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STUDY THE EFFECT OF SKIN COLOR AND CAMERA LIGHT SENSITIVITY ON POINT CLOUD QUALITY USING STRUCTURED LIGHT MEASURING

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Abstract:

In recent years, the 3D scanning technology has been developed and applied in many fields such as: fashion, health, beauty, However, the 3D scanning on the human skin still has disadvantage due to the skin color and camera gain. This paper shows the result in studying the effect of hand skin color and light intensity on the accuracy of 3D scanning method using structured light. Point cloudis evaluated by the number of 3D points acquired when measured the skin surface. The result shows that the light intensity has great effect of the number of points, the same intensity on different skin colors have different numbers of points. Each color of skin corresponds to a suitable range of hightlight of camera, the light intensity of camera is from gain 4 – gain 20. The study result shows that the light intensity on bright skin should be 6 – 12, dark or brown skin should be 14 – 20, average skin color should be 9 – 15 for the best result. The studying on suitable lighting mode with each skin color is very important for the accuracy of 3D measuring method to support the beauty processes or glove designing better.

Keywords: *Structured light, light intensity, skin color, number of points, light intensity.*

1. Introduction

The birth of 3D technology has great meaning in providing the standard measurements system, contributes greatly to the designing and manufacturing the suitable clothes. The traditional measuring methods need a lot of time and high cost are gradually replaced by the 3D scanning technology. The accuracy of the 3D scanning data depends greatly on the surface data acquiring method.

The hands with different colors are 3D scanned using a system of 180 cameras. Each hand scanned has to be processed: noise filtering, smooth…[1]. This method can scan the hand data quickly, however the system includes 180 cameras so that it's very bulky and expensive. The shape and size of human bodies is becoming more various, the population is growing, that makes the traditional measuring methods hard to meet the demands especially in the fashion, beauty which are growing fast. Therefore, non-contact measuring method using structured light is studied and applied greatly. The 3D scanning devices provide the surface profile data of the subject in form of point cloud. The point cloud data can be converted to the surface data to get information about shape, color, size…. [2]. The information acquired from 3D image help the ability of observing, recognizing and simulating be more accurate. Nowadays, non-contact 3D measuring technology using optical methods is being researched and applied very much in measuring human body sizes. The advantages of this method is fast, suitable for massive sampling. The development of 3D body scanning technology allows us to quickly exploit and synchronize the body measurement and customize for any number of people.

The body scanner uses the structured light technology, projects stripe patterns into the body and captures the images by camera. The 3D model of the subject is generated by analyzing the distortion of the patterns projected into the body. The 3D

measuring technology has made a breakthrough with innovative advantages of measuring time and accuracy, it's applied to acquire the data of human body sizes and shapes. Some countries in the world have used the 3D measuring technology such as Japan (1992), UK (1999), China (1999), USA (2002). The skin scanning method has been studied to apply in building body sizes system, beauty surgery, simulating and designing clothes. However, there are some difficulties during scanning such as difference of skin colors. The scanning of the hand skin has to be guaranteed about safety and health of the scanned person.

3D technology has been applied to scan hands and print hand figures.

Figure 1. 3D scanning of hand [4]

Amy Karle used a Artec scanner to scan the hand then used 3D printing technology to print a hand figure with exactly the same shape and size [4]

The NextEngine scanner was used to scan the hand however the shaking of fingers made it hard to acquire the data. Pushan used the Artec scanner and instead of moving around the object, the author rotated it in a rotary base.

The hand 3D scanning using AFO Scan device is applied in gloves designing, manufacturing. The scanned person put arm aside and the hand is parallel with the floor. Use a handheld scanner to move around the hand and scan, the 3D data is displayed on the computer software.

Figure 2. The posture of hand in 3D scanning

The hand scanning methods still have disadvantages due to high cost, data processing system setting complication. Therefore, it's necessary to study and build a 3D scanning system using structured light to apply in 3D industry. Nguyen Thi Nhung et al. has initially built the 3D scanning device using structured light for measuring human body anthropometric. However, the devices specialized for human body parts scanning still has disadvantages. The studying on scanning methods and elements affect scanning accuracy still has many problems to work on. Therefore, studying the effects of elements on accuracy of 3D scanning using structured light has important meaning in increasing scan quality. There're many elements affect the accuracy of measurement such as skin colors, vibration, equipment, light… This research evaluates the effects of light intensity and skin colors on the amount of points and faces. The result is proposing of the method to classify the skin colors and choose the light levels suitable with each group of skin colors.

