

Innovations Report

An analysis of the ageing process, and simulation of this process in Computer Graphics

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Abstract

This report discusses the ageing process and the changes that occur at different ages. It details how, using this research into ageing, the ageing process has been broken down into five year intervals. It then examines various techniques to illustrate this process in 3D, thus enabling the creation of a short animation of youth to old age on a generic head model.

Introduction

It became apparent early on, during the modelling stage of my major project, that there seemed to be a lack of available information on portraying old age in CG. There is a wealth of information on various aspects, including great tutorials on how to texture wrinkles etc, but I couldn't find a single book or tutorial that went into much depth on the subject. Once I had worked out which elements I needed I could search for them individually, for instance, my first assumption was that my old person would need crow's feet, so I could search for tutorials on creating these, but it became apparent early on that there was a need for some collated information on the subject.

I also noticed that it was very rare to see a character that actually had realistic looking aged skin, most old people were depicted with smooth, young looking skin, only a sprinkling of grey hair and some glasses giveaway their supposed age.



Voice actor Jonathan Harris compared with Geri the cleaner from toy story 2, Geri is very smooth and clean looking in comparison, only the major wrinkles have been depicted.

As well as for my project, and larger more significant animations, I realised that a concise study of the aging process and how to replicate it in CG would be useful in other fields, such as forensic science, missing persons, and also for medical purposes and cosmetic surgery, etc.

The Project

Aims

To investigate the many changes that occur during the facial ageing process, particularly the changes that become evident from the age of about fifty onwards.

To document the changes that occur at regular intervals between the age of 20 and 80.

To explore the different methods of replicating these changes in CG.

To utilise my research into facial aesthetics and the ageing process, and explored methods of replicating these in CG, to create a short animation showing the ageing process from youth to old age in about 30 seconds.

How I intended to achieve my aims

After deciding upon researching the ageing process for the innovations project, the next task was to come up with an innovative way of presenting my findings.

Possible ideas included using my research to predict how someone will look in the future, or looked in the past, or creating a tool that modifies the shape of a human head based on the age of a character. After some preliminary research I discovered that an NCCA student had done a similar project in 2004, entitled, *The Simulation of the Aging Process and Implementing Wrinkles in Computer Animation*, this student researched wrinkles and came up with a tool to create them. After much deliberation, I decided that the best way to present my research would be to create an animation showing the ageing process.

Initially I intended to do this as a 2d animation, but after a few attempts I realised that drawing from just one view was very restrictive, and I couldn't show all the detail that I wanted to, so I decided that 3d was the way forward. As the project was fundamentally just about research into ageing, there was no need to use CG, and so a stop-frame type animation using a clay head seemed to be a feasible idea. However, as my research progressed, I became more interested in the way age is depicted in CG, and also, it seemed to be the most valuable option with regard to the future usefulness of the skills I would potentially acquire.

It is obvious that the ageing process is a unique one, and that obviously no two people will wrinkle and age in the exact same way. For this reason I decided I would focus part of my study on one particular person and how ageing has aesthetically affected them. Initially I was going to use photographs of my grandfather, but it was hard to really see a lot of the changes due to the poor quality of most of the older photos, so I decided I would use a famous face instead so I would have easy access to a lot of photographs. I opted for Marlon Brando as his face was not too unusual, and I could find a lot of pictures of him at various ages.

The next step would be to utilise this research into the stages of the ageing process to come up with a 2d hand drawn study. When these drawings are satisfactory, then a 3d study can begin and using the drawings as reference, as well as the general research into ageing and the Marlon Brando data, I can begin to produce the animation.

In order to find out the most effective way of portraying ageing in CG, I plan to research the various methods, using CG books and internet tutorials as my main guides.

Continuity of Identity through the ages:

An important factor for my animation would also be to ensure continuity of identity through age, if the person at the end of the animation bears no resemblance to the person at the start, then the project will not have been very successful. If I work closely with my research and try and maintain stronger features this shouldn't be too big a problem.



According to the DataFace website, <http://face-and-emotion.com/dataface/facets/aging.jsp> even though there are dramatic changes in the face as it ages, 'The identity of the face is preserved throughout the person's life. The elements of facial identity of each person can be detected from early childhood through old age, though it may be difficult to match a face using only the extremes of age, versus seeing the steps as the face develops and ages.' This means that providing I maintain similarities between each transition, even if the end result doesn't look much like it did at the start, seeing the animation going through the ages will bridge the gap and keep it believable.

Similar projects

When I first decided I was going to do an animation of the ageing process, several course mates advised me to watch BBC3s 'Honey, we're killing the kids'.



This terrifying mug shot of how this small boy may look by the time he is 40 is calculated by "state-of-the-art" technology and "certified assessments based on measurements and statistics", the types of food the boy currently eats, and his lifestyle choices (or rather his parents) It is debatable how accurate these calculations are, but the results are frightening. Digitally aged images of the kids at 40 created with "state-of-the-art" technology and "certified assessments based on measurements and statistics".

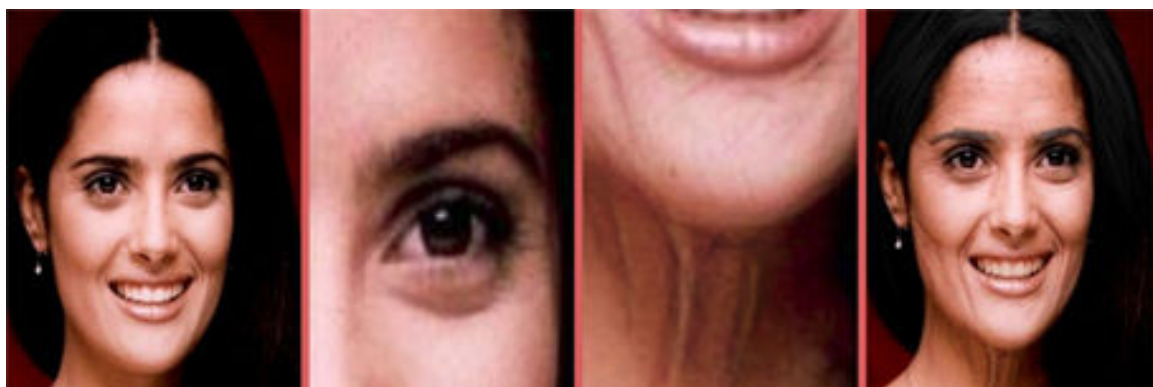
Ageing celebrities

There are several attempts at ageing famous people that can be seen online, most of them turned out to be quite poor efforts, the faces weren't really aged, the bodies had just been made obese and the hair greyed. However there were a couple of realistic ones to be found that actually look quite disturbing.



This prediction of how Angelina Jolie will look in old age was found on boreme.com. The continuation of identity is really good, apart from the fact that I have found the picture this was obviously created from and the angle is the same etc, even if you hadn't seen the original, I think it's very clear that this is Angelina Jolie. This is perhaps due to her having strong, noticeable features.

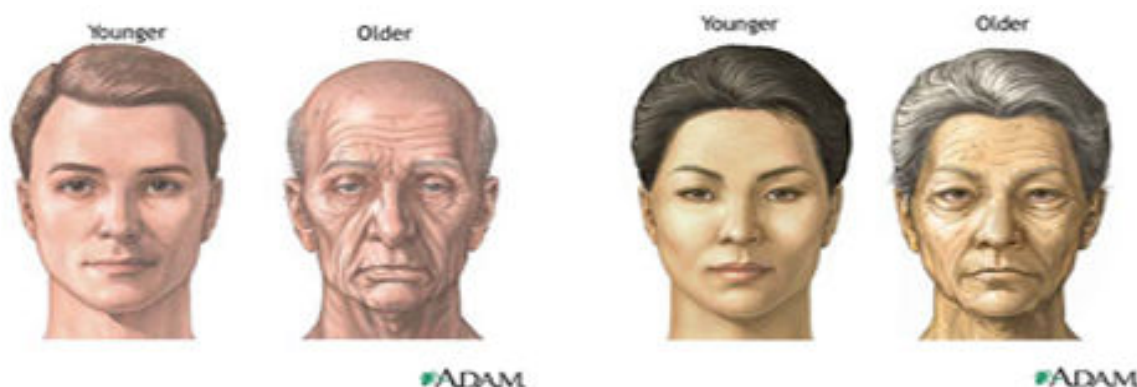
Apart from the obvious differences like giving her grey hair, the addition of crows feet, tight wrinkling around the lips, deeper laughter lines and a wrinkled neck add years to Angelina. However, the face hasn't changed shape at all, which makes this image seem unconvincing.



