A Practical Male Hair Aging Model

D. V. Volkmann and M. Walter

Institute of Informatics - Universidade Federal do Rio Grande do Sul
Porto Alegre - Brazil

Abstract

The modeling and rendering of hair in Computer Graphics have seen much progress in the last few years. However, modeling and rendering hair aging, visually seen as the loss of pigments, have not attracted the same attention. We introduce in this paper a biologically inspired hair aging system with two main parts: greying of individual hairs, and time evolution of greying over the scalp. The greying of individual hairs is based on current knowledge about melanin loss, whereas the evolution on the scalp is modeled by segmenting the scalp in regions and defining distinct time frames for greying to occur. Our experimental visual results present plausible results despite the relatively simple model. We validate the results by presenting side by side our results with real pictures of men at different ages.

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation—

CCS Concepts
• ***Computing methodologies*** → ***Rendering;*** *Modeling and simulation;*

1. Introduction

Hair aging is a natural phenomenon that affects every human being. At about 30 years old, on average, our hair starts to lose pigmentation at a rate of $10-20\%$ every ten years [Tob08a]. At 50 years old, between $6-23\%$, of people will have 50% grey hair [PLL12]. Even though there have been many advances in the rendering of human hair [RZL*10, OXKP12, C*16], this dynamic aspect has not been addressed before. We developed a biologically-inspired simulation of the hair aging phenomena. The loss of pigments is noticeable as the original color of the hair turns to grey and finally to white. Our model has two main parts: greying of individual hair strands and how the greying propagates on the scalp. As a first approximation, our focus was on aging for males, and we use a simple model where the desaturation of the hair (loss of pigmentation) is modeled as a single gradual transition of hair with an initial amount of melanin to no melanin. We implemented the model on Blender, an open-source 3D software, and our simulations show visual plausibility with real hair whitening. In Fig 1, we show two frames of greying hair from our system.

2. Biological Background

In this section, we first present basic information on the Biology responsible for individual greying of hairs, followed by more general information on how the greying spreads on the scalp.

When we are born, we have around 100,000 hair follicles on our scalp, and with time they start to lose density, pigmentation, and thickness. The mechanisms of hair pigmentation are well understood [Tob08b]. Figure 2 (left) is a representation of a hair follicle together with some of its biological elements. Melanocytes present in the hair bulb produce melanins that are transferred to the hair shaft and give the hair its color. In the lifetime of a hair bulb, melanocyte stem cells provide a reservoir of melanocytes. With time, there is a progressive decline of both melanocytes and stem cells, causing a gradual loss of pigment along the same hair shaft until the whole shaft is light grey or white. Despite progress in understanding this process, the exact mechanism of melanocyte loss is still unclear [Tob08b].

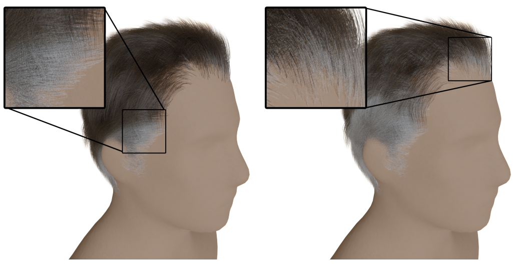

Figure 1: *Example of result from our simulations. Progression of Hair greying.*

Figure 2 (right) is a microscopic picture taken from a human scalp where hair aging already started. We can see that the pigmentation loss does not affect all the follicles the same way. During the aging process, black, white, and grey hairs all coexist in the same region, meaning that some hairs grow already as a white fiber. There is no quantitative information, however, on their distri-

DOI: 10.2312/egs.20201017

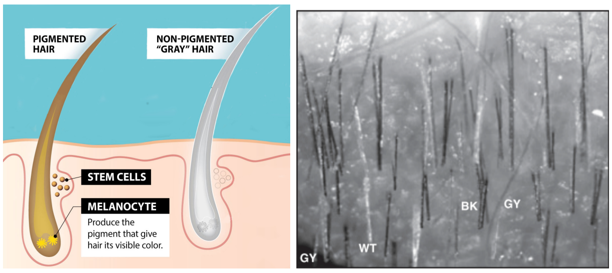

Figure 2: *Left: Hair follicle and greying process. Right: Macroscopic view of greying scalp showing a mixture of white (WT), grey (GY) and pigmented (BK) hairs. Source: [Tob08b].*

butions on the scalp. Therefore, we only model the grey type, with the transition from the original color to white along the shaft.