2. Experiment

2.1. Components of scanning equipment

The experience devices include an Infocus LightPro projector, a DFK 41BU02 camera with resolution of 960 x 1280 pixels, the HN-3D scan software. Those equipment are to set into a scanning module that connected to a computer. The computer has high specs requirement: 8GB of RAM, Core i5 4460 processor with speed of 3.2GHz, dedicated GPU to process point cloud data with high speed.

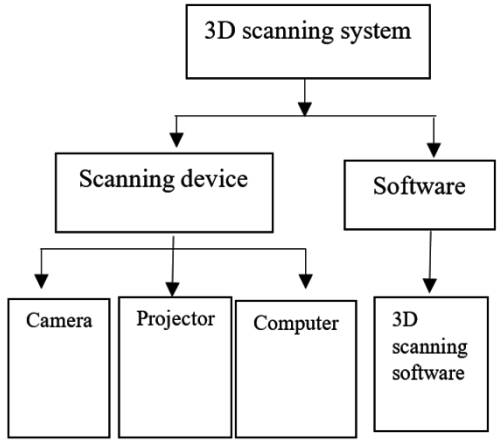


Figure 3. Structural diagram of 3D scanning system

2.2. System calibration

System calibration is important to the measurements using structured light because it relates to the real 3D coordination system measuring from 2D coordination space of camera and projector. The calibrating the system accuracy includes: calibrate camera, projector and geometry relation between two devices. Use a black and white chess board with size of each square is 10mm, DxR = 12x15 cm. Adjust the sharpness of the camera and the projector in different angle in measuring area. Calibrate at least 3 images in 3 different directions.

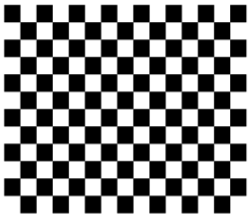


Figure 4. Calibrating chess board

2.3. Effects of light on 3D scanning accuracy

The measuring sample is scanner in laboratory following standard condition of TCVN 71141:2008. The light receiving mode of camera is set at Gain levels from 4 – 20 correspond with different light intensities. Light direction is straight directly to the skin evenly in every angle [5].

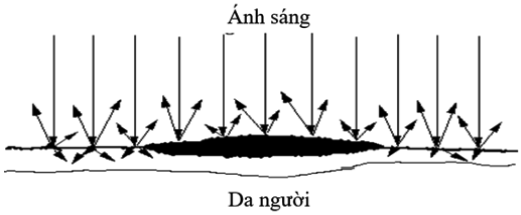


Figure 5. Light direction is straight directly to the skin

Figure 6. 3D scanning with several lighting modes

In order to test the effect of light intensities to the numbers of points, a hand is experimentally scanned with the light intensities from Gain 4 – 20, correspond with 16 scanning times. The accuracy of the results is calculated by the numbers of points acquired in each measurement. The light levels are illustrated in Figure 6.

2.4. Effects of skin colors on point cloud quality

The human skin color is various from darkest to brightest [6]. Classify and test scan on 7 subjects with different skin colors and scan in the same conditions of distance, light.

The skin color classify method of Fitzpatrick is based on 36-level scale of Von Luschan [7], and Fitzpatrick skin type [8].

Type	Regular name	Von Luschan's color scale
I	High white	0–6
II	White, light white	7–13
III	Medium, white to light brown	14–20
IV	Medium brown	21–27
V	Brown, dark brown	28–34
VI	Very dark brown to black	35–36

Group 1 (N1) has slightly dark, brown and dark brown skin. Group 2 (N2) has medium, white and pale brown skin. Group 3 (N3) has bright, white skin.

a. Group of dark, brown hand skin (N1)

b. Group verage skin color(N2)

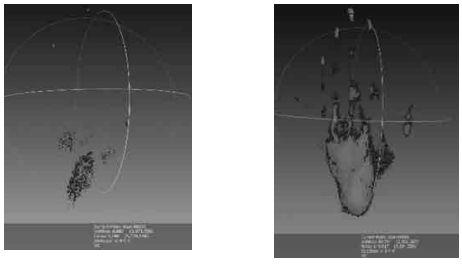
c. Group of white, bright hand skin (N3)

Figure 7. Classify skin color groups

3. Results and discussion

The amount of points is one of the evaluation criteria of 3D point cloud quality and scanning accuracy, therefore, the more points and faces are obtained, the more accurate the measurement is. Each lighting mode acquires different point cloud and different number of points. With the light range from level 4 to level 7, the amount of points is just from 6882 to 134959, the amount of faces is from 8248 to 245355, the points amount is low, the shape of hand is not clearly formed.

