quality images at the exit of a virtual studio.

***Keywords*—** chroma key, back light, front light, color tolerance, virtual studio.

I. Introduction

CHROMA process in the television replaces the studio set design and reduces the costs of the production of the program. It is a way of mixing two video signals, in which the solid background color of a video signal (signal with the live picture from the scene) is replaced by another video signal. Replacement is done by a fast switching circuit that alternately turns on and of a video signal from foreground (FG) and a video signal of the new background (BG). The process of changing the background is called keying [1], [2]. Inserting a video signal of the new background in a monochrome background of the foreground, is made at the time of scanning, on the border between the object or the participants in the foreground and the background. In this way it is created the impression that the objects of the foreground are in a scene that comes from some other source. One color background can be of any color, provided that the color is not on objects or participants in the front of the stage [3]. Today, blue or green color are used for the background.

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Chroma key procedure gives satisfactory results for static scenes (news programs, panel discussions, weather, etc..), but when it comes to shooting scenes with dynamic movements of participants, it is not following changes in the of angle shooting, the transition from zoom to the total, or movement from one camera to another, and it is disturbing the real relationship between the participants and the objects of the scene and the sense of space and depth in images is lost.

Because of this, the range of chroma key effects is limited to static relationship with the foreground. Therefore, when a natural relationship of the background and foreground in television production is desired, producers are using virtual studio [4], [5].

II. Virtual TV Studio

Virtual TV studio provides a natural relationship between the participants and the scenery generated by a computer, with real-time corrections of the scenery, generated from computers and coordinates obtained depending on the position of the camera, which gives the foreground. In this way the logical relationship between the set and the participants is preserved, and there is also a sense of depth in the images. In virtual studio it is possible to generate scenery that is in the foreground, and that can be opaque or translucent (transparent). Computer-generated scenery has the visual appearance of real decor in the background, and in this way it is possible to create a variety of decors, even surreal decors, so there is a visual impression that the TV studio is a lot larger than it is. Software packages 3D Studio Max, Maya, SoftImage and LightWave are used when we want to create a computer-generated scenery [6], [7].

Virtual studio technology is based on allready described chroma key procedure. In chroma key procedure static two-dimensional computer generated graphics is uses for scenery, and that graphics is inserted as a background image. But it does not follow the changes of angle of shooting, the transition from zoom to total or movement from one camera to another, and results in a disruption of the real relationship between the participants and the scenery. In virtual studio, data on the

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position of the camera are processed in the computer and real-time adjustments on the position of the generated 3D graphics and animations are made, based on the data from the camera. Therefore, the naturalness is retained, there is an illusion of spaciousness and logical relationship between participants and objects in the video signal of live image and scenery is reatined [8].

A studio which implements virtual studio is generally L-shaped or U-shaped, and the newest studios are circular. Scene (walls and floors) should be uniformly colored blue or green while the side walls and places where the wall crosses into the floor should be rounded, to avoid creating of unwanted shadows. Blue or green screen can also be used. Diffuse lighting is mostly used, to awoid creating of the create shadows. Participant is in nearly empty space, usually with no or only a few real elements in the studio, and the other scenery is generated in a pre-production by a computer and it is combined with the video signal from the camera.

Main equipment of the virtual television studio consists of a camera with CCU (Camera Control Unit), sensors for determining the position of the camera, a computer with high processing power, a chroma keyer and a delay line. Block diagram of a virtual studio with one camera is shown in Fig. 1.