Concerning the onset and spreading of grey hairs, for quite some time in the academic community, there was a 50/50/50 "rule of thumb," stating that at age 50, 50% of the population has at least 50% grey hair [KW65]. Panhard and colleagues revisited this rule [PLL12] who found that the actual global rate of 50% greying at 50 years old is between $6-23\%$, on a study with 1464 middle-aged male and female volunteers, spread out over five continents. Greying on average first appears around 30-40 years old, depending on a person's origin, background, and lifestyle, and presents a linear increase with age [PLL12].

Figure 3 illustrates the scalp regions. Geographically, grey hair first appears in men on the temporal area (60.6% observed) and then spreads to the vertex region affecting the occiput last. In women, it seems to appear first in the frontal area (38.6% observed) [J*12], and the rate of greying of the temporal and vertex regions are similar.

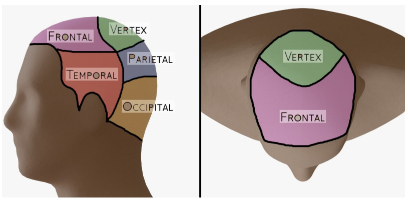

Figure 3: *Scalp regions.*

3. Related Work

Figure 4: *Results comparing the evolution of the state-of-the-art on hair rendering. Source: left [iAUK92] and right [C*16].*

The rendering of hair has seen great advances over the last years. Ward and colleagues present a comprehensive survey, although 13 years old now [WBK*07]. From the pioneering work of Anjyo and colleagues [iAUK92] to more recent approaches [RZL*10, OXKP12, C*16], hair rendering has reached increased levels of visual faithfulness. In Figure 4 we compare the development in this field with results from [iAUK92] and [C*16]. The more recent result has more depth, subtle shadows, and self-shadowing.

These increased levels of realism are partly due to better understanding and modeling of more complex hair structure and its interaction with light. Although covering many aspects of the hair rendering problem, current solutions have not addressed the issue that we are addressing in this paper, i.e., hair aging. There are, however, greying effects in some games and movies. It appears that game companies and movie studios have their in-house solutions, with no published research.

4. Methodology

In this section, we present how we developed our hair aging simulation system. Even though we are using Blender for our results, our technique does not depend on Blender and can be adapted to other 3D rendering systems, or even in stand-alone applications. Below we detail the main steps.

4.1. Greying of individual hairs

The input to our simulation is a head model and a scalp area, which is the region where the hair is added. The hairs are defined with a particle system attached to the scalp. The number of particles is user-defined. As a reference, for the images in this section, we defined around 13k hairs, but in the results, we show images with more hairs. We model individual hairs as tapering cylinders with a given number of sections. In our simulations for short hair, we used eight sections, and the standard hair mechanism creates all hairs the same.

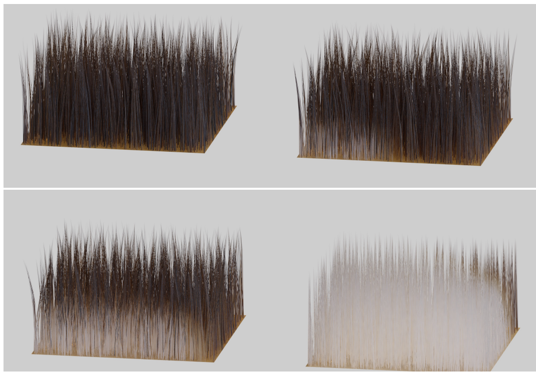

Figure 5: *Example of individual melanin transition on the hair strands.*

To model the greying of individual hairs, we gradually change the melanin of each strand based on its thickness. As a tapering cylinder, the hair strand base is thicker than its tip, even if by a small amount. The removal of melanin starts at the hair's base at the scalp and slowly advances towards its tip. To allow a more natural appearance, we added noise in the thickness information, that is, the hairs are still modeled as tapering cylinders, but their thickness information is slightly influenced by noise, making the grey transition appear more natural when looking at bundles of hair near each other. The noise thickness does not affect the hair geometry, just how the thickness information is interpreted to interpolate the melanin concentration on the hair. Figure 5 exemplifies the effect on a hair patch. The whitening rate of each hair is variable and explained in the next section when we explain overall whitening on the scalp.

4.2. Distribution and development of aging hairs on the scalp

Once we know how to grey individual hairs gradually, we now explain how we model the greying effect on the scalp as a whole. To model the variation in time that defines when a given hair starts its greying, we first randomly define for each hair in the scalp one of three possible whitening rates. Figure 6 illustrates the initial distribution of aging rates in the scalp, painted red (10%), green (15%), and blue (20%). We use these values since these are the average rates of whitening every 10 years [Tob08a].

