LENGTH INDEPENDENT HUMAN HAIR DARKNESS DETECTION USING AVERAGE METHOD IN COLORED SCANNED IMAGE ANALYSIS

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ABSTRACT

This paper describes an algorithm for detection of human hair darkness. In this algorithm, the strand of the hair is first scanned in colored mode and 1200 dpi with 2 different background colors and in four different lengths followed by eliminating background's pixels. The pixels left belong to the object scanned (strand of human hair). Greyness of each pixel is computed using average method. The average greyness of all pixels of the hair represents the darkness of the hair. Since all pixels of the object are considered and then the ratio is used as output (darkness), the algorithm is independent from length of the hair.

Keywords *- hair darkness; length independent; average method; image analysis; background*

INTRODUCTION

When it is talked about hair analysis, most of the time it refers to the chemical analysis of the hair. Chemical hair analysis may be considered as an alternative method when urine or blood is no longer expected for containing a specific infection (Smart, 2009; Eastern Research Group, 2001; Rogers & Koike, 2009). Although several fields in medicine use chemical hair analysis, but forensic toxicology is a pioneer followed by environmental toxicology (Inoue et al., 2007; Rogers, 2006). In the last decades numerous researches were performed in chemical analysis related to the human hair. Nevertheless, because of some limitations, researchers were not able to perform great works on human hair in physical analysis. In physical analysis, some characteristics such as color, darkness, thickness, and growth of human hair may be considered. Unfortunately these characteristics are subjective and there are problems regarding result indication and demonstration.

Beside subjective-ness, there is another problem in physical analysis of human hair which is measurement (scale). Since naturally hair is thin, it is difficult to measure some characteristics. These two problems somehow forced researchers to use digital image processing as a tool and help to work on physical aspects in human hair analysis. In this context, many researches were accomplished regarding growth of human hair (Neste & Trueb, 2006; Yazdanbakhsh & Fisahn, 2009; Hoffmann, 2001; Hoffmann & Neste, 2005).

Although some researches have been performed via digital image processing in color analysis for human hair (Rousset, 2008), there is no research performed using digital image analysis in darkness of human hair. Characteristics of human hair play important role in forensics. Beside that, hair darkness has relation with many fields such as age (Tobin & Paus, 2001; Robbins, 2002; Tobin et al., 2004; Gao & Bedell, 2001; Nagase et al., 2009; Tajima et al., 2007; Robbins & Kamath, 2007) and intelligence (Lynn, 2006; Serre & Paabo, 2004; Handley et al., 2008). In this regard, researcher proposes an algorithm to distinguish darkness of human hair.

In this study since scanner is used and strand of hair is narrow and weedy, shadow of hair is ignored. Hardware used in this study contains a desktop computer (CPU: Intel core i5, RAM: 4GB DDR3), a scanner set on 1200 dpi. Software used; Linux Ubuntu 14.04 as operating system, JPEG9-a, and Imagelab2012 as library function which works in C++ and RGB mode – one byte for redness, one byte for greenness and one byte for blueness. The minimum value for redness, greenness and blueness is 0 and maximum value is 255. Based on this, greyness has 0 and 255 as minimum value and maximum value respectively. Greyness 0 is equivalent to black (pure black) and 255 means white (pure white).

This research offers a basis for other researches and studies which are based on hair darkness. Strength of this research is not only use of ordinary hardware and open-source software available for all, but also use of pure average method which makes this study length independent. Moreover, since this study was performed on both black background and white background, future researches may be done in any of these two, based on the situation of research. Although this research was done on human hair, it may be used for any kinds of hair, or even for tiny objects which shadow can be ignored.

METHODOLOGY

This study was performed on 20 different strands of hair from 20 different of persons. The hairs were different in length and color. Two different approaches were considered based on color of background. In this study the terms “greyness” and “darkness” are used as alternatives with respect of having opposite meanings. To eliminate ambiguity, these two terms are always mentioned with value. This is why, because of having value, both terms of “darkness” and “greyness” have the same functionality.

White background

Since printers cannot print white color, researcher had to try many white sheets to find the best one, the one which is the nearest to the pure white (255). To distinguish the average darkness, each sheet was scanned with 1200 dpi. Then darkness of each pixel was computed using average method followed by adding all of these different types of darkness and then the result was divided by number of all pixels. The best sheet had average darkness of 251. This white (almost white) sheet was used as background in scanning of 20 different hairs. Each hair was scanned in 1200 dpi while the background was the white sheet said, and then the average darkness of hair is computed. Fig. 1 shows the flow of average darkness computation of each strand of hair with white sheet as background.