The video signal from the camera that captures the foreground, through delay lines is fed to chroma keyer. Information from sensors that determines the position of the camera is fed to a computer with large processing power, on the basis of which real-time correction of the generated scenery is done, and then the corrected information is transsmited to chroma keyer where the two images are combined. The computer has a video output for preview, a video inputs, an audio inputs and outputs, a delay-line for video and audio signals. Supports SD and HD standards, PAL and NTSC formats. The computer is controlled by a software suite that consists of active relational database for fast and easy visualization (rendering) of the graphics. All individual set designes have their own separate database. Data on the position of the camera during shooting allows computers to,

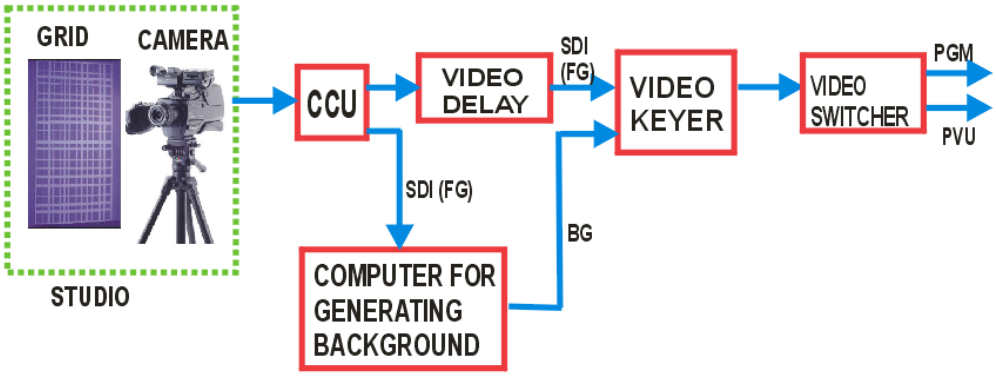

Fig. 1 Block diagram of a virtual studio with one camera

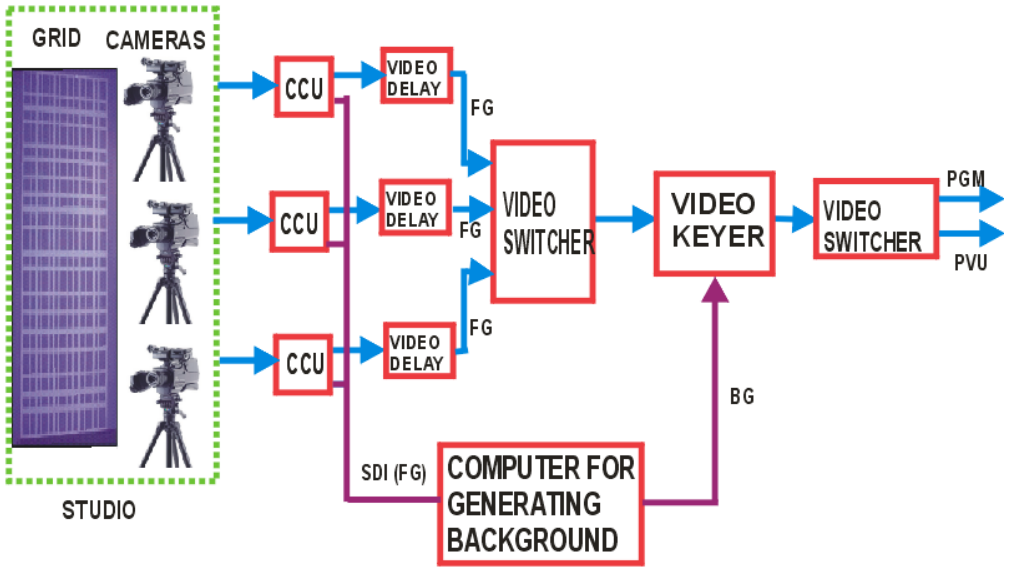

Fig. 2 Block diagram of a virtual studio with multiple cameras

after data processing, adjust the position of the generated graphics for scenery, so you can maintain the illusion of spaciousness and naturalness.

If we are using multiple cameras, then they are, through switches and routers, connected according to the block diagram shown in Fig. 2.

Manufacturers have developed various methods for determining the position of the camera and the measurements of basic movements that each camera can make (pan, tilt, displacement along the x, y, z axes, zoom and focus). Pan sets the horizontall movement, tilt determines the verticall movement, zoom enlarges or reduces the actual size of the image or the frame and the focus determines the sharpness of the image

In Pattern System (recognizable grid), a grid is drawn (network) in blue or green chroma key background that lies behind the performers, Fig. 2. The grid is drawn in a lighter shade of blue or green. The video signal from the camera is led to the computer with a special video processor and sophisticated software that determines the exact location and orientation of the camera from the video signal, including settings for zoom and focus. Depending on the system, the process of re-calculating the position of the camera lasts from 1 to 3 frames.