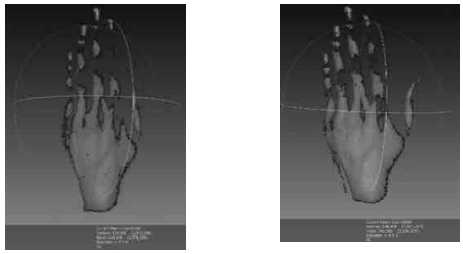
Within the light range of 4-7, the light with level 4 has least points and faces, just 6882 points and 8248 faces.



Points: 6882 *Points: 80704*
Faces: 8248 *Faces: 143617*
Level 4 *Level 5*

Figure 8. Point cloud at light level 4-5

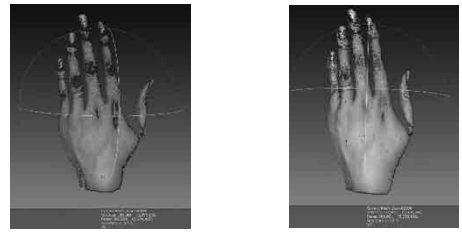
The number of points increases through the level 5,6,7. At level 6,7 the point cloud almost formed like the hand, but the fingers is not clear due to low number of points is show in the graph [Figure 9].



Points: 114682 *Points: 134959*
Faces: 210368 *Faces: 245355*
Light level 6 *Light level 7*

Figure 9. Point cloud at light level 6-7

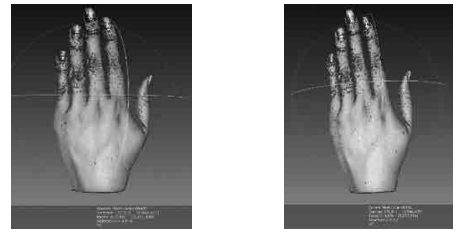
With light level 8-9, the number of points increases highly, about more than 160000 points, the hand shape is formed quite clearly, however, the fingers is not fully formed. With light level 10-15, the number of points increases highly about 172510 – 181266 points, the faces number is 315036 – 329089, the color is almost like the subject's skin color.



Points: 155366 *Points: 167845*
Faces: 282988 *Faces: 306601*
Light level 8 *Light level 9*

Figure 10. Point cloud at Light level 8-9

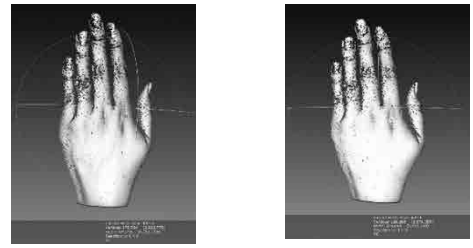
Light level 10 -11



Points: 172510 *Points: 172510*
Faces: 315036 *Faces: 315036*
Light level 10 *Light level 11*

Figure 11. Point cloud at light level 10-11

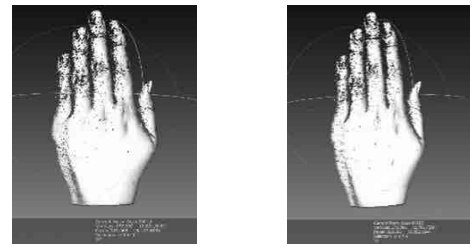
Light level 12- 13



Points: 178764 *Points: 181266*
Faces: 324755 *Faces: 329089*
Light level 12 *Light level 13*

Figure 12. Point cloud at Light level 12-13

Light level 14 - 15



Points: 177902 *Points: 176391*
Faces: 324006 *Faces: 320681*
Light level 14 *Light level 15*

Figure 13. Point cloud at Light level 14-15

Light level 16-17

Points: 177192
Faces: 320385
Light level 16

Points: 173736
Faces: 314432
Light level 17

Figure 14. Point cloud at Light level 16-17

Light level 18-19

Points: 180448
Faces: 327378
Light level 18

Points: 174065
Faces: 314935
Light level 19

Figure 15. Point cloud at Light level 18-19

Light level 20

Points: 180768
Faces: 327589
Light level 20

Figure 16. Point cloud at light level 20

With the average skin, the light level from 16 to 20 still has the high number of points but the color is not like the real skin, it becomes bright white. The number of points and faces is show in the graph [Figure 17].