Black background

Since printers can print black color, the researcher tried some printers of types ink-jet and laser-jet and many kind of sheets to make the best black sheet, the one which is the nearest to the pure black (0). To distinguish the average darkness, each sheet was scanned with 1200 dpi. Then darkness of each pixel was computed using average method followed by adding all of these different types of darkness and then the result was divided by number of all pixels. The best sheet had average darkness of 3. This black (almost black) sheet was used as background in the scanning of 20 hairs. Each hair was scanned in 1200 dpi while the background was the black sheet said, and then the average darkness of hair is computed.

As shown in Fig. 1, the white background used has greyness 251. It was the best sheet near to white (255) found after testing many white sheets. Therefore when it is talked about white background means the sheet having greyness 251 – not exactly 255. Based on grayness 251, before scanning of a hair, we are aware that if the greyness of the hair is greater than 251, then the algorithm collapses. That is why, as default, the value 251 is considered as average darkness (average greyness). For distinguishing hair darkness, number of pixels of the hair and darkness of each pixel are needed. Then using average method, summation of different types of darkness is divided by number of pixels. The value of this ratio is the darkness of the hair. To do this, the strand of hair is scanned and greyness of each pixel is computed using average method. If the greyness is less than 251, it means the pixel belongs to the hair. Now, the greyness is added to total greyness and number of pixels increases by 1. After reading all pixels, we compute ratio of total greyness and number of hair-pixels that is darkness of hair.

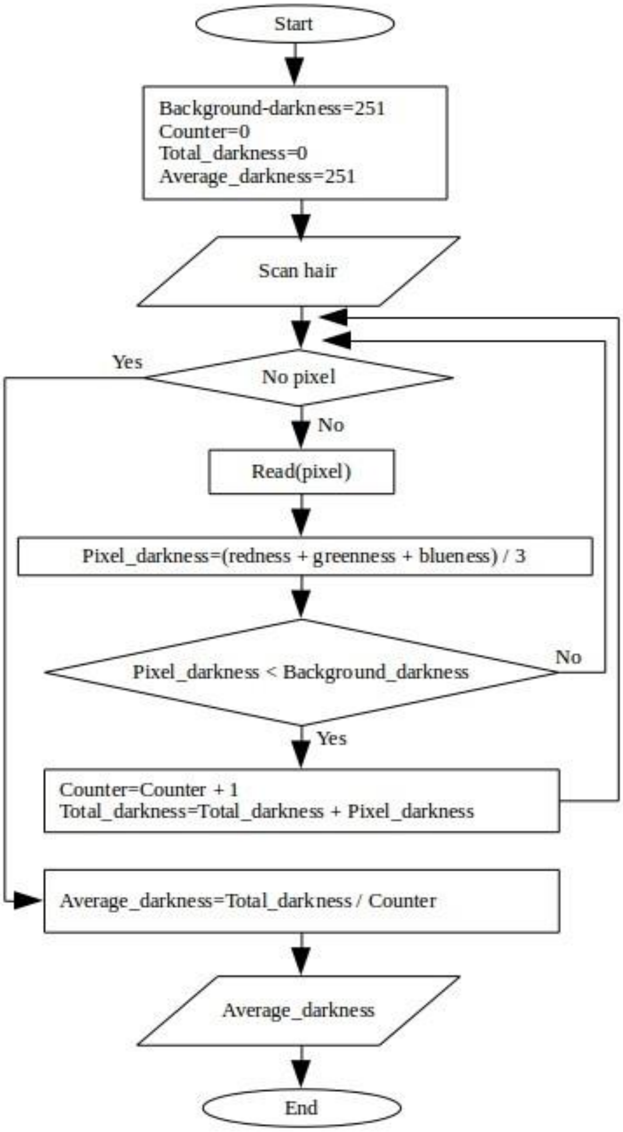

Figure 1. Flow of average darkness computation of each strand of hair when background is white

In Fig. 2, the black background used has greyness 3. It was the best sheet near to black (0) found after testing many black sheets. Therefore when it is talked about black background means the sheet having greyness 3 – not exactly 0. Based on grayness 3, before scanning of a hair, we are aware that if the greyness of the hair is less than 3, then the algorithm collapses. That is why, as default, the value 3 is considered as average darkness (average greyness). For distinguishing hair darkness, number of pixels of the hair and darkness of each pixel are needed. Then using average method, summation of all different types of darkness is divided by number of pixels. The value of this ratio is the darkness of the hair. To do this, the strand of hair is scanned and greyness of each pixel is computed using average method. If the greyness is greater than 3, it means the pixel belongs to the hair. Now, the greyness is added to total greyness and number of pixels increases by 1. After reading all pixels, we compute ratio of total greyness and number of hair-pixels that is darkness of hair.