III. The Choice of the Background Color

In the chroma key process insertion of a new signal can be done with any color in the background, provided that the color is not on the objects and the participants in the front of the stage. For the background color saturated blue and saturated green are used, and, in special cases, pink. Green is currently used as a background more than any other color, because the sensors in digital video cameras are most sensitive to the green color, and the human eye is most sensitive to green light (Bayer form) [9]. The green channel of the camera has the least "noise" and thereby gives the clearest picture of (key / matte / mask). Additionally, less light is needed to illuminate green background because of the greater sensitivity of the camera sensor [10].

The blue color was more used in cameras with analog video signals, although it is still widely used in the TV production for weather reports, children's shows and for special effects. Reflections of the light in the blue background are smaller then reflections of different colors, and in nature and in human facial skin blue color is the least prevalent. Sometimes pink color is used (# FF00FF) for the background; it is used in applications for the scenes in which there are only objects [10].

Reflective background that does not require additional lighting is also used, except for the standard shooting, and in some cases only light that is produced by the LED located on the ring around the camera lens is used.

The biggest challenge when setting up a scene (bluescreen or greenscreen) is setting the light and avoiding shadows, because we have to achieve a uniform new color of the background. Shadows can cause appearance of the darker background color, which will not be registered when background is changing. Such errors can be seen in the shows, which are broadcasted live, where mistakes can not be corrected later. Also, we should bear in mind the type of show that is being recorded, because the types of materials affect the quality of lighting facilities. Shiny surface will have areas that reflect light and look too pale, and some areas will be too dim. Matte surface will have a wider range of colors from diffuse reflected light. In order to obtain a better quality of recording it is necessary to make a difference in color (in color coordinates) between the subject and the background, so as to increase the difference between the color of the background or subject. For lighting it is usually the same setting as the default setting for the recording that includes three lights (front, side and rear) [11].

IV. Lighting

When we are implementing multimedia studio lights the most important directions are: front light, side light, back light, back side light, the lower light and three-fourths light.

Front (direct, main, critical) light is set in the direction of the the camera, in the angle of 0° - 30° on each side, with vertical angle of approximately 45°. Highlights the greater part of the face, the smaller part remains in the shadows. Provides good visibility. This light is perfect for portraits, conceals wrinkles and facial irregularities. Devides face to illuminated and non illuminated half. It should be somewhere between hard and soft light. Too strong or too soft light is generally undesirable for most subjects. In the studio this "golden mean" is achieved by a Fresnel light [12, 13].

For the side light, the supplementary light is placed at the angles from 45° to 90° on either side of the camera, or 90° from the main light, but the safest place to be is at 45° from the camera. It needs to be less strong than the main light and softer. The main and supplementary light should be in the ratio 2:1 (2000 lx : 1000 lx). It eliminates shadows that come from the main light. With this illumination there is a danger of over-emphasizing impurities and complexion. It is suitable for creating a realistic atmosphere and emphasis on texture.

Background (rear, back) light is placed opposite of the camera from 135° to 180° on each side, with the slope of 45°; back light illuminates the subject from behind. It is placed directly behind the subject being filmed, and in relation to the camera that is doing closeups. From the above viewpoints, we should be able to draw a straight line from the camera through the person being recorded to the back light. This light is less in quantity compared to the front light, it is placed closer to the subject, and more reflectors can be used. Back light color temperature is not as critical as it is for the main and supplementary light. Change in the color temperature to ±150 °K can be tolerated, because the human eye doesn't notice them. Draws the outline of the recorded object. Emphasizes the third dimension of the images, separates the subject of the recording from the background, respectively it is separating

foreground from background.