Experiments show that the quality of point cloud depends on the light intensity. With the same object, the same equipment and the same measuring condition, the point cloud quality is lowest with light level 4, the number of points is lowest with light level 5,6,7. The number of points at level 8 – 20 is approximately the same.

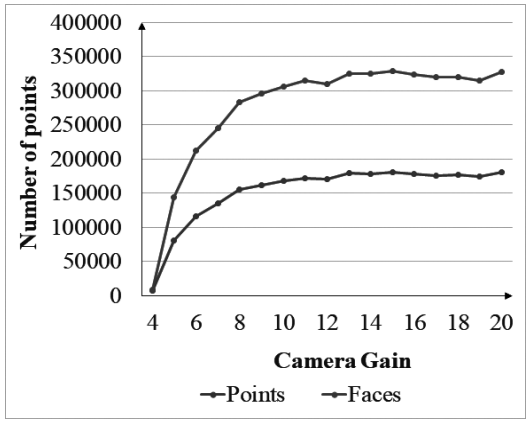
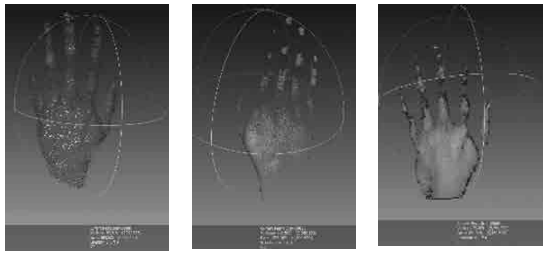


Figure 17. Number of points and faces with different camera gain

3.2. Effect of skin colors

In the same condition: the same equipment using structured light, the measuring distance from the measuring head to the object is 404mm, light is at Gain level 8, the point cloud result is showed in Figure 18.



Points: 163916
Faces: 203535

Points: 142562
Faces: 237962

Points: 98029
Faces: 164948

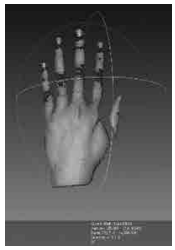
Figure 18. Point cloud of dark, brown skin

In the same condition, the points number of the dark hand skin and the brown hand skin is not the same, the number of points is not high, from 98029 to 163916, faces number is from 164948 to 237962. The quality of point cloud is not high, the shape of hand is not clear, some positions of the fingers is blur due to the low number of points. The faces are not clearly and tightly connected.

With the average skin color, the point cloud has higher number of points and faces, the points number of average skin is higher in comparison with the dark and brown skin, the color is almost the

same as the real skin color. The number of points is about more than 185048.

Points: 185124
Faces: 340768



Points: 185048
Faces: 336313

Figure 19. Point cloud of average skin

With bright skin, the points number is higher in comparison with the dark and brown skin but lower in comparison with average color skin. The color of the point cloud is brighter than the real skin color, the smoothness of the fingers and hand is not high.

Points: 119877
Faces: 194464

Points: 156090
Faces: 235450

Figure 20. Point cloud of bright skin

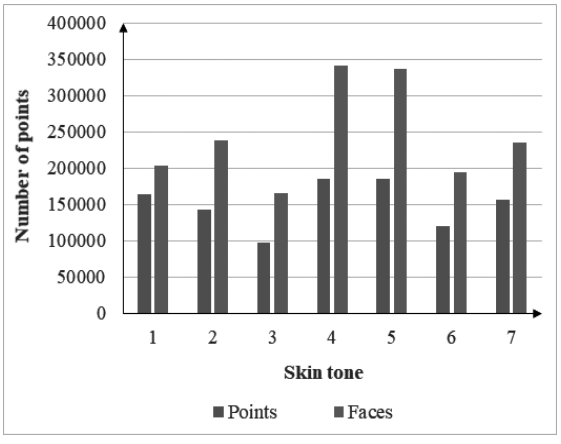


Figure 21. Points number in different hand colors

In the same condition of equipment, light, distance, each type of skin has different number of points and faces. With light level Gain 8, 6 dark brown skin (N1) from lever 1 – 3, the points and faces number is approximate the points and faces number of level 6, 7. Level 4, 5 has the highest points and faces number, about more than 340000.

