Realistic Hair Visualization in Maya:
A new work-flows and methods
<table>
<thead>
<tr>
<th>Table of Content</th>
</tr>
</thead>
</table>

1. **Introduction** ........................................................................................................... 03

2. **Abstract** .................................................................................................................. 04

3. **Overview** .................................................................................................................. 05

4. **Application in Maya** ............................................................................................... 06
   4.1 Geometry base hair .................................................................................................. 06
   4.1.1 Zbrush hair ......................................................................................................... 06
   4.1.2 Polygon cluster hair .......................................................................................... 08
   4.2 Software Hair tools in Maya .................................................................................. 12
   4.2.1 Maya Paint Effect Hair ..................................................................................... 12
   4.2.2 Maya Hair ......................................................................................................... 16
   4.2.3 Maya Fur ........................................................................................................... 16

5. **Integration & Practicing** .......................................................................................... 22
   5.1 Overview of pros & cons of previous methods .................................................... 22
   5.2 Suggestion of a preferable method in Maya ......................................................... 22
   5.3 Implementation ....................................................................................................... 24
   5.3.1 Stage 1: Polygons to Curves ............................................................................ 24
   5.3.2 Stage 2: Creating Paint Effect Hairs ................................................................. 26
   5.3.3 Stage 3: Apply Hair Style systems ................................................................. 27
   5.3.4 Stage 4: Apply Hair Dynamics systems .......................................................... 29

6. **GHM Hair Creator MEL Scripts** .............................................................................. 32

7. **Final Products** .......................................................................................................... 36

8. **Future developments** .............................................................................................. 40

9. **Conclusion** .............................................................................................................. 41
1. INTRODUCTION:

Hair modeling is a fundamental part in creating virtual human in CG. Many artists are successful in creating human head & body but have not archive the same result with hair. Hair varies from its form, shape, color and material to its dynamics property. Hair modeling is a complex issue which has many problems due to its complexity. Hair hasn't got a complete industry standard solution yet. Many companies and individuals have developed their own tools and method to create and manipulate CG hair. Modeling and rendering hair to look close to realistic are difficult but also simulating its dynamics are even more problematic.

Hair Modeling can be divided into 3 main categories: hair styling, simulation (dynamics) & rendering (Magnenat - Thalmann, 2001). In general, there are two groups of methods in Maya which can be used for hair creation. These two groups of methods are: Geometry hair and native software tool in Maya. The former can be further classified into Zbrush hair and Polygon patches, and the latter can be divided into Maya Paint Effect Hair, Maya Hair and Maya Fur. I will study how these methods can be used in Maya for production. Finally, I will combine these methods together to come up with a more flexible and preferable way of creating hair after studying pro & con of these methods.
2. ABSTRACT:

In this report, I propose a new work flow and method for hair modeling. Through investigating the existing methods of hair modeling, identifying their pros and cons. In order to combine the strengths of the existing most common three methods together and avoid their weaknesses, I first model polygon hair as usual, then using Paint Effect tubes to generate curves base on these polygon hair surfaces. Finally I assign Maya Hair to those Paint effect curves so that they inherit the looking/render of Maya Hair nicely while still able to keep the neat control properties of Paint Effect tubes.

This will result in a system of multi resolution editing for Hair modeling, which allow user to edit at multi levels of the hair system from overall silhouette to micro detail of individual hair strands. Besides it also has a great advantage in dynamics solving as well.

I also wrote an Mel Scripts for my proposed work flow and method, which provide an easy way and user interface to manage and organize data used for the hair models. The application examples given in this report demonstrate effectiveness of my proposed work flow and method.
3. OVERVIEW:

Firstly, we should consider the characteristic of human hairs. Hair style varies among different persons and races. Naturally, hair style and other properties of hair varies depend on the characteristic of individual hair strands to some extent. For example, African's hair style tend to be afro-like and solid shape because their hair strands are very hard, thick, and curly. Asian hair are tend to be smooth and thin because their hair strands are small and round while European are little curly and ellipse shape.