Background sidelight is placed on the side of the subject to be shot, from 90° to 135° on each side and is used to illuminate the space background and to get the depth and the separation. The intensity of the background light should be about 2/3 of the intensity of the main light elements in the scene. This ensures that the central subject is separated from the background. If the key light is at about 2000 lx, then the background light should be about 1300 lx. Any type of light can be used as a background light, provided that it gives even illumination of the background, especially in chroma key, that it does not illuminate the subject and that the total amount of light is uniform (flat) [12], [14].

Lower light source is placed below the camera, and in this case shadow direction is opposite to the direction that we are accustomed. Lower light seems least natural. It is used when

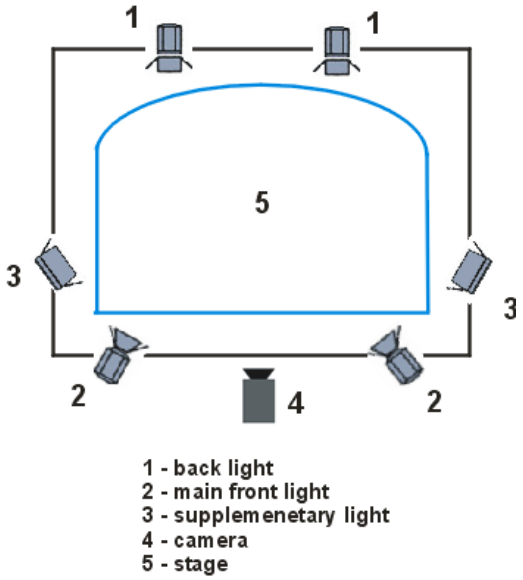

Fig. 3 Types of lights in the implementation of the virtual TV studios

you want to achieve unusual or unnatural impression.

In Fig. 3 types of lights in the implementation of the virtual TV studios are shown.

Three-quarter light is set from 30° to 50° to the side of the camera. Three quarters of the human face is lit and a quarter is in the shadow. This proportion of light and shadows best describes the depth (volume) of oval objects including a human face. This light is not suitable for every face. If it is well done, it gives strength, character and volume to the face, but can act very harshly. Three-fourths light demands precision in the performance. Small movement of the head can disrupt his balance. Therefore it is not always convenient for the cadres with multiple cameras.

The light sources are characterized by the color temperature. Color temperature (°K) is the temperature to which the black body should be heated - (a light source) so its color is colorimetric most similar to the color of the secondary sources of daylight. The spectral power distribution and chromatic coordinates of the light source - black body, depends only on the temperature to which it is heated.

Color of the light is expressed by color temperature and is measured in degrees (°K). An instrument for measuring the color temperature is comparing ratio of blue and red, or green and red light of the sources. Higher temperatures give blue light. Change of the color temperature can be made by placing colored filters in front of the reflector. To create a cozy and warm atmosphere sources with high color temperature are used, for the cold and the dark atmosphere sources with a lower temperature than normal are used. Temperature of the direct sunlight at noon is approximately 5500 °K, and the standard color temperature for TV lighting is 3200 °K; bulbs of 100 W are giving 2850 °K [13], [15].

The intensity of light (luminous intensity I) falling on a surface depends on the strength of the light source, and the distance between the source and the area to be illuminated.

Luminous intensity (intensity of the light source, cd, I) is the amount of light energy that a point source of light emitted per second in one direction given by unit of spatial angle

Brightness (luminance intensity, lx, E) is the amount of light energy that per second falls on a unit area. Units are lux (lx) and foot-candle (fc). Lux and foot candle are units of volume illumination. The difference is that the lux is metric and foot-candle Saxon measure [15].