So, the light intensity level and skin color have effect on points number. Light needs to be projected at suitable level to assure the points number acquired is highest. With the average skin and the light level 9, the points number acquired is high. With the brighter skin, the points number decreases. Therefore, it's necessary to choose the suitable level of light sensing to acquire high number of points. With the dark skin, the light gain level should be 14.

Mức sáng / Màu da	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Sáng																	
Trung bình																	
Nâu sạm																	

Figure 22. Light levels for 3 skin color levels

4. Conclusion

Experiments show that the light intensity and skin color directly affect the accuracy of the 3D scanning method using structured light. Different skin colors have different numbers of point cloud. Studying the effects of skin color and light intensity on the points number acquired has important meaning to increase the point cloud quality and the accuracy of the measuring result. Dark and brown skin need higher light level. The average skin needs average light level. Brighter skin needs lower light level for sharper shape. Lower light level has lower points number. If the light level is too light, the model is not clear, the number of points decreases. Therefore, it's necessary to set the light level from gain 9 to 15 so that it's suitable for average skin. The light level for the dark skin should be at gain 14 – 20. The light level for bright skin should be at gain 6 – 12. The variety of skin colors is one of the reasons that make difficulty in the data scanning. Therefore, it's necessary to classify the skin colors in levels and adjust the suitable light for the scan on human skin.

Acknowledgments

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NGHIÊN CỨU ẢNH HƯỞNG CỦA MÀU DA TAY NGƯỜI VÀ ĐỘ NHẠY SÁNG CỦA MÁY ẢNH ĐẾN CHẤT LƯỢNG ĐÁM MÂY ĐIỂM KHI SỬ DỤNG PHƯƠNG PHÁP ĐO 3D BẰNG ÁNH SÁNG CẤU TRÚC

Tóm tắt:

Trong những năm gần đây công nghệ quét 3D phát triển và được ứng dụng trong rất nhiều lĩnh vực như: thời trang, y tế, thẩm mỹ.... Tuy nhiên, công nghệ quét 3D trên da người vẫn có những hạn chế do đặc điểm màu sắc da và độ nhạy sáng của máy ảnh. Bài báo này trình bày kết quả nghiên cứu sự ảnh hưởng của màu da và độ nhạy sáng của máy ảnh tới chất lượng đám mây điểm khi đo 3D bằng ánh sáng cấu trúc. Chất lượng điểm ảnh 3D được đánh giá thông qua số lượng điểm ảnh trên bề mặt thu được. Kết quả cho thấy độ nhạy sáng của máy ảnh có ảnh hưởng lớn tới số lượng điểm ảnh. Độ nhạy sáng quá cao hay quá thấp đều làm giảm số lượng điểm ảnh, cùng một mức nhạy sáng nhưng các màu da khác nhau cho số lượng điểm ảnh khác nhau. Mỗi màu da sẽ tương ứng với mức nhạy sáng phù hợp của camera, cường độ thu sáng của camera từ cấp độ gain 4 – gain 20. Kết quả nghiên cứu chỉ ra rằng: với màu da sáng nên đặt chế độ của camera ở mức nhạy sáng từ 6 – 12, da màu sạm hoặc nâu đặt ở mức sáng từ 14-20, da màu trung bình đặt ở mức sáng 9 – 15 cho kết quả tốt nhất. Việc nghiên cứu các chế độ nhạy sáng phù hợp với từng nhóm màu da là cần thiết để đảm bảo chất lượng đám mây điểm thu được tốt nhất, phục vụ cho quá trình phẫu thuật thẩm mỹ hoặc thiết kế găng tay và các trang phục ôm sát cơ thể.

Từ khóa: *Ánh sáng cấu trúc, cường độ sáng, màu sắc da, găng tay, số lượng điểm ảnh.*