This example of Selma Hayek was found on <http://www.photoshoplab.com/aging-people.html> it gives a Photoshop tutorial on how to imitate the aging process in Photoshop. The liver spots on her forehead and subtle wrinkles work well, and note the close up of the detail around the eye. The crow's feet look convincing and work well in this example. The fine wrinkles on the chin and the illusion of a veiny, old neck are impressive too. However, once again the face doesn't seem to have changed shape and there is no sign of gravity taking its toll on either of these women.

Aging of the face

-Intrinsic/Extrinsic ageing



Reference images found at <http://www.averahealthplans.com/ahp/adam/2/8665.adam>

These images show a slightly crude example of the ageing process, I intend to research and analyse the stages in between, and work out roughly when all these changes occur. I decided to focus on men in particular as this would be particularly useful for my major project.

Research suggests that there are two types of ageing, intrinsic and extrinsic. Intrinsic (internal) aging is caused by genetic inheritance; it is a natural, continuous process that normally begins around the age of twenty although most of the changes are not visible till much later.

Intrinsic aging occurs because collagen production in the skin slows, and the skin gradually loses its elasticity. Thin and transparent skin, fine wrinkles, hollowing cheeks and eye sockets due to loss of underlying fat, dry skin, and sagging skin as bones shrink away from the skin are all signs of intrinsic aging. Genetics dictate how quickly these changes will take place.

Extrinsic (external) aging occurs greatly because of exposure to the sun, but there are many more external factors that affect how aged our skin looks, such as smoking, gravity, rapid weight loss, poor health/diet, air pollution and sleeping positions.

Wrinkles or skin folds due to muscle movement are referred to as dynamic wrinkles whereas those that are simply due to aging of the skin are referred to as adynamic wrinkles.

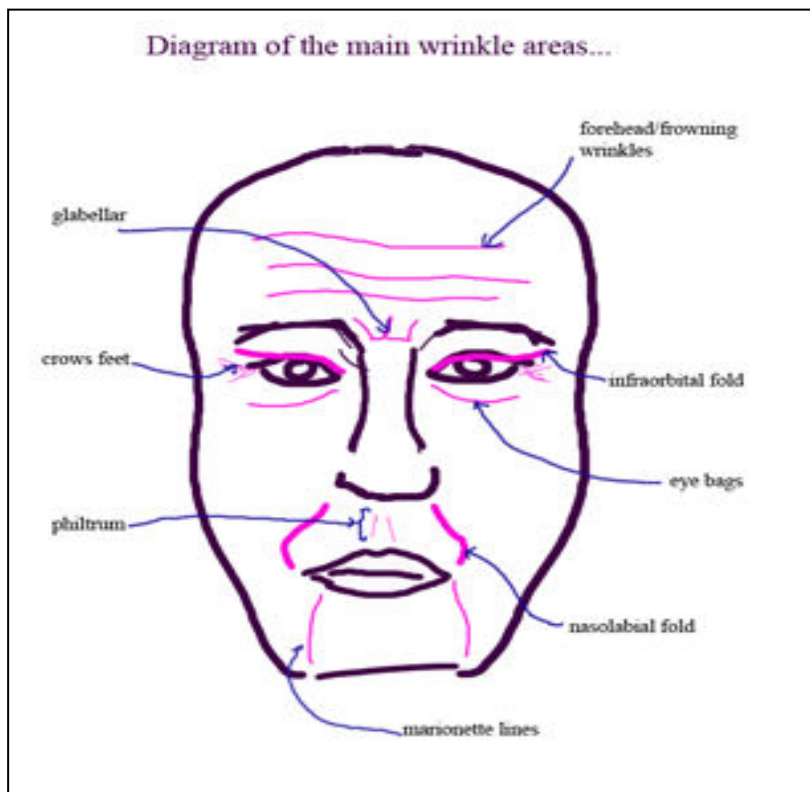
How the face changes at each stage in the ageing process

In order to create an accurate animation of the ageing process it is necessary to break down the stages of the ageing process and understand at what age the different changes usually occur.

A number of factors determine how an individual will be affected by ageing. These factors should be taken into account when trying to predict how someone will have aged. These are some of the factors to be regarded:

- Gender
- Environment
- Occupation
- Make-up?
- Health
- Smoker?
- Drinker?
- Habits
- Scars?
- genetic predisposition
- emotional stress
- Dramatic changes in weight?
- Exposure to extreme climates e.g. chronic sun exposure, cold temperature or wind exposure

Before you start working on a character you will naturally have considered most of these factors. They may be evident in your story or your character backgrounds/profiles. In other applications, for instance if you were trying to accurately estimate how a celebrity might look in the future, you should also consider these before progressing further. The following diagram indicates the most common wrinkles:



According to Gerald Imbers book, 'the youth corridor', these are the noticeable signs of facial ageing, and this is the order they usually occur in

- Circles under eyes
- Fine wrinkles under eyes
- Smile lines outside eyes
- Dry or blotchy skin
- Oily, irregular skin
- Discoloration or abnormal pigment
- Deepening nasolabial line or fold
- Nasolabial line etched into skin
- Parentheses lines at corners of mouth
- Vertical frown lines between eyebrows
- Vertical line son upper lip
- Fine wrinkles on cheeks
- Slight fullness along jaw-line-, loss of clean line
- Fullness under jaw line
- Small fatty pouches alongside mouth
- Irregular patches of colour on skin



The people shown here are all at different stages of the ageing process, you can see, where the red and blue markings are, the extent of their wrinkles.

Although they are all different people at different ages, you can see that the positioning of the wrinkles, and the areas that are most affected are fundamentally the same in each case.

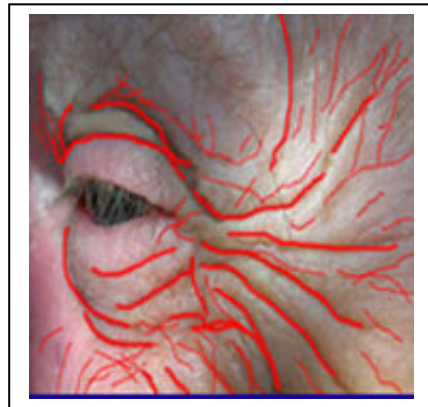
For example, notice Jose Mourinho's cheeks beginning to show signs of hollowing, in a similar way to the old oriental man in the bottom right corner. Despite all looking very different, all of the people shown illustrate comparable patterns of wrinkling.

Crow's feet

Consistent facial expressions cause the skin to wrinkle as it loses its elastin. Frown lines between the eyebrows and crow's feet radiating from the corners of the eyes build up as the small muscles in those areas permanently contract.

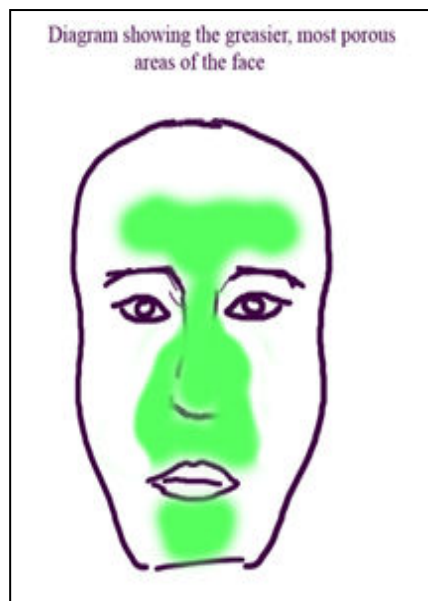


Notice the difference between the crow's feet on the 45 year old woman above and the much older man below, where I've made the thick red markings indicates the deeper wrinkles, and the finer marks show the finer wrinkles. The older person has much deeper wrinkles and folds around his eyes. Notice also how the wrinkles follow the contours of the eyes.