( source: http://en.wikipedia.org/wiki/Hair )

However, due to the massive numbers of hair that human have on head (average 100,000 strands) (Anna Sokol, 2003) With the current computing ability and hardware limitation, we cannot represent and simulate accurately every individual strands of hairs on human's head but we have to find a way to simplify hair to a general shape and volume, which is easier and lighter to control and manage. These methods below are different approaches of simplification of the hair as well as control and dynamics handling. I will go through each of them and evaluate the following characteristics (Kelly Ward, 2004):

- Hair dynamic
- Performance vs Visual Fidelity.
- Unique stylish / Easy to control.
- Variation in Hair property and shape.
4. APPLICATION IN MAYA

4.1 GEOMETRY BASE HAIR

GEOMETRY BASE hair - is the most common method of creating hair used in game and animation nowadays, because it's simple, easy to model, compute dynamics and render. Until now it is the most simple way to model hair and it is effective.

This approaches is based on the characteristic of real hair, hair tend to group together and being static enough to maintain a solid overall silhouette. This method represent group of hair as an identical shape geometry such as trigonal prisms or generalized cylinders (Kelly Ward, 2004).

This approach give user an easier and quicker way to model and decide the hair shape and form as it is merely straight forward polygon modeling. User can quickly block out the overall hair shape and freely in creating style using geometry modeling techniques.

Below are some different popular way of creating polygon hair:

4.1.1 Zbrush hair:

Using a powerful sculpting and modeling software like Zbrush, we can create various polygon hair style. Given a base mesh, then start sculpting to form the overall hair shape. However Hair model from Zbrush or any other Sculpting software will have problem in Rendering and dynamics as it consists of high density vertex geometry which is nearly impossible to render and make dynamics in animation software like Maya, Max or XSI...etc. This model can be used only for single rendering like still image and poster and prototyping hair style. However they are also can be used to generate normal for low polygon hair in Next Gen games.
Hair sculpting using Zbrush

By Rodrigue Pralier (2008)

Block out overall hair shape

Creating loose hair strands using Zsphere

By Joe Lee (2009)  Complete hair

Zbrush version  In game version

Army of Two: The 40th Day - Electronic Arts (2009)
Pro:
- Fast to prototype hair style, easy to stylish and block out overall shape.
- Good for one piece compact hair style (such as short male hair).
- Suitable for creating Normal Map to use in low-poly game art.

Cons:
- Lack of natural detail like loose strands, small curly hairs.
- Great consuming of polygon which is difficult to rig dynamics & render.
- An overall hair texture need to be made manually.

4.1.2 Polygon cluster/wisps:

The most popular way of creating polygon hair is using clusters of polygon to represent wisps of parallel hair strands. These polygon clusters vary in shape and form which will greatly alter and affect the looking of hair. These are typical forms of polygon clusters: strip (thin flat patch of NURB or polygon surface), cylinder, box, ...etc. Cluster polygon hair are often used in game and animation. As they are easy to model, texture, take less much time to render and also easy to make dynamic.

Example of polygon cluster hair patches:
Each patch of polygon are representation of a number of hair wisps, the more polygon patches used, the better the result would be because hair surface will be represented more accurately and closer to real hair model. However more surface patches mean more computing when rendering and dynamic. In the example below, when using 4 large hair geometry patches, the render time is 2.34 minutes.
But if we increase the number of hair patches to represent the real hair model (12 patches) the result is much closer to real hair but instead we lose the performance in rendering time & dynamics simulation.
Because of the characteristic of the simplification method by grouping hair into clusters of polygon patches. This method has a big flaw in interpolation between two cluster, this artifact can be seen clearly at the intersect point of two cluster when viewing in close up. Beside, we can also see the boundary of patches at some odd angle, this lead to unrealistic looking and make the hair looks like groups of thin shape plates. In order to prevent this artifacts we either have to increase the number of poly patches as well as lower the hair strands that each patch represent. Also more accurate collision detection are need to prevent crossing intersection among patches.
4.2 SOFTWARE HAIR TOOLS IN MAYA:

Maya also has its native tool to create hair, it comes with 3 tools included: Paint effect Hair, Maya Hair and Maya fur.

4.2.1 Maya Paint Effect Hair:

This is basically Paint effect tool in Maya which generate Paint effect Hair look-alike strokes.

**Pros:**

Using Paint Effect the user can either paint the stroke directly on surface or make the stroke follow a specific curve or surface.