V. System Model

Analysis of the impact of the front and back lights on the quality of the implementation of the chroma key effect was done in a TV studio with area of 12x8 = 96 m^2 and a height of

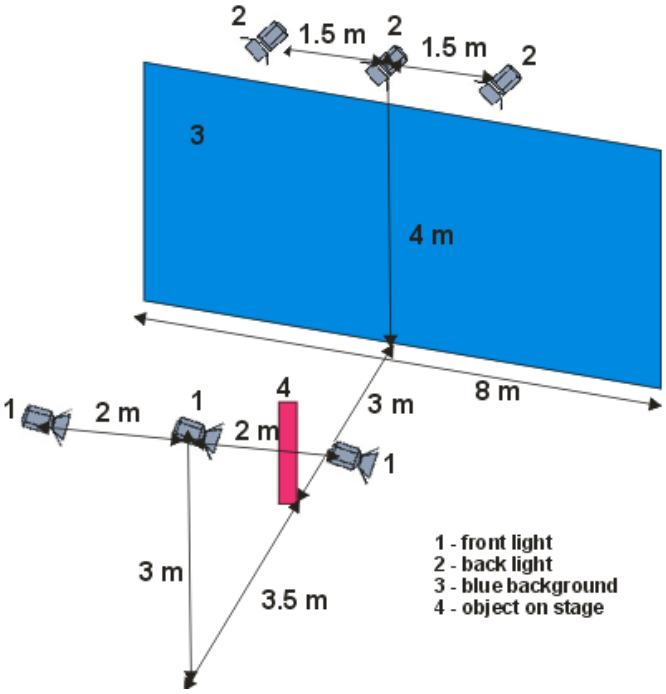

Fig. 4 Disposition of the lighting in TV studio

4.5 m. Dimension of the blue background is 8 x 3,5 m.

Disposition of the lights in relation to the object in the scene is shown in Fig. 4.

Number of the front and the rear lights is 3, and all light are set at an angle of 45° to the horizontal plane. Horizontal distance between the front and rear light is 6.5 m. The spacing between the rear lights is 1.5 m and they are placed at a height of 3 meters in relation to the scene. As devices for the formation of the back lights Reflector Fluorescent soft lights 2 lamps 55 W, 3200 K were used. The front lights are mounted at a height of 3 meters in relation to the scene, and the spacing between them is 2 m. As a devices for the formation of the front light Fresnel Reflectors lens (150 mm Fresnel lens and G22 lamp holder, halogen lamp 1000 W, 3200 K) were used.

For the color temperature control an instrument was used to measure the color temperature Minolta Color Meter II [16]. For the control of the light intensity digital luxmeter VDVM1300 [17] was used.

In this analysis, the object that is being filmed is at a distance of 3 m from the background (and the back light) and 3.5 m from thefront light. For filming the object in the scene a digital camera Canon EOS 550D [18] was used. It is set at a distance of 2 m from the object.

In practical cases the object in the scene can be placed at any distance between the front and the back lights

VI. Analysis of the Back Lights Effects

Analysis of the effect of chroma key for virtual studio was done by the software package Adobe After Effects CS3 Pro Video with Color Key effect. This effect can be applied to video material in which the solid background color should be replaced with the desired (transparent) background. Parameter Color Key effect - Color Tolerance – is expanding or reducing the scope of color that should be transparent. Higher values increase the range. In the experiment a blue background was used.

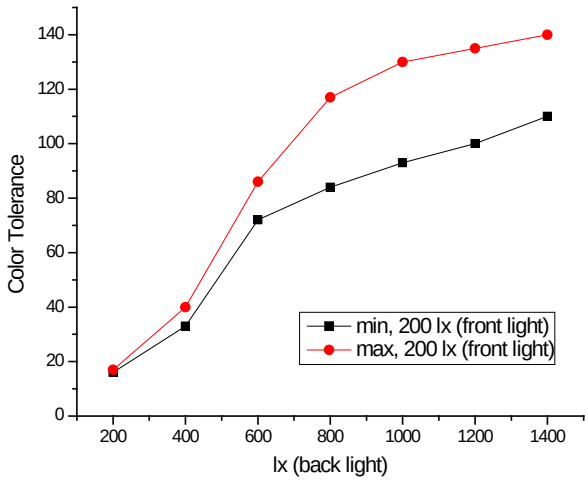

Fig. 5 Color Tolerance range for fixed front light of 200 lx

In the first part of the experiment headlight is fixed, and the back light changes in the range from 200 to 1400 lx.