Dry or blotchy skin/oily, irregular skin

There are a lot of variations in complexion, but to generalise, skin tends to be either dry or oily, or somewhere in between. Dry skin can be flaky, the pores are less visible, and the skin is matte, with soft specular highlights. Oily skin has large visible pores, shiny skin and sharp specular highlights. The following diagram points out the areas of the face with most pores





Above are close ups of three nose tips belonging to a twenty year old, a forty five year old and a seventy year old respectively. The first one has few visible pores, and is flaky and matte looking with soft highlights; the pores aren't very clean, possibly clogged with make up. The second is very shiny with sharp highlights and more specularity. The final one has very visible dark pores and sharp specular highlights. Some pores appear to be concave (inward) whilst some are convex (outward).

Nasolabial fold

The crease that runs from the nose to the corner of the mouth is known as the nasolabial fold. It separates the upper lip from the cheek, it can become more noticeable due to factors such as excess skin, thinning of skin or drooping of cheek fat.

Abnormal pigmentation

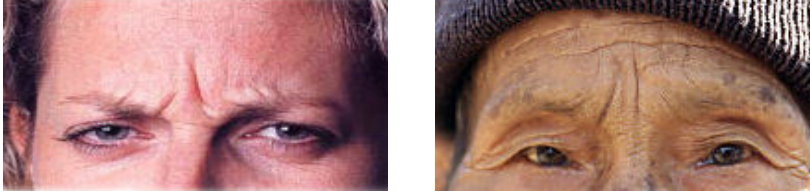
Liver spots, blemishes, discoloration and other abnormal pigmentation are all associated with old age. Liver spots are modifications in skin colour linked with older skin. The increased pigmentation can be caused by aging, exposure to sun or other forms of ultraviolet light, or other unknown reasons. Liver spots are particularly common after the age of forty.



The image on the left is a close up of a liver spot on an elderly mans forehead. The pictures on the right detail some of the different variations of skin blemishing. Images found on <http://www.mayoclinic.com>

Glabellar

The glabellar, or furrow lines become very deep with age, they are thick vertical creases that develop between the eye brows, and even a young person can have a less defined version of these when they frown hard enough.



Observe how even this woman in her thirties has very deep glabellar when frowning, whereas the older man is not frowning in the picture, but these expressive lines have become etched into his face.

Forehead wrinkles

The forehead is one of the most noticeable areas for wrinkles, as unless it is covered by hair, it is usually a wide expanse of skin, and the wrinkles here tend to be the longest and most pronounced of the whole face. This image is of a middle aged man, it shows the criss-cross pattern of forehead wrinkles at an early stage

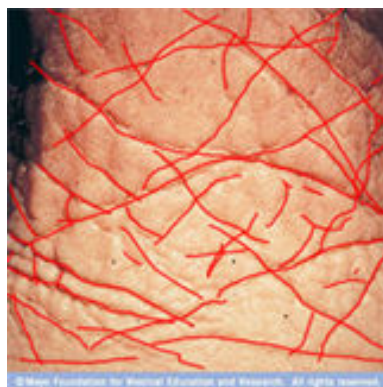
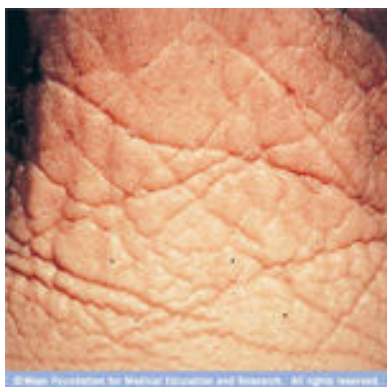


The lines on the lips, the vertical lines are deeper and are intersected with more shallow, finer horizontal and vertical lines.



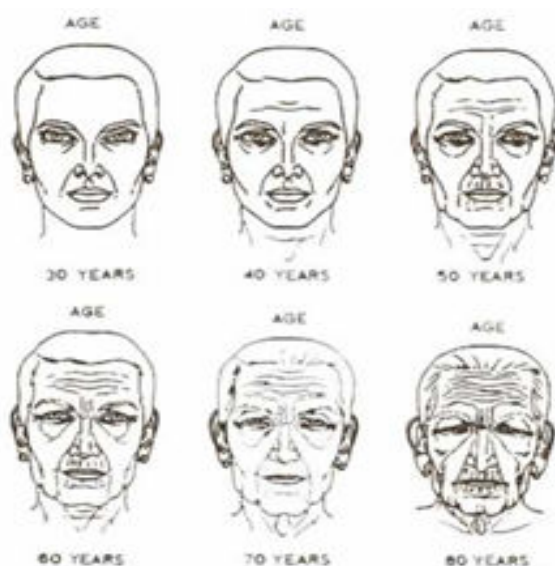
Neck Wrinkles

The neck is very susceptible to photo aging; such sun damage to the neck causes the leathery appearance as shown in the image below.



Observe the unusual diagonal, criss-cross patterns of the wrinkles and also the bumpy uneven texture of the skin.

The stages of ageing



(Image taken from Gonzalez-Ulloa M and Flores ES: Senility of the face-Basic study to understand its causes and effects. *Plast Reconstr Surg* 36:239, 1965.)

In the 20-30 age group, skin characteristics remain similar to that of youth, apart from the skin may be slightly drier, and less prone to acne. Normally no visible changes take place in the form of wrinkles although the skin's surface may become less even and slight blemishes may start to appear.

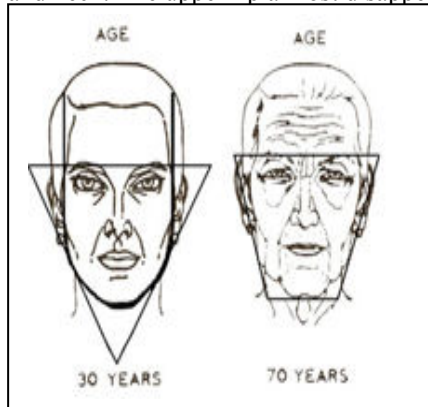
In the 30 to 40 age group the upper eyelids become redundant, an upper eye lid fold of skin is visible when eyes are opened but there is minimal overhang. Skin condition is drier still and crow's feet appear at the eyes outer corners. The nasolabial folds become deeper. The eyes will show smile lines, the glabellar will deepen and the bags under the eyes will become more noticeable. Slight fullness may develop around the cheek and mouth due to damaged elastin and collagen.

In the 40 to 50 age group, gravity begins to take its toll, lower eyelid bags appear, and more obvious forehead wrinkles appear. The outer brows begin to sag. Cheek fat begins to descend downward towards the jaw and nasolabial lines now turn into cheek folds. Loose neck skin begins to appear.

Facial hollows in the temple area and cheeks will appear. In some people the eyes become gaunt as a result of fat wastage rather than forming eye bags. Smile lines deepen. Vertical lines deepen on the upper lip.

In the 50 to 60 age group, the neck wrinkles noticeably, jowls (broken jaw line), and marionette lines appear. The eyebrow droops even further. The tip of the nose droops. The lips thin so there is less of the pink area (where lipstick would be worn) showing. Nasolabial lines become etched into the skin.

In the 60 to 70 age group the facial skin thins, fat shrivels in the cheek and temples and the skins pigment cells enlarge in number and in size in a blotchy pattern giving rise to brown spots on the face and neck. The upper lip almost disappears whereas the lower lip begins to protrude.



This diagram illustrates how during the ageing process, the outline of the face transforms from a triangle with the peak pointing downwards into a trapezoid or oblong because of sagging skin and the downwards descent of the cheeks soft tissues.

How Marlon Brandos face changes at various ages



Marlon Brando in 1940 aged 16.

Although the photo is old and not of a very high quality, you can see that his skin appears young, smooth and firm.



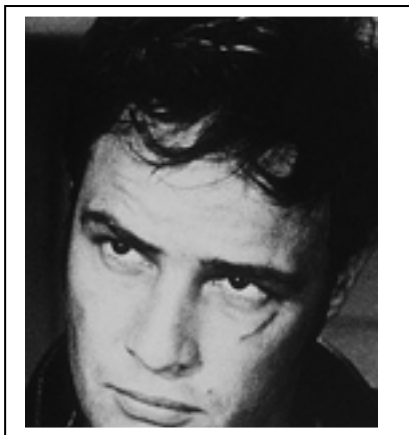
1944 aged 20.