This way we can control where the hair should be put and easily create a path that the hair grows along. This give us an easy and accurate way to manipulate the grow path of hair or create hair whorl.
Paint effect Hair have many attribute to control the way hair growing by using control curves, this allow user more flexible and absolute way to create various hair style. The users can also control properties of individual hair tubes such as Width, Width scale, length, curl...etc. Besides, using Paint effect Hair we can specify the path that hair grow and create unique hair style by making the hairs tubes run along user's control curves.

Paint effect hair can render in a short amount of time using Maya software render. To be able for Mental Ray to render Paint Effect Hair, the user can convert it to polygon. This will make it become polygon type hair which we can manipulate at vertex level and also assign custom textures and shaders to it.
**Cons:**

The weakest point of Paint effect Hair is its looking. Although it is rendered quickly using Maya software render, but the lighting, and shadow quality is not good enough for production - which will require more works during postproduction process later.
The reason is paint effect Hair is comp in as a post process via Z depth sorting if using Maya software render. In those illustrations above, we can see there are no self shadow among each hair tubes at all, and the shadow they cast on the wall or face mesh is fake offset shadow.

On the other hand, converting paint effect Hair to polygon and using custom shader improves the way it look much more, however If we convert it to polygon Hair and render with mental ray, we would need a massive amount of polygons which is heavy, expensive and not efficient for rendering and simulation.

Besides, Paint effect Hair Does not support dynamics solver, We either need to rig the polygon hair manually or apply a dynamics solver to Paint Effect stroke.
4.2.2 Maya Hair:

Maya Hair is a native tool to create and simulate realistic Hair in Maya. It is basically a dynamics curve system. Maya hair has almost covered all the weak point of paint effect Hair including dynamics solving, rendering, optimizing for speed...etc. Maya hair consists of number of groups of Hair follicles. These follicles will be used to solve the dynamics of the hair. They are also representation of hair clumps which consist groups of small hair strands.
PROS:

Similar to the method of simplification of polygon hair path, each follicle is a representation of a group of hairs. Therefore, the more follicles we use, the more realistic & accurate simulation will be and more control over individual hair strand we have.

We also have control over individual follicle properties to assign an unique look for each hair group such as density, curl, color ...etc. It also can generate hair braid easily if we check the option for braid.
Maya Hair also provide us with a number of attributes to control hairs texture and random noise in diffuse, specular ...etc which can make the looking of hair closer to realistic.

Maya Hair can be rendered fairly quickly using software render with decent quality. It can also be rendered in Mental ray for better quality without having to convert it to polygon as it is fully integrated into the scene when using Mental Ray. Maya Hair render is much more accurate and closer to reality hair than Paint effect hair.

**CONS:**

Despite of these big advantage over Paint effect hair, Maya Hair is very difficult to model and maintain overall hair style and shape using the conventional workflow which are:
- growing Hair follicles on surfaces or points.
- using Maya curve editing tool, deformation tool or Maya Hair- Modify curve tool to edit those curve / model the hair style.

This method is slow and hard to style the hair to user's desired shape, especially when there are too many follicles. The result will be dull looking hair or very primitive hair style. It would take a lot of time and effort to create complex styles hair.
Another backward is that Maya Hair dynamics will break the initial hair style or the initial shape of the curve during the simulation process, to prevent this we can tweak the stiffness and attract to curve value, but this will result in unrealistic dynamics and very stiff hair.

For example, using the Dynamics setting A shown in this illustration, we can keep the shape of the Hair style during the simulation. However, if the base object rotates and points downward, the hair still keep its shape and point upward rather than being pulled down by gravity. This is not how the real hair will behave. If we change the Dynamics setting to another one for example setting B, which allows the hair can be pull down by gravity then it cannot keep its style and initial form after the simulation.
4.2.3 Maya Fur

Maya Fur is simpler than Maya Hair and it is specialized for creating fur, however we can use it to generate Hair styles that have similar characteristic to Fur such as Afro, short male hair, punk hairs...etc.

It is fast to modeling using painting tool that can paint baldness, color, length, polar...etc maps. However as stated above it's only for short hair style only, it's nearly impossible or very difficult without any additional script or plugin to model long hair style using Maya Fur. Therefore it's ideal to use Maya Fur to model the extra small and short hair that poke out of overall hair volume or short curly hair around the back of the neck.
5. INTEGRATION & PRACTICING

5.1 Overview of pros & cons of previous methods:

After finish studying about different methods of making hair in Maya, I am able to conclude that:

+ polygon hair modeling is the quickest method and give the users the easiest and most accurate control to model and style the overall shape of the hair to users' desired style. However it is lack of realistic feeling of individual hair strand, clump interpolation and dynamics solving. It is only good for modeling overall silhouette of the entire hair style.