Range of Color Tolerance for variable back light, and constant values of a front at 200, 800 and 1400 lx are shown in Fig. 5, Fig. 6 and Fig. 7, respectively. Range of the Color Tolerance is determined by its minimum and maximum value required for the full implementation of the chroma key effect. The wider the range, ie. the greater the difference between the minimum and maximum values of the Color Tolerance, larger the quality of the realized chroma key effect. In that case, it is less likely that the monochromatic backgrounds that is

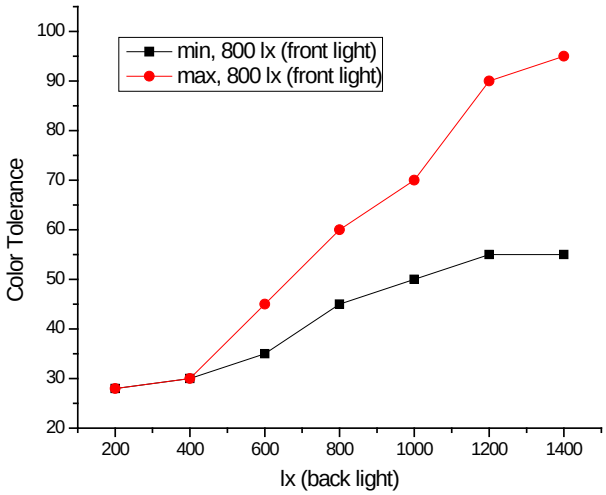

Fig. 6 Color Tolerance range for fixed front light of 800 lx

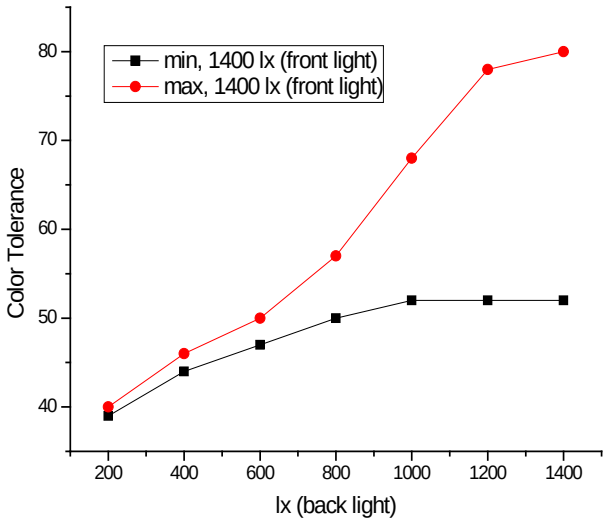

Fig. 7 Color Tolerance range for fixed front light of 1400 lx

replaced will be appearing in the video, especially in the border between the object and the monochrome background and new background.

From the given images we can see that the increase in the background brightness increases the range of Color Tolerance.

If one compares the values of Color Tolerance for different values of the front light, it can be seen that the range expands with increasing values of the front light. Also, with the increase in the value of fixed front light, value of the Color Tolerance is reduced for several values of the back light.

Fig. 8 shows a of realization of chroma key effect for constant value of the front light of 1400 lx and variable values of back light from 200 to 1400 lx.