Not much has changed, apart from the jaw has become more prominent and square, and the face appears slightly narrower around the cheek area.



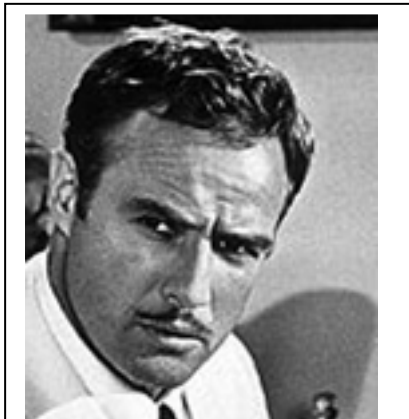
1951 aged 27.

A few creases have appeared on the forehead, and minor bags are noticeable underneath the eyes



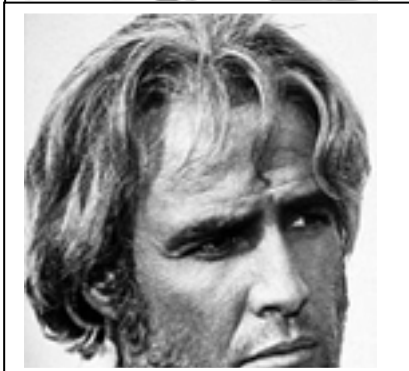
1953 aged 30.

Tiny wrinkles (crow's feet) have begun to appear in the corners of his eyes.



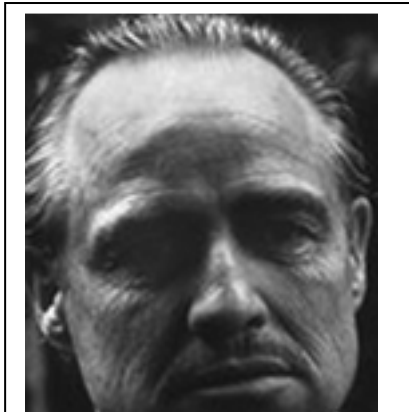
1961 aged 38.

Frown lines have become much more prominent, and vertical creases between the eyebrows have appeared, bags under the eyes are heavier and laughter lines are starting to show much more clearly.



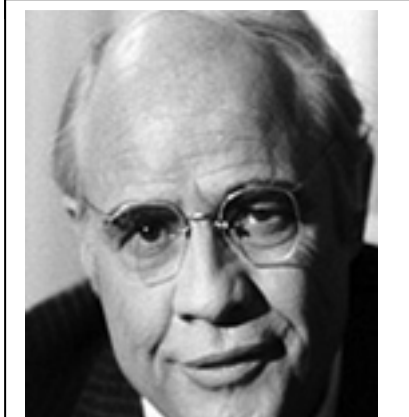
1969 aged 46.

Stubble hides a lot of wrinkling, but the laughter lines and also the fine lines on the lips remain visible. Forehead creases look much more prominent and the crow's feet are more defined.



1972 aged 49.

Bags under eyes, much more noticeable wrinkles around the eyes and mouth, frown lines more prominent, chin appears wrinkled also. Ears and tip of nose have dropped due to gravity too.



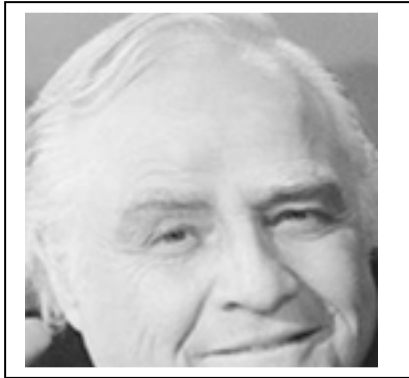
1980 aged 57.

Bottom lip protrudes slightly more than usual, crow's feet more distinct, laughter lines deeper, and tip of nose has drooped further.



1990 aged 67.

Chin and jaw area are much less defined, almost merging into Brando's neck, he has developed jowls and general sagging in the cheeks. The eyes overhang is much more significant, and the upper lip has got thinner.



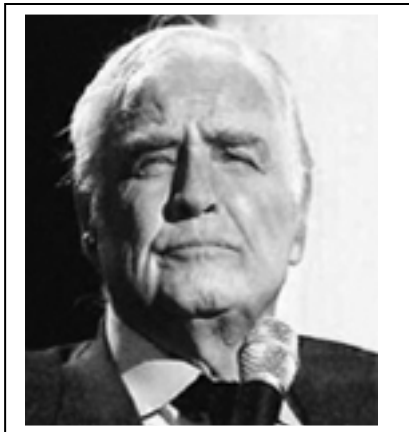
1995 aged 72.

The upper eyelids droop is very clear here, as are the crow's feet and laughter lines. However most other details are hidden by the lighting.



1996 aged 73.

Only a year later so no major changes, but it is worth noting the bags underneath the eyes are very clear in this shot.



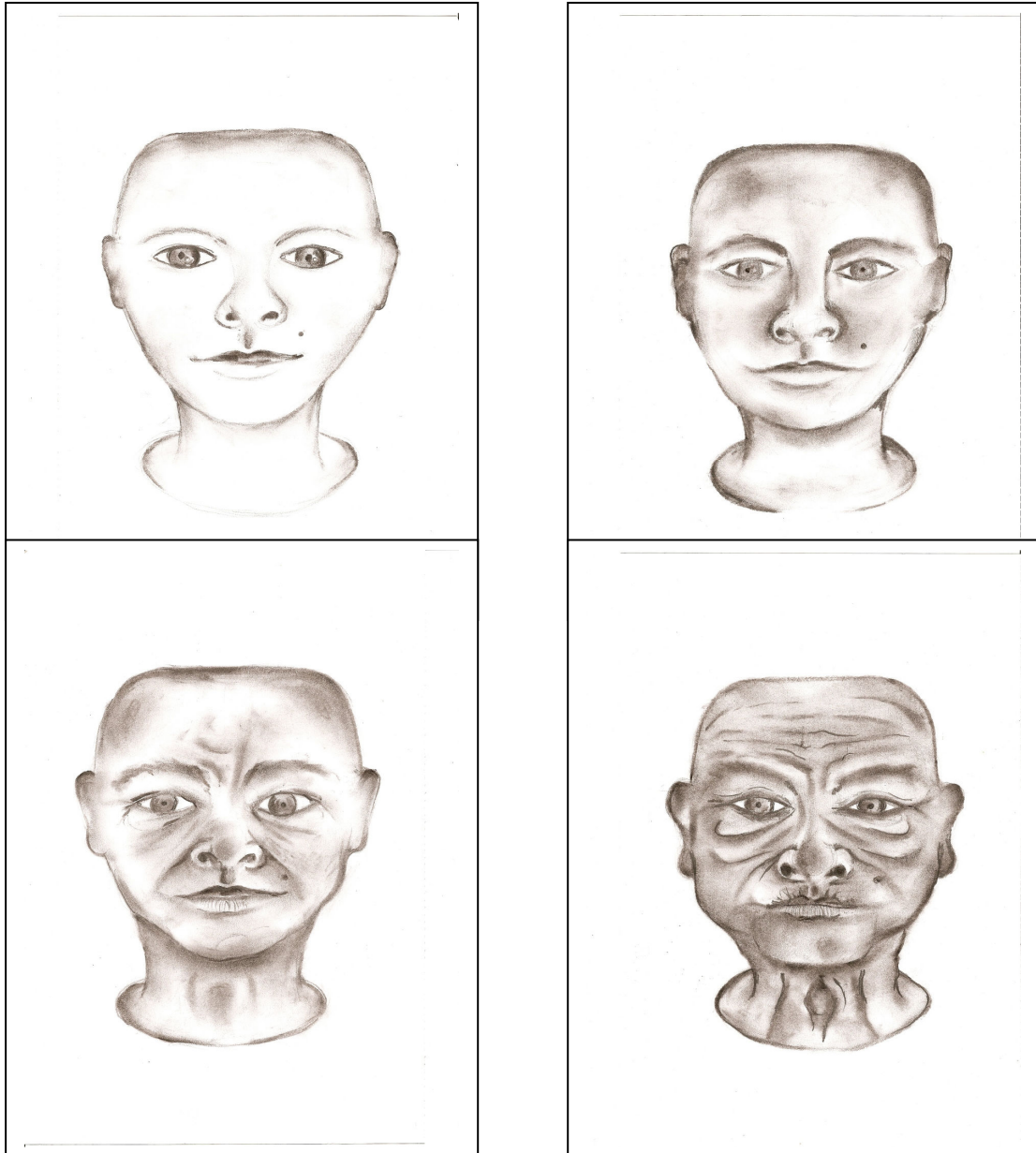
2004 aged 80.