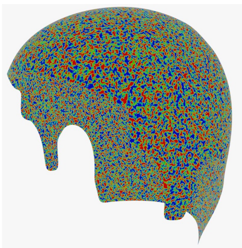

Figure 6: *Whitening rates: Red (10%), Green (15%), Blue (20%).*

Since greying starts first and advances faster at the temporal regions, we need a second mechanism to model this effect. We define a mask of spherical shape to control the advance of greying in the temporal parts as if a wave is spreading the old age on the hair. The mask progression is shown in Figure 7. There is no data comparing the relative speeds of hair whitening in the temporal area and the rest of the scalp. Therefore we experimentally defined a 35% rate of whitening in this area every 10 years.

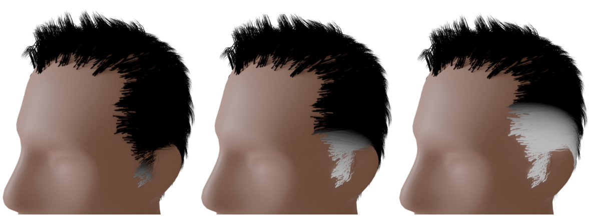

Figure 7: *Temporal region mask to spread the greying effect*

We restrict the effect of this mask to the scalp areas marked as not belonging to the top of the scalp since we know that the top of the scalp is the last region to grey. We need, therefore, a method to segment the top. We segment the top region using a black&white texture aligned with the scalp such that the top is black, and the rest is white, as illustrated in Fig. 8. We the help of this texture, we process each hair and mark as belonging to the top the ones that are attached to the black patch. Having both the general graying mechanism defined and the graying in the temporal areas defined, we can run the simulation as we explain in the next section.

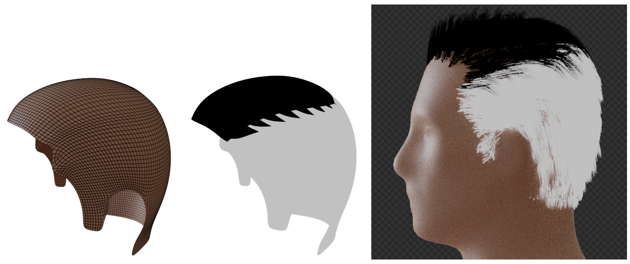

Figure 8: *Segmenting the top of the scalp with a black&white texture. Hairs in the black area are defined as being in the top region.*

5. Experimental Results

In this section, we present and validate the results of our simulation. The recent hair rendering approach presented by Chang and colleagues [C*16] is implemented in Blender as a shader. It is flexible enough for our purposes. This shader implements a *Bidirectional Scattering Distribution Function* (BSDF) for rendering hair and fur [Ble19]. The shader provides many modes for hair color setup. For our purposes, the amount of melanin defines the hair color. From a user's viewpoint, the shader requires only the amount of melanin desired, in the range $[0,1]$ equivalent to $[0\%, 100\%]$.

Our method requires the user to define the total simulation time, and the initial time for two effects: the greying of temporal areas, and the starting time for overall greying. Sometimes it is more convenient to think in terms of the total number of frames and define at which frame the different effects start. For the results in this section, we defined a total of 400 frames and a span of 30-70 years old, meaning each frame corresponds to $1/10$ of a year. We then defined the onset of temporal greying at frame 55 (approximately 35 yo) and the onset of greying overall at frame 80 (approximately 38 yo). We set the initial melanin value, used to describe the original hair color as 0.9, a dark brown, predominant for over 90% of the world's human population [Tob08a].

Figure 9: *Young man (around 30 yo) with no signs of aging. Source right: www.gettyimages.com*

Our results present a visual comparison with men of different ages. In the sequence of figures, from Fig. 9 to Fig. 12, we show side-by-side our results and images of men with increasing ages. The parameters were adjusted to match subjectively the greying of each man. The results do not match the real images exactly, mostly due to the universal aspect of the simulation and differences in the background and lifestyle of subjects. Nevertheless, our visual results prove accurate in terms of predicting the pattern of aging and the overall coloration. We rendered all results in this section using $68K$ hairs at 1080^2 pixels.