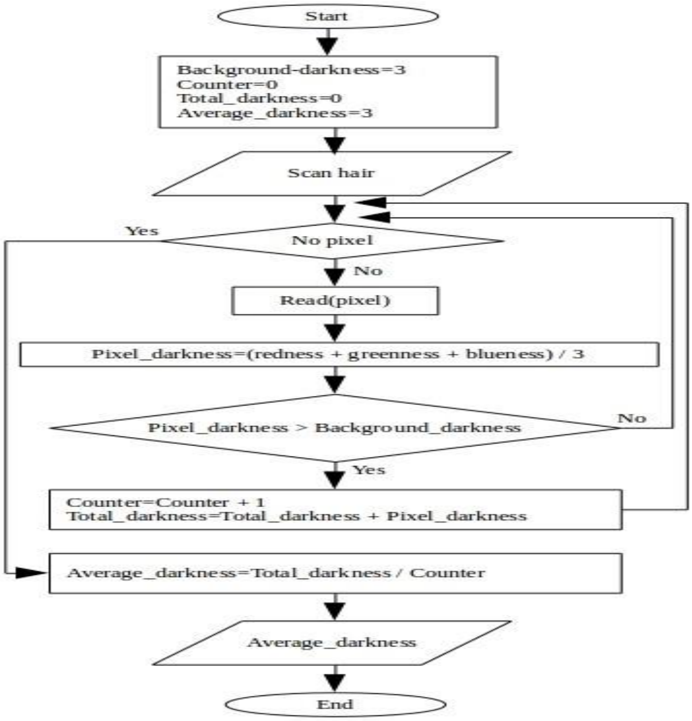

Figure 2. Flow of average darkness computation of each strand of hair
when background is black.

Both methods of white background and black background were applied on 20 different hairs. For each strand of hair 4 different lengths were considered.

In the following figures – Fig. 3, Fig. 4, Fig. 5, and Fig. 6, when background is white, hair number 6 is shown in different length; longest, long, short, and shortest respectively. While, Fig. 7, Fig. 8, Fig. 9, and Fig. 10, when background is black, hair number 6 is shown in different length; longest, long, short, and shortest respectively