His eyes have become so small and squinty due to the gravitational pull of the eyelids. His cranium seems to have shrunk in height; the top of his head appears smaller. His ear lobes are almost in line with his lips, whereas in his 20s they were more in line with his nostrils.

Unfortunately Marlon Brando died in 2004.

2d study of the ageing process

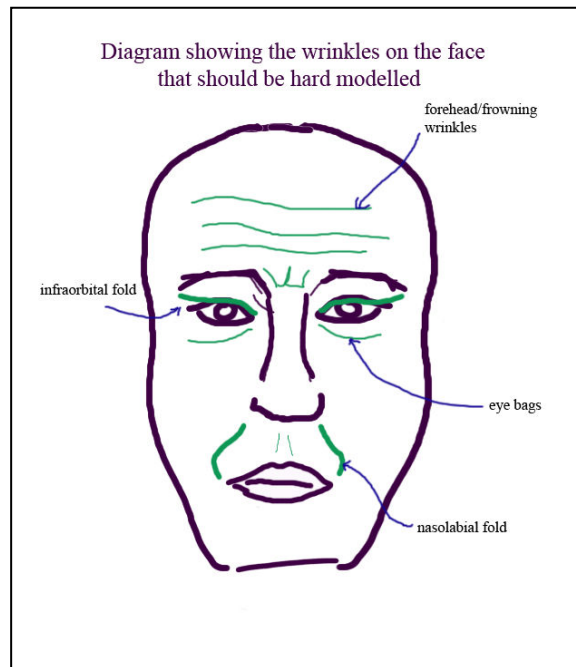
The first stage was to draw a basic, generic male face that was supposed to look approximately twenty years old. Then, based on my research how; he would look at about eighty years old. Ending with a couple more to show the in between stages culminating in a boy, a young man, a middle aged man and an old man, trying to keep the continuity of identity, as well as showing how he had aged.



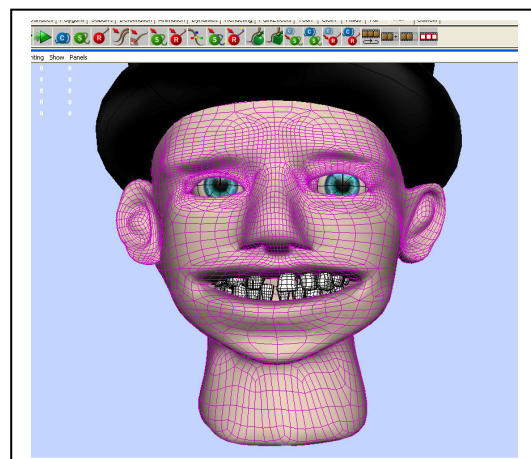
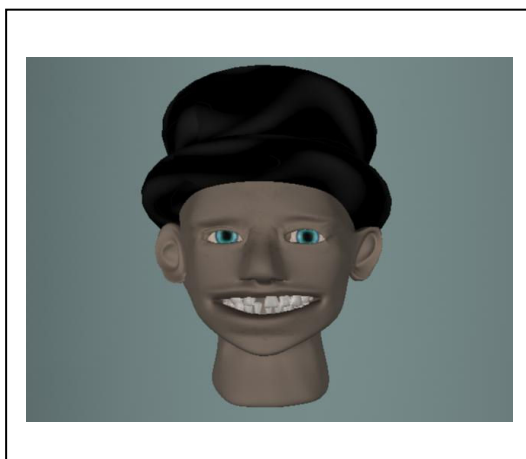
The Approach

Modelling

The human skull changes shape with age, although not drastically. I decided to create 8 blend shapes to show this gradual change in shape as the face ages. After reading, Learning Maya 6 | Modelling I discovered that the best way to create an old person in CG is to hard model only the deepest lines and wrinkles, and show all the finer details in the colour and bump maps.



I wanted a very generic, average male face to use for the animation, I also wanted the model to be quite simple, for time reasons, and also, because this project is not about good quality modelling, the model was just a tool to aid my simulation of ageing. I modelled a very simple boys head, starting with a simple sphere:

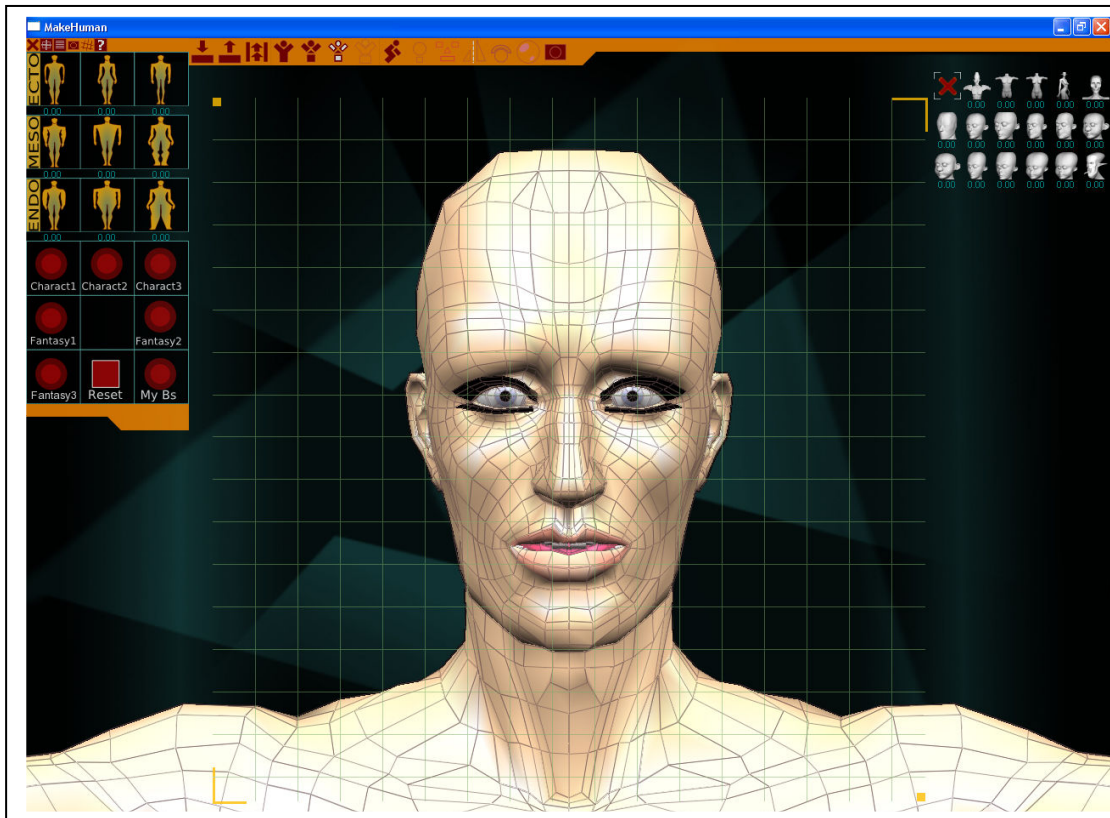


As you can see in the wireframe model, the topology is very messy, especially around the eyes and mouth, which could prove very problematic when making blendshapes and possibly when texturing too.

Although I have achieved a quick, simple head like I intended, the topology was very bad, and also the UV layout was very warped. When someone suggested downloading a basic head model from the internet, I was bothered that I didn't think of it sooner!