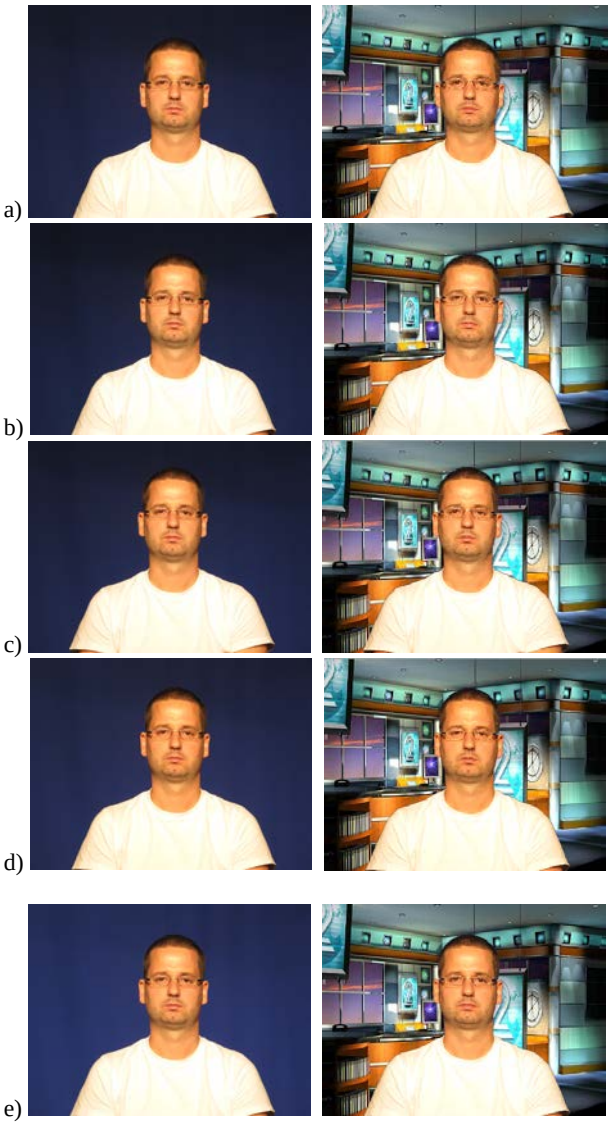

Fig. 8 Example of realization of the chroma key for a constant value of the front light of 1400 lx and variable values back light: a) 200 lx, b) 400 lx, c) 600 lx, d) 800 lx, e) 1000 lx, f) 1200 lx, g) 1400 lx

VII. Analysis of the Front Lights Effects

In the second part of the experiment back light is fixed, and the front is changed in the range from 200 to 1400 lx. Table 1 provides the minimum and maximum values for the Color Tolerance during realization of chroma key effect, with the front light changing and the back light at a fixed values of 200, 800 and 1400 lx.

Range of Color Tolerance for variable front light, and constant values of a back light at 200, 800 and 1400 lx are shown in Fig. 9

From the figure we can see that the increase in brightness of the object (person) in front of a single color background increases the range of Color Tolerance. If one compares the values of Color Tolerance for different values of the back light it can be seen that the range extends for several values of the front light. Range limits for lower back lights have a low value of the Color Tolerance, while higher values have higher maximum and minimum limits.

Fig. 10 shows a of realization chroma key effect for constant value of the back light of 1400 lx and variable front light from 200 to 1400 lx

Table I: Minimum and maximum values for the Color Tolerance for fixed back light

back light [lx]	front light [lx]	200	400	600	800	1000	1200	1400
200	MIN Color Tolerance	27	27	27	26	25	23	20
	MAX Color Tolerance	27	27	27	28	29	31	34
800	MIN Color Tolerance	50	50	48	45	42	37	30
	MAX Color Tolerance	60	60	62	65	68	73	80
1400	MIN Color Tolerance	60	60	58	55	50	40	30
	MAX Color Tolerance	110	110	113	115	120	130	140