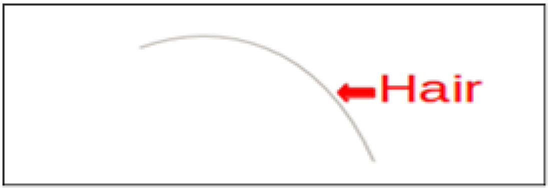

Fig. 3 Hair number 6 in length longest with white background

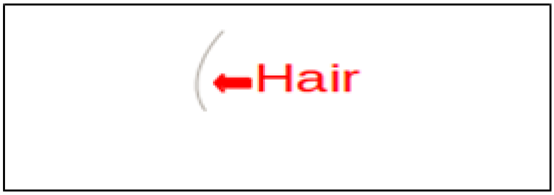

Figure 4 Hair number 6 in length long with white background

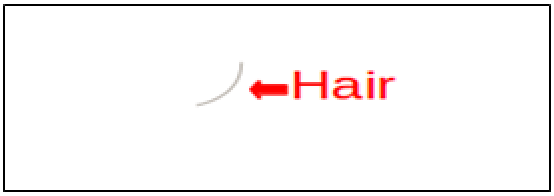

Figure 5 Hair number 6 in length short with white background

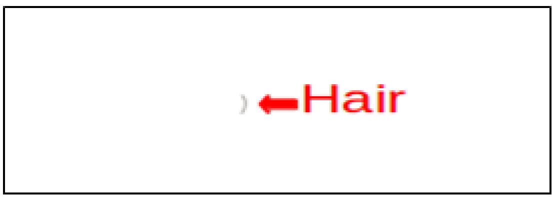

Figure 6 Hair number 6 in length shortest with white background

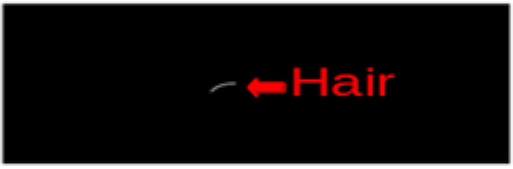

Figure 7 Hair number 6 in length longest with black background

Figure 8 Hair number 6 in length long with black background

Figure 9 Hair number 6 in length short with black background

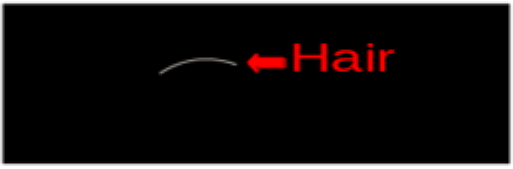

Figure 10 Hair number 6 in length shortest with black background

RESULTS

Based on two algorithms explained (use of white background and black background), 20 different strands of hair from 20 different parsons (male and female having different age) having different size and different color were considered. Before process of scanning, all strands of hair were washed and then dried. Both algorithms were applied on each hair in 4 different sizes. These 4 different lengths were called longest, long, short, and shortest. The only relation between these lengths in each strand of hair is: longest > long >

short > shortest. Of course longest, long, short, and shortest for each hair have the same length in white background and black background. Table 1 represents the result when the background was white

Table 1. Darkness computation result with white background

Hair Number	**Size**			
	Longest	**Long**	**Short**	**Shortest**
1	28	29	29	30
2	26	26	27	27
3	16	16	16	18
4	19	19	19	19
5	59	59	59	61
6	133	133	134	135
7	187	185	182	182
8	209	205	203	202
9	235	230	229	223
10	92	92	92	92
11	181	181	180	177
12	55	55	55	57
13	38	38	38	40
14	201	199	196	196
15	243	240	239	230
16	18	18	18	18
17	16	16	17	16
18	26	26	28	27
19	74	75	75	75
20	23	23	25	25

On the other hand, Table 2 shows the result of darkness computation when background was black.

Table 2. Darkness computation result with black background

Hair Number	Size			
	Longest	**Long**	**Short**	**Shortest**
1	29	26	27	27
2	26	26	29	27
3	16	16	15	19
4	18	17	16	15
5	59	63	60	62
6	131	135	132	129
7	188	185	186	182
8	209	209	205	210
9	235	235	232	232
10	90	92	92	92
11	181	179	180	177
12	56	55	55	57
13	38	40	40	42
14	200	199	198	196
15	247	243	245	245
16	19	19	17	18
17	16	16	17	16
18	25	22	26	24
19	75	74	75	75
20	25	23	25	25

DISCUSSION

Based on Table 1 - where the background is white, if darkness of hair in longest, length is greater than or equal to 181, when length of hair decreases, then greyness is non-increasing. Hair number 7, 8, 9, 11, 14, and 15 have this property. In other words, in none of these hairs, when length decreases, greyness increases. In these hair strands, the greyness in longest length is greater than or equal to greyness in long length, greyness in long length is greater than or equal to greyness in short length, and greyness in short length is greater than or equal to greyness in shortest length. All of these hair strands have greyness greater than or equal to 181 in length longest, greyness greater than or equal to 181 in length long, greyness greater than or equal to 180 in length short, and greyness greater than or equal to 177 in length shortest as Figure 11 shows.

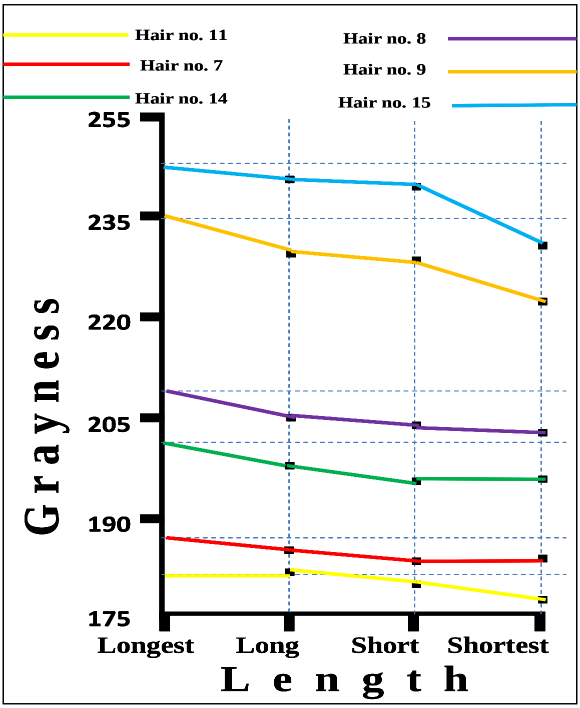

Figure 11. Non-increasing of greyness in hairs number 7, 8, 9, 11, 14, 15 when background is white