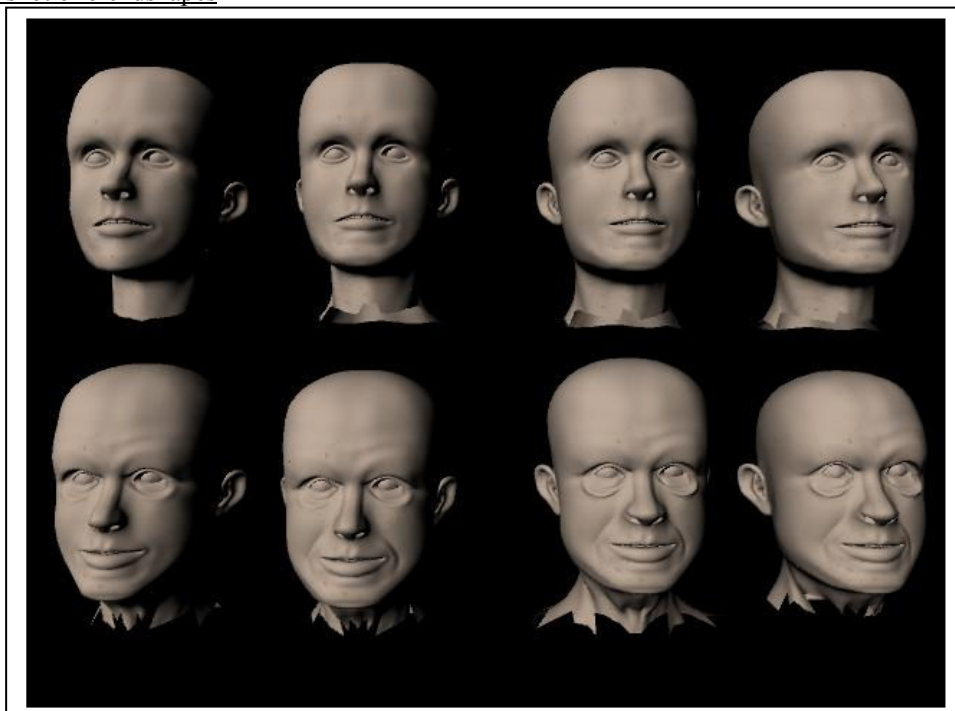
I actually found something better than just downloading a generic head; a course mate recommended using a piece of software called makehuman. This allowed me to create a head, with the features in the places I wanted them to be, and then export the mesh as an obj file into Maya. Although it was a tricky program to use, the result was very satisfactory, even the UV's were mapped out already; I just had to tweak them.

Screenshot from makehuman



Once I had exported the face from make human, I then created 8 blend shapes to show the changes in head shape and structure and to show the deeper wrinkles and sagging skin as the face gets older.

Screenshot of blendshapes



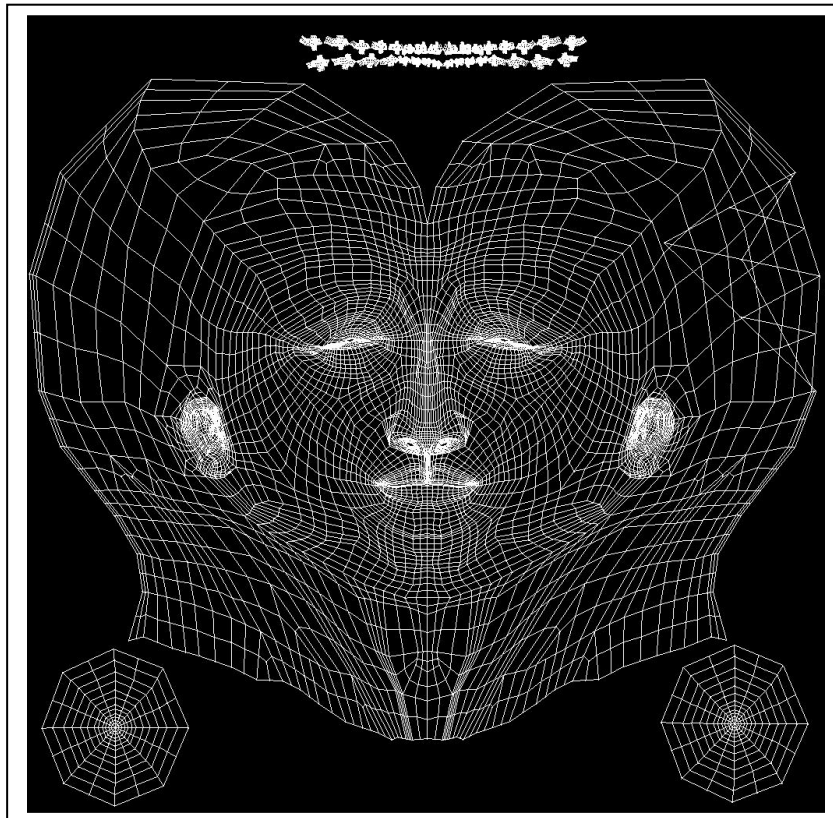
Texturing

Colour/texture maps

I didn't want to go for complete photorealistic texturing as this seemed like too much of a challenge and would have detracted from the more important aspects of the project. However, I did want the animation to be realistic and accurate so I tried to make it close to photorealism.

Luckily the makehuman software laid out the UV's already, all that I did was scale up the main area to be textured so it would be a higher resolution, and I deleted or hid all the UVs that wouldn't be seen so more space was available for the ones that would. I used 1024 x 1024 textures and bumps.

Screen shot of UV layout



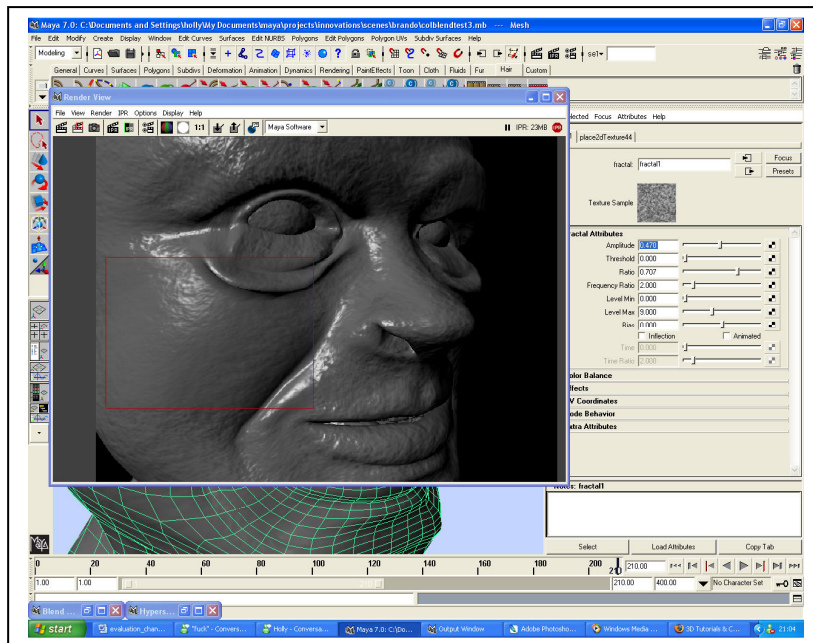
To make a realistic skin tone I used several layers, to build up the translucent look that skin has, I added a lot of random noise and Gaussian blur to layers to make a more believable surface. I then took photos of some family and friends skin of different ages and blended this with the different texture maps to increase the believability of the texture.

I started off with a smooth, quite pale colour map that would be used for when the model is in his twenties, and then gradually added layers to create colour maps that would be updated every "five years" in the animation. Using lots of reference photos I created layers to add the changes that occur with age such as liver spots, bluer lips, lighter eye colour, greayer eyebrows, and skin more leathery and pigmented, nose reddens, eye bags darken, and so on.