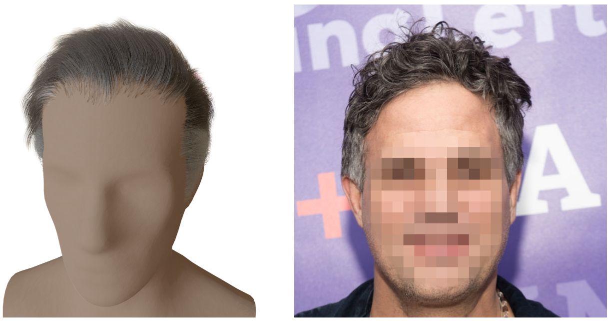

Figure 10: *Middle aged man (approximately 50 yo) with completely grey temporal areas, but just a few grey hairs in other regions. Source right: www.gettyimages.com.*

Figure 11: *Middle aged man (approximately 65 yo) with several follicles lacking pigmentation. Source right:www.gettyimages.com.*

We used 8-bit color channels, and the built-in denoiser in Blender with a radius of 4, strength of 0.2, and feature strength of 0.5 in an Intel i5 processor with 10GB of RAM, a GTX 960 graphics card and Windows 10. With these settings and 256 samples, it takes 36 hours to render 400 frames. Rendering hair that lacks melanin takes longer because it has transmission data, meaning the follicles are somewhat transparent, taking longer for the ray tracing and denoiser to compute. This performance would not work for realtime applications such as games. However, we plan as future work to adapt our technique to work within a game engine, with more efficient techniques for rendering.

Figure 12: *Senior man (approximately 70 yo) very few follicles with pigmentation remaining. Source right: www.gettyimages.com.*

6. Conclusions and Future Work

In this paper, we have presented a basic understanding of the hair aging phenomena and developed a procedural approach for simulating the greying effect using Blender, although the methods here presented could, in principle, be transferred to other rendering systems. Our visual results show that many levels of greying are possible according to the character's age, with visual quality for many graphics applications.

We believe that we have provided a simple initial model that can be explored in future investigations. For instance, it would be interesting to adapt the simulation based on the ethnicity of the character, to improve the graying transition from the temporal region to the scalp, to implement hair loss and hair thinning to support the greying effect further. We want to expand the model to represent females models as well. The simulation could also be adapted to simulate other types of greying, such as facial hair. Having different hairstyles does imply slight differences in the simulation, making it likely that long hairstyles would not work with the current setup since the temporal region masks would not reach the tips of follicles in the region.

References

[Ble19] BLENDER: Principled hair bsdf, 2019. URL: https://docs.blender.org/manual/en/latest/render/cycles/nodes/types/shaders/hair_principled.html. 3

[C*16] CHIANG M. J.-Y., ET AL.: A practical and controllable hair and fur model for production path tracing. *Computer Graphics Forum 35*, 2 (2016), 275–283. 1, 2, 3

[iAUK92] ICHI ANJYO K., USAMI Y., KURIHARA T.: A simple method for extracting the natural beauty of hair. In *Proceedings of SIGGRAPH 92* (July 1992), pp. 111–120. 2

[J*12] JO S. J., ET AL.: Hair graying pattern depends on gender, onset age and smoking habits. *Acta dermato-venereologica 92*, 2 (2012), 160–161. 2

[KW65] KEOGH E., WALSH R.: Rate of greying of human hair. *Nature 207*, 4999 (1965), 877. 2

[OXKP12] OU J., XIE F., KRISHNAMACHARI P., PELLACINI F.: Ishair: Importance sampling for hair scattering. *Computer Graphics Forum 31*, 4 (2012), 1537–1545. 1, 2

[PLL12] PANHARD S., LOZANO I., LOUSSOUARN G.: Greying of the human hair: a worldwide survey, revisiting the 50 rule of thumb. *British Journal of Dermatology 167*, 4 (2012), 865–873. 1, 2

[RZL*10] REN Z., ZHOU K., LI T., HUA W., GUO B.: Interactive hair rendering under environment lighting. In *ACM TOG* (2010), vol. 29, ACM, p. 55. 1, 2

[Tob08a] TOBIN D.: Human hair pigmentation–biological aspects. *International journal of cosmetic science 30*, 4 (2008), 233–257. 1, 3

[Tob08b] TOBIN D. J.: *Biology of Hair Follicle Pigmentation*. Springer, 2008, pp. 51–74. 1, 2

[WBK*07] WARD K., BERTAILS F., KIM T.-Y., MARSCHNER S. R., CANI M.-P., LIN M. C.: A survey on hair modeling: Styling, simulation, and rendering. *IEEE TVCG 13*, 2 (2007). 2