+ Paint Effect is good at controlling the way that individual hair clump grow and run while still keeping the overall shape. It also automatically generates hair strands on a given path curves which saves user a lots of time.

+ Maya Hair is very powerful in shading, rendering, controlling over individual hair strands and clump. It also provides an internal dynamics system to solve hair dynamic. However it consumes large amount of work and time to style the hair to user's desired style using the conventional workflow.

5.2 Suggestion of a preferable method in Maya.

Base on the pro and cons above, I thought of a way to combine the advantages of each method and form my own way of creating hair in Maya.

My basic idea is: Model and stylish overall silhouette of the hair using polygon modeling. Then I will use paint effect to generate curves going along these base geometries, it will result in a group of curves that take form of the hair silhouette that we created in polygon modeling stage (These curves would be used for representation of hair clump or strands later). Finally, using those Paint Effect curves as the input for Maya Hair so that Maya hair clumps will run along the curves that created by Paint Effect earlier.
To sum up of my method above, basically we model polygon hair as usual, then using Paint Effect to generate curves based on these polygon surfaces, these curves can be tweaked/controlled using Paint effect control for a more natural look. Finally, to be able to render these paint effect curves, we assign Maya Hair to them.

This method would inherit full advantages of the three methods above. We can model and style the hair as easy as polygon modeling, have much control over the hair strands like paint effect while still keeping the overall silhouette, and inheriting the render setting and looking of Maya Hair system. It also has some extra benefit when we want to carry out editing at
different history level, solving dynamic...etc. These extra advantages and the internal structures of my method will be discussed further below.

5.3 Implementation:

Below are detailed practical stages of my work flow for this method.

5.3.1 Stage 1: Polygons to Curves

Firstly I modeled the hair style using polygon modeling. Then convert it to curves using my own MEL script. In order to do this, the polygon surface need to be converted to a NURB surface, these curves are actually the duplicated of the NURB surface 's CV curves. So the polygon surfaces need to be in form of tube or flat patches, which mean only consist of one NURB path when it 's converted otherwise it will not work. Then using those converted curves as control and path curves for Paint Effect tube hair to grow.

Besides, as stated above these curves are duplication of C and V curves of the NURB surface, if C are control curves then one V curve at the end of the NURB surface must be path curves for Paint Effect Hair and vice versa.
Why do we need to create curves base on a polygon surface but not draw the curve directly in 3D space without having a base mesh?

The reason I did this because there are chances that we need to tweak and edit the overall shape of hair style many times later, it would be very time consuming if we need to edit all those curves to change a major part of the hair silhouette. These curves were created in 2D space on the NURB surfaces with histories & connections being kept therefore if we change the base surface, those curves will automatically update to adapt. Doing it this way, if we want to edit the hair style, we just need to edit the base mesh using what-ever tool we like to edit polygon surfaces.
5.3.2 Stage 2: Creating Paint Effect Hairs

I created a Paint Effect tubes stroke using these curve in earlier stage as path curves and control curves. These Paint Effect tubes will be used as Maya hair input curve later. Paint effect's tube curves automatically fill in the gap between two control curves so I does not need too much effort to fill all the rest hair strands on human head. I also can edit those control curve manually to get rid of the parallel looking between hair strands.

In this stage we can also control the hair style at hair clumps level using Paint effect control settings for tubes. We can make them bend, curl, spiral...etc and control the amount of how much should they follow the path, control curves...etc. This step makes the Hair style looks much more natural as it gets rid of the parallel artifacts of the hair simplification method and adding more follicles to our Hair model.
As you can see in the example above, Maya hair using Paint Effect Curves as follicles have much more natural looking than Maya hair using surface 's CV curves as follicles directly.

This whole process build up a Multi-resolution Editing system for the hair model (Kim and Neumann, 2003) Which allow user can easily pick any level of control that they want to edit such as large overall shape of the hair model or small details of individual hair strands.

5.3.3 Stage 3: Apply Hair Style systems

From this stage we can either render Paint Effect strokes in Software or convert it to polygon and render in Mental Ray. However for a better result, I output Paint Effect as curves then use these curves as hair strands for Maya Hair System by assign Maya Hair System to them.