Bump maps

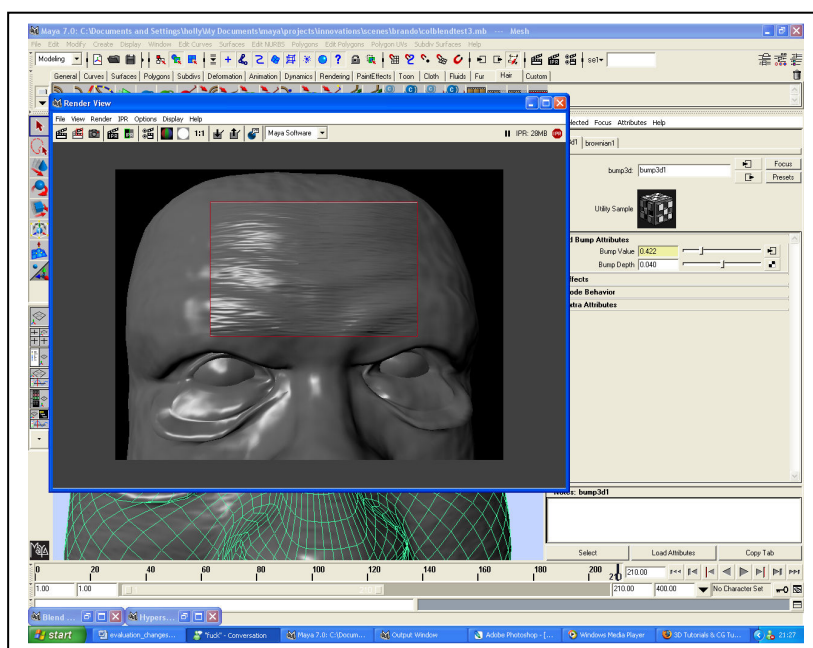
I found that the best way to create a bump map was to use IPR render in Maya and keep adjusting the settings till you achieve the desired results, then export the file into Photoshop and edit the different layers together. This was a much more efficient method than creating bump maps in Photoshop then assigning them to shader nodes in Maya and testing them every time you need to make a tiny alteration.

This Screenshot illustrates how IPR render can be used to test bump maps as they are updated.

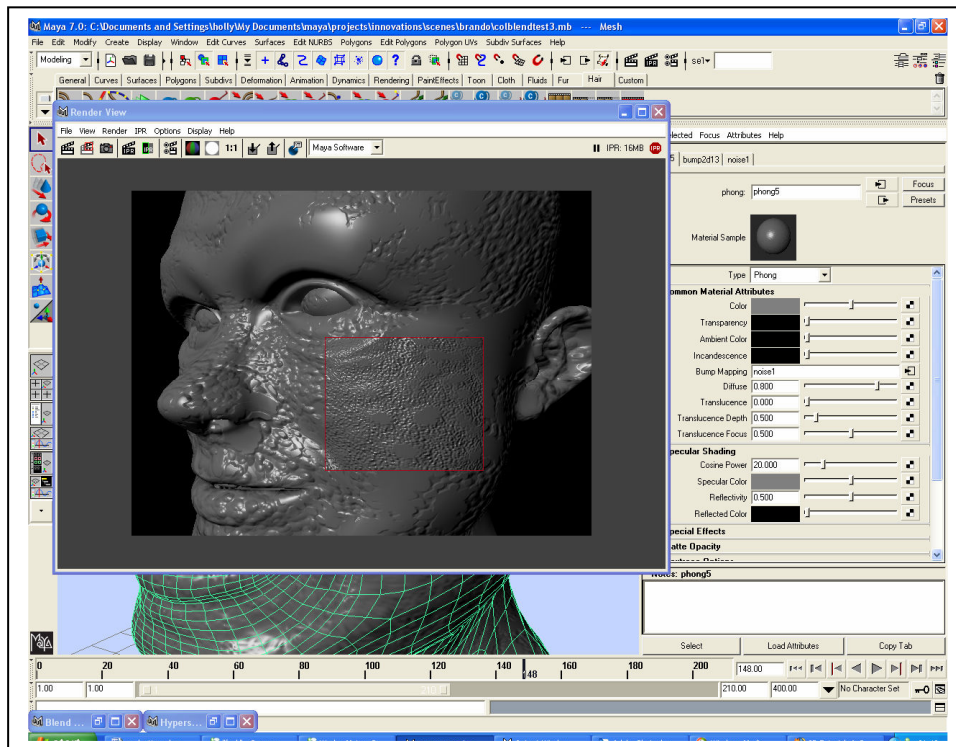


The area inside the red box updates as the attribute settings on the right are adjusted, notice how I have changed the amplitude of the fractal to create this skin-like texture. Once satisfied with the bump map, it can be converted to a file texture and opened in Photoshop and added to the final bump map.

The next screenshot shows a Brownian texture, which I used to make the very fine wrinkles that you see around the neck and the forehead.



This screenshot shows how I created the illusion of spots and potholes on the skin using noise texture. A lot of the spots will be deleted in Photoshop, as I don't need this many.



Once I had my base layers for the bump map, I then needed to create all the different wrinkles that I would require from twenty years to eighty years, I set up individual layers for each one so that I could hide them and then increase the opacity of each one to make each bump map. I wanted to make a different bump map to show each wrinkle that appears as it appears, and then blend between them to show the wrinkles deepening and growing with age.

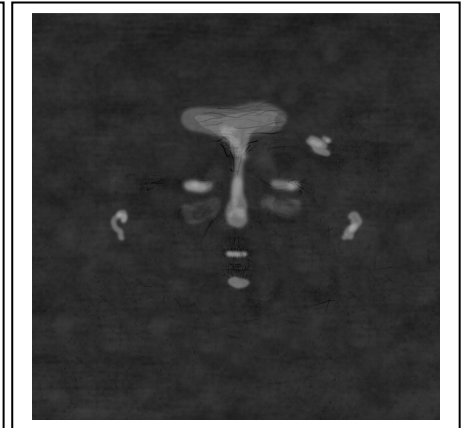
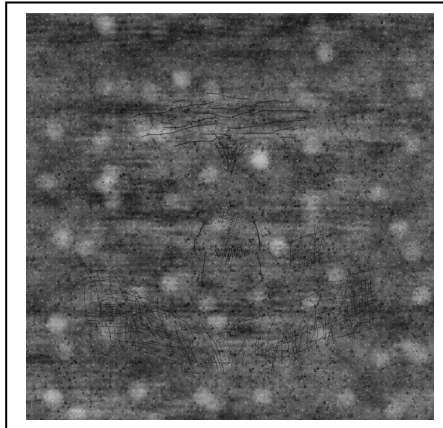
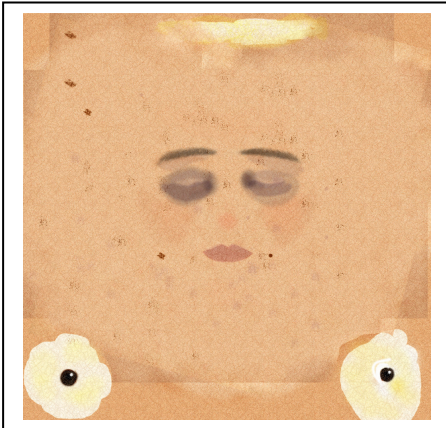
Some useful points are to use a soft edged brush for wrinkles, to avoid abrupt lines in the middle of the forehead, and also to use small irregular brushes and adjust the scattering and so on to give realistic lines. I also made a layer for the pores on the nose.

This website has some useful tips on the basics of bump mapping (<http://www.paulsprojects.net/tutorials/simplebump/simplebump.html>)

Specular maps

I made three different specular maps, to enable me to show how the skin often goes from being quite oily on young people, to more matte in middle aged, and then very dry and flaky in old age.