Another matter about hair strand numbers 7, 8, 9, 11, 14, and 15 which have greyness greater than or equal to 181 - in longest length is; minimum and maximum diversity of greyness in different lengths is 5 (for hair strand number 7) and 13 (for hair number 15) respectively, while these values for other hair are 0 (hair number 4 and hair number 10) and 2 (hair number 1, 3, 5, 6, 12, 13, 16, 18, 20). Moreover, in hair strand numbers 7, 8, 9, 11, 14, and 15 greyness in longest length has direct relation with diversity; hair number 11 has the least greyness in longest length (that is 181) and the least diversity (that is 4). These values for hair number 7 are: 187 and 5, for hair number 14: 201 and 5, for hair number 8: 209 and 7, for hair number 9: 235 and 12, for hair number 15: 243 and 13. Finally, the minimum diversity of greyness in Table I is 0 (hair number 4 and hair number 10), while maximum diversity of greyness is 13 (hair number 15). The difference between maximum diversity of greyness and minimum diversity of greyness is 13.

Although based on data represented in Table 1 regarding white background, some information could be constructed and some relations could be found, in Table 2 – when background is black – the point can be talked about is minimum and maximum diversity of greyness in different lengths. Minimum diversity of greyness in Table 2 is 1 (hair strand number 17 and hair strand number 19), while maximum diversity of greyness is 6 (hair strand number 6 and hair strand number 7). The difference between maximum diversity of greyness and minimum diversity of greyness with black background is 5.

CONCLUSION

The comparison of data related to 20 different strands of human hair shows, when background is white and greyness of a strand of hair is greater than or equal to 181 in longest length, greyness will not increase if the length of the hair is shortened. In other word, there is an inverse relation between length of the hair and darkness of the hair when background is white and greyness is greater than or equal to 181 in longest length. It means, the shorter-the darker. Aside from this relation in this group of hair, another relation is when hair is darker (less greyness), difference in length causes less diversity in darkness. Although darkness 181 (longest length for hair strand number 11) and darkness 243 (longest length for hair strand number 15) are lower bound and upper bound for the group having these relations, there is a gap between 181 and 133 (longest length for hair strand number 6). There is no hair strand having darkness between 133 and 181 in the data existed. The lower bound might be less than 181. This is also about upper bound that is 243. There is no hair having darkness between 243 and 255. The upper bound might be greater than 243. Moreover when background is white, all different types of darkness of hairs in different lengths have maximum diversity of 13, while with black background the maximum diversity is 6. It shows generally, black background is more reliable than white background.

Accuracy

In the work on white background, since the real greyness of background is 251, if the strand of hair scanned has greyness greater than or equal to 251, then the algorithm cannot distinguish the real greyness of the hair. In this situation the algorithm returns value of 251 as darkness of the hair. In other word, this algorithm cannot distinguish darkness of hairs having 251, 252, 253, 254, and 255 as greyness. This is why in study over white background there is an error equal to 5/255 which is 1.96%. Besides that, there is a diversity of darkness in different lengths. The maximum value of this diversity is 13 making an error equal to 13/255 which is 5.1%.

In the work on black background, since the real greyness of background is 3, if the strand of hair scanned has greyness less than or equal to 3, then the algorithm cannot distinguish the real greyness of the hair. Here, the algorithm returns value of 3 as darkness of the hair. In other word, this algorithm cannot distinguish darkness of hairs having 0, 1, 2, and 3 as greyness. This is why in study over black background there is an error equal to 4/255 which is 1.6%. Besides that, there is a diversity of darkness in different lengths. The maximum value of this diversity is 6 making an error equal to 6/255 which is 2.4%.

RECOMMENDATION

As explained, the accuracy of the study in black background is higher than white background. Because of this, to distinguish human hair darkness, the use of black background is suggested although before scanning the hair, darkness of black background should be computed and used as the basis. If darkness returned by algorithm is less than or equal to the darkness of background – used as a basis, use of white background is needed. Before scanning the hair, darkness of white background should be computed as basis.

Since there are gaps for finding exact upper bond and exact lower bound in the work with white background, use of more data is suggested.

Although this study has been done on human hair, it could be done on any object which is thin and narrow. Thickness of object is significant since shadow removing has been ignored in this study.

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