I also found a way to enable one follicle to have different looking hair assigned to it. Commonly each Maya Hair system has its own follicles groups and from these follicles it know where and how the hair strands should be through the attributes "currentPosition" and "outputHair". However by applying one more Hair system to the follicle by connecting the
outHair attribute of existing follicles to inputHair attributes of the new Hair system. Besides, we don't need to make a connection for the currentPosition attribute of the second Hair System as the follicles already received position data from the first Hair System. Thus this new hair system will use the position of the existing follicles instead. The new hair System's style will be added to the existing follicles, so these follicles will have 2 different looking hair styles at a same time with different setting yet share the same positions and follicles. It is efficiency to do this and save unnecessary follicles when using multi hair system on a same hair model.
Using this technique, I can efficiently add extra hair systems styles to my hair model without increasing in number of follicles and computing for dynamics solving but also reuse of existing follicles. In this case I added these extra little thin hairs around the hair model to make it looks more realistic and natural.

5.3.4 Stage 4: Apply Hair Dynamics Systems

Even though there are more than 100,000 strands of hair on human head, however luckily hair strands tend to move in group or in a similar direction to their neighbors strands (Kelly Ward, 2004). Base on this fact, we don’t need to solve dynamics for every single hair strands. Because of the internal structure of this method, the actual Maya Hair are driven by Paint effect Curves, and those curves are actually driven by control curves which are based on polygon surfaces. All of these control levels histories are kept during the making process so we can solving hair dynamics by applying dynamics system to any of those three levels of control. The rest of the hair model will move according to the dynamic parts.
- We can solve dynamics by applying a Ncloth dynamics system to the base geometries level, however this will only solve the dynamics in level of large hair surface to each other but not individual clump.

- The other ways is we can use the dynamics property of the Maya Hair in the final level control. This will solve the dynamics at level of individual hair clumps. However because we want a natural looking hair, we suppose to have a fairly large amount of hair follicles in the modeling stage, so that hair would not look too clumpy. This will result in a large numbers of follicles which are difficult to be dynamics and very slow to preview and tweak the setting. Moreover, There is an artifact that applying dynamics at this final stage will also fade away the initial style and form that we model earlier. It will be very difficult for follicles to keep it initial form after and during the simulation process.

- Finally, the most optimal way of solving dynamics I can think of so far is applying dynamics to the control curves at level 2 control: Paint Effect tubes. when These control curves are made dynamic, they are not limited to the level of "surface to surface", each of them will have their own dynamics and collide feature.

Paint Effect Curves follow these control curves while still keeping all the setting of the Paint Effect stroke, So they can still keep the initial form while moving dynamically to those control curves. Also performance speed is much better since we only need to solve the dynamics for those few control curves.
To implement this, I decided to use dynamics system of Maya Hair (or Dynamics Curve system). The CV Curves that are duplicated from the NURB surface will be plug into a Maya Hair system as input curves to solve the dynamics. This dynamics Hair System will output group of curves which are then used as control curves for the Paint Effect tubes. This Maya Hair System doesn't need to be render, but to be used to solve dynamics only, so it doesn't need a PFXhair node connected to it.

To optimize speed when previewing the Hair dynamics in animation we just need to turn off visible of everything but output curves of this Hair system, which are few enough to run smoothly and enough for represent the overall hair model's behavior.

However, this method is only a simplification of full dynamics solving for the hair. It has a weak point of solving accurate collision among the small hair clumps with outside influence objects due to its interpolation nature. To cover this, we have to enable collision at the final level control of the hair system, however doing this will slow down the performance a lot.

It depends on the different situations and hair styles to decide which stage we need to put our dynamics solver. This study does not mainly focus on dynamics solving for hair so I would not go too deeply into this issue.