Images of one each of the colour, bump, and spec maps I used

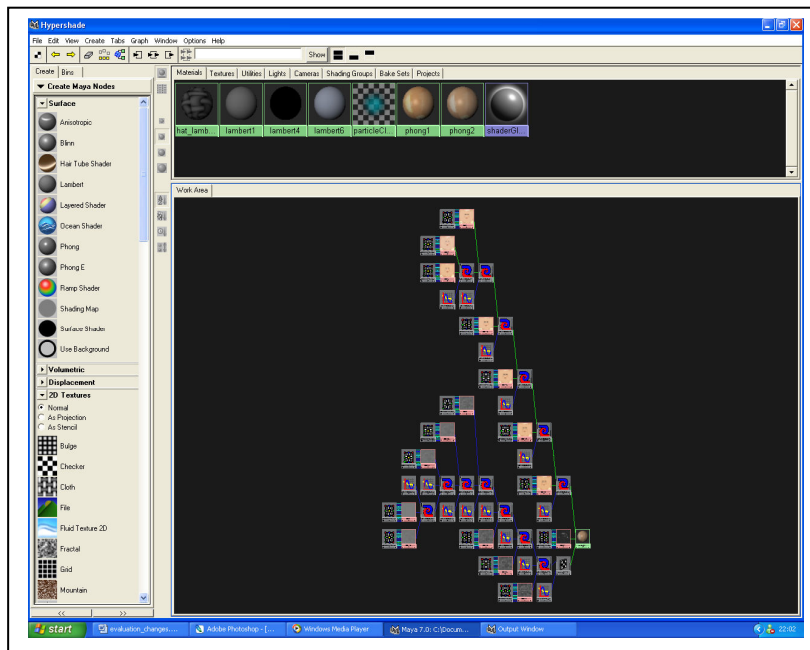


For a good tutorial on texturing, I recommend this website (http://www.eliteops.com/sama/uv_tutorial/index.htm)

Blending

I had intended to just put all the maps together in a movie file and assign the movie to the shader, according to the Maya handbook this is possible, but I could not get it to work when the time came, so instead I had to use the hypershade and manually manipulate the shaders graph networks to allow me to blend between the colour, bump and specular maps at different frames.

Screen shot of graph network

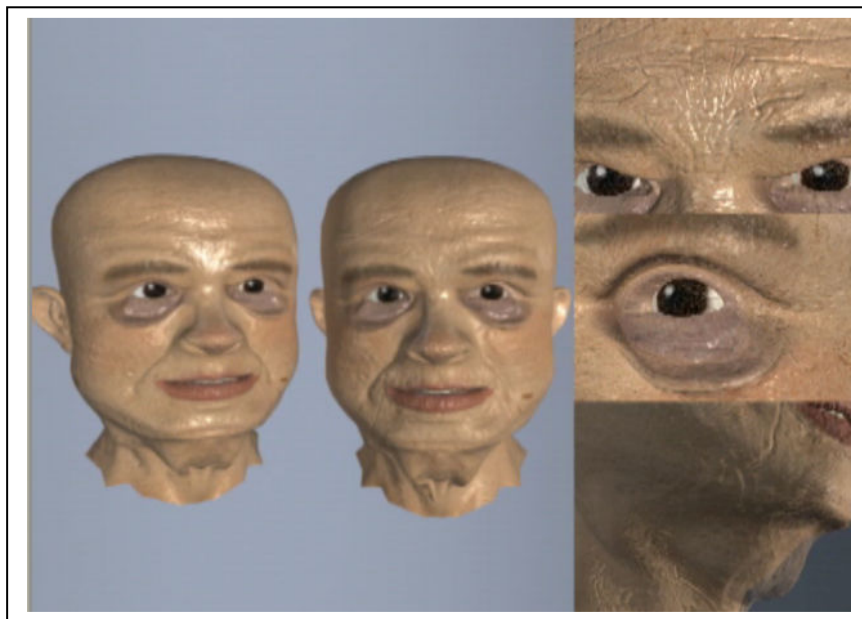
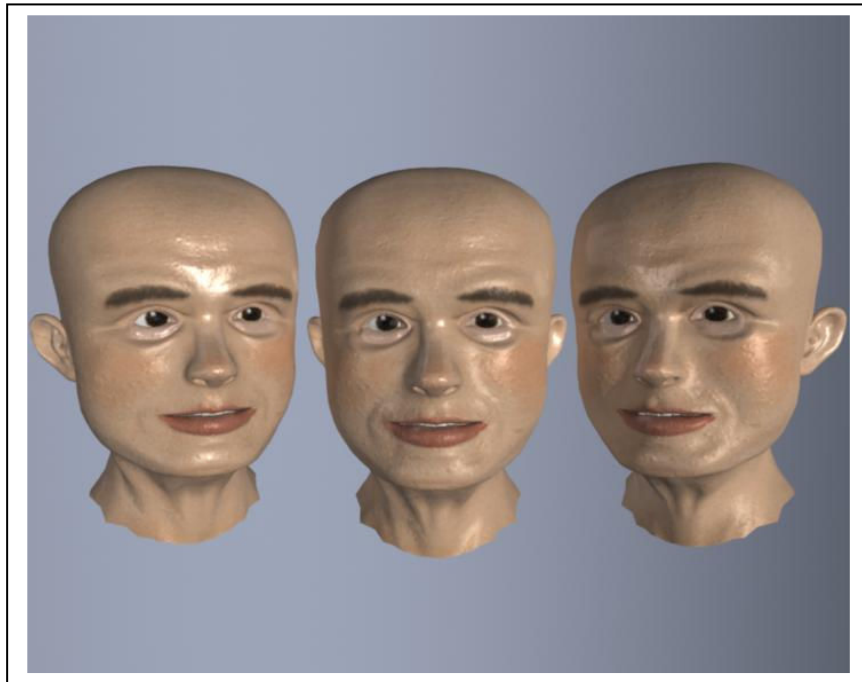


Notice how complicated the graph network is, and its not even complete here, every single colour file, bump file and specular file had to be connected to blend nodes and then key framed.

The animation

I wanted to show a front and side view so that the full extent of the ageing process would be visible. However, the composition of this alone was uninteresting, and so I added three boxes on the right hand side to show the details of the forehead, eyes and neck ageing in close up. I used a plain neutral blue background so that it wouldn't detract from the heads. I then lit the faces to show off the details and rendered using mental ray and final gather as after reading Jeremy Birns 'lighting and rendering', this appeared to offer the best results for what I was hoping to achieve.

Render of final set up



Conclusion

How this project could be developed further

If I had more time, I'd like to look into other aspects of the ageing process, such as the greying/whitening and thinning of hair, eyebrows, etc. I'd also like to investigate random facial hair that occurs in old age from peculiar places like the odd long hair that pops out from an elderly woman's chin. And if I had a lot more time I'd like to further my study and research the changes that occur across the whole body with age.

Evaluation

The animation provides an interesting and informative portrayal of the ageing process. Although every person ages at a different rate and it is therefore impossible to predict the exact moment in time that their first wrinkle appears and so on, I have tried to make it as accurate as possible. I have done a lot of in depth research into the ageing process, and I have broken down the average ageing process into five year intervals. For each of these timeframes I documented every change that occurs and imitated these changes using a mixture of blend shapes, bump maps, texture/colour maps and specular maps, in order to depict the ageing process in the most precise, realistic manner.

Texturing was a completely new, unexplored area for me, and undergoing this project has equipped me with a much greater knowledge of texturing theory and technique that I'm sure will prove very useful in future projects. It would have been interesting to have made my project photorealistic, but as the project was essentially a study on ageing rather than a texturing project, this seemed an unnecessary challenge given the time constraints.

Lighting and rendering were also new areas to me, I didn't have chance to learn as much as I did about texturing, but the procedures I learnt were very useful and effectual and I'm sure I will use them again, for example, using final gather was really effective for picking out the shadows of the face cast by wrinkles and skin folds. I did a small amount of research on lighting and rendering in mental ray, and this was sufficient to allow me to set up my own facial and environmental lighting, and to alter the settings of mental ray to create shadows, final gather, and many other attributes. Using the default render settings, I would not have been able to achieve this result. I think the final rendered style depicts the smaller details very well, and I was very pleased with the outcome.

I believe this study will be a very useful reference point in the future when designing characters. There are a number of quite significant changes that occur at various ages that I never would have noticed before, but the addition of these small features will add more character and believability to future designs. Since starting this project I have made several alterations to the old male character in my major project, so this research has proved very beneficial in that respect.

Conclusion

It is difficult to say how successful this project has been in terms of how innovative it is. None of the ideas or techniques I have used are new, most of this information is available online or in books, I have simply researched it, collated it together and applied it to create the final product. It is perhaps not the most effective or efficient method of simulating ageing, but the manner I have gone about this project, and the ideas and techniques used have been innovative to me.

I have learnt a great deal about texturing and modelling that will be useful in current and future projects, and I now understand the fundamentals of lighting and rendering. Also, I have become a kind of expert on the ageing process and the causes of wrinkles, information that I'm sure will benefit me somehow in the future.

For these reasons, I feel that I have been reasonably successful in creating an innovative project, and overall I am satisfied with what I have produced. Finally, a word of advice – always wear sunscreen!

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