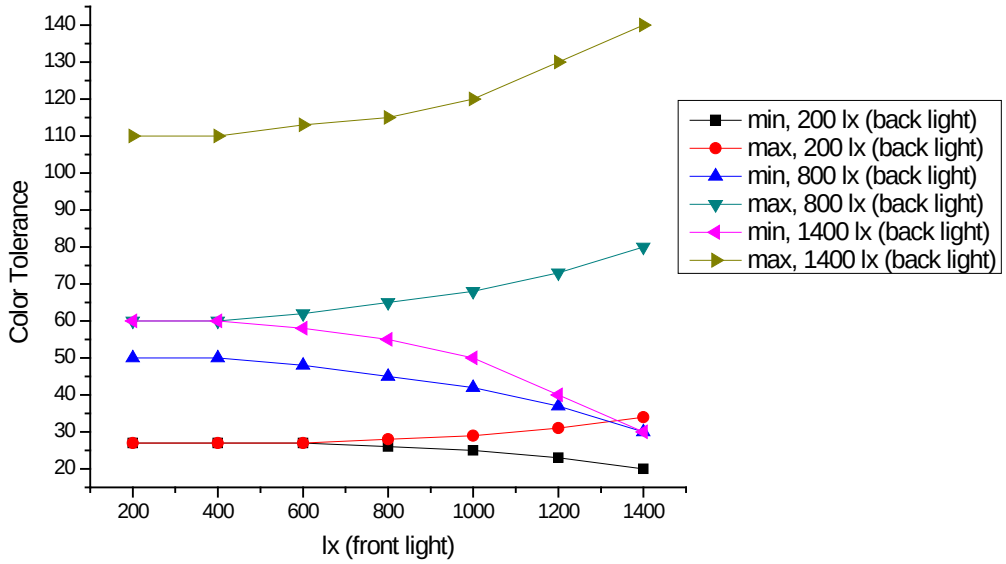

Fig. 9 Color Tolerance range for fixed back light of 200, 800 and 1400 lx

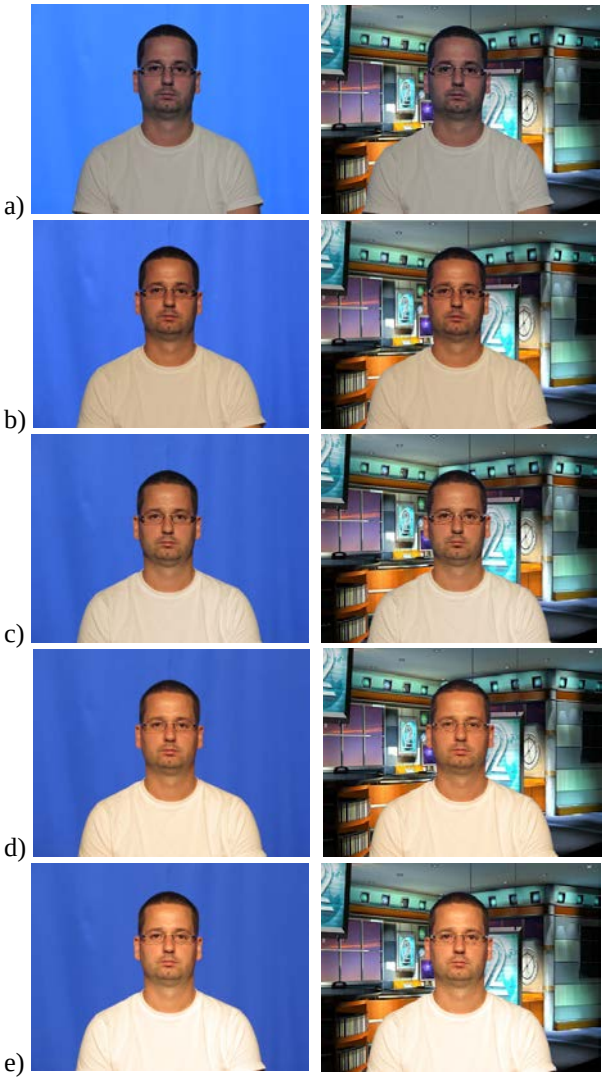

Fig. 10 An example of realization of the chroma key effect for a constant value of the back light of 1400 lx and variables front light: a) 200 lx, b) 400 lx, c) 600 lx, d) 800 lx, e) 1000 lx, f) 1200 lx, g) 1400 lx

VIII. Conclusion

Based on the implementation of chroma key effect for different values of the front and back lights in the studio, ranges of the Color Tolerance were determined. With the increase in the brightness of the background the range of the Color Tolerance also increases. The range extends for several values of the constant front light. Also with the increase in the value of fixed front light, Color Tolerance reduces its value with the increase of the value of the back light.

For the case of the fixed back light, and the change in the front light, with the increase of the brightness of the object

(persons) in front of a single color background, the range of Color Tolerance increases. Range limits for lower back lights have a low value for the Color Tolerance, while higher values were higher than the maximum and minimum limits.

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