Here is a sample video showing the hair driven by dynamic control curves:

[ File: hair_dynamic.avi ]
6. GHM Hair Creator MEL Scripts:

Because of these complex steps in creating the hair, my method became having too many steps and difficult to implement manually as well as to maintain and organize objects and control layers. So I decided to write a Mel Scripts that can summarize these steps in a few buttons, also provide an easy way and interface to manage and organize every curves, stroke, style and hair system...etc. I name it base on the characteristic of the method: "Geometry Hair to Maya hair creator - Geo-MayaHair". In the process of writing this script and using it, I also find out some extra interesting and efficient way of making hair.
Here are some features of Geo-MayaHair to help users create Maya hair easier:

- **CONVERTING MESH TO CURVES:**
  
  User can convert polygon objects to curves to use in the first stage of the method. As mentioned before, in order to get the correct result, polygon objects need to be in tube shape or flat patch of surfaces. However, tube shapes are recommended because the way the script works. Using tube shapes, users can extrude and edit polygons while still keeping the hair growing along with it, as long as it is in tube shape. Flat surface shapes are fine but the user can only edit the shape but not change the topology after converting it to curves.

- **CREATE AND APPLY PAINT EFFECTS:**
  
  After finishing modeling the polygon hair and converting it to curves, users can create different PFX styles and apply them to any surface patch that has been converted to curves earlier. Even after applying the PFX stroke to polygon mesh, users can still edit the polygon.

  Using a list of stroke and brush, users can manage and organize PFX styles and styles easily. It's easier to select a stroke in the list rather than select them on the viewport when it's converted to Maya hair later.
- **CREATE AND APPLY DYNAMIC HAIR SYSTEMS:**

For the moment, I only include the option for apply dynamics system to control curves only, which I consider to be the most optimum way for this method. User can create different dynamics hair system and apply these system to different strokes in the scene.

- **CREATE AND APPLY STYLIST HAIR SYSTEMS:**

The user can create and modify different hair system then apply to whichever stroke he want. As said above, multi stylist Maya Hair system can be applied to a single stroke without increasing in number of follicle that stroke has which mean all the stylish hair system apply to a stroke will share the same groups of follicle and follicle override settings as well.

- **MANAGING AND EDITING FOLLICLES:**

To take advantage of the feature that Maya Hair has over each its follicles that users can tweak override settings for individual follicle such as: intensity, twist, color ...etc. However selecting follicle is very difficult in Maya viewport and in Maya Outliner. This Script allow you to quickly get a list of follicle from selected stroke or Hair System or group of selected curves.
Here is a demonstration video showing the usage of the script.

[ File: script_demo.wmv]
7. Final Products

Using this script has saved me a lot of time in creating and editing Maya Hair with this method. All the sample images below are created in less than 1 hour (the actual time in making the hair model excluding the render time)
8. Future developments

For further development of my workflow and method of creating Hair in Maya, I would like to study further into hair dynamics to solve the existing dynamics problem that the hair losing its initial form and shape during and after the simulation process.

Beside I would like to develop a tool that allow user to model polygon hair easier and faster such as: drawing path for extruding polygon, and also provide a more free way to style the hair like combing and dragging the polygon hair, painting follicle attributes & color...etc. As for the GHM hair creator Mel Script I would like to add some extra template settings for PFX style, dynamics hair system and stylist hair system for different hair style like: Afro, Asian, Western, blonde...etc and different hair condition such as: wet, dry, electric shocked hair...etc.

However I am quite happy with the current state of the project. I took me days of working and a lot of effort to get a good looking hair in Maya before I come up with this method of creating hair and Geo-Mayahair creator Script.
9. Conclusion:

A new work flow and method has been proposed in this paper to achieve realistic hair visualization in Maya. This new work flow and method incorporate the advantages of the three existing most common hair modeling method in Maya: Polygon hair, Maya Paint Effect hair and Maya Hair. The applications indicate that my proposed workflow and method are advantageous over each these methods. With the using of my GMH Mel script and the new work flow, I was able not only to produce high quality hair model in short amount of time but also edit and changing properties of hair model easily and quickly.

Working on this project I have understand more about the internal structures of different Maya hair systems and how are they connected together and take advantage of it. Making a realistic and good looking CG hair is a difficult challenge, which involve not only style modeling, shading, looking of the hair but also dynamics of the hair as well. Because of the massive number of hair human have and the complexity of various hair styles as well as its dynamics properties, visualizing hair in 3D is a tricky field, we need to make the best out of everything we got in order to have a good result.
Reference


2 - "Practical Real-Time Hair Rendering and Shading"- Thorsten Scheuermann (2004).


4- "Rendering Skin and hair" - Jonathan Gibbs, 2001.

5-"Using maya Hair" - J. Adrian Herbez , 2006).


Further readings:


11- "Interactive multiresolution hair modeling and editing" - Kim and Neumann, 2002.