Innovations Report

Ba Computer Visualization & Animation Year 3

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COMPUTER GENERATED RAIN EFFECTS: THE REASON, REPRESENTATION AND IMPLEMENTATION

Abstract

I have implemented a tool in Maya that has the ability to generated particle simulations that can produce rain effects with various degrees of detail. Depending on the needs of the users. It has three separate layers, a background layer streak based, mid ground layer sprite based and a foreground layer blobby particle based. The system fully automates the set up of all the particles with shaders, textures and necessary attributes. The user is able to specify target collision objects and set up advanced collisions were particles flow along the surface of the object in a more realistic fashion. There is also the option to set up a custom camera which has a functionality for collisions of particles to appear on its lens.

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1. Aims

My aim is to create a tool that has

- A simplified way for the user to generate rain effects
- Fast simulation capabilities
- Be able to render at reasonable speeds
- Be adaptable
- Be easy to setup and run
- Collision capability with different degrees of interaction based on the users needs

2. Introduction

The aims of this project and report is to document research involved into the creation of rain effects. To understand the process and considerations involved in designing ways to simulate them and to successful implement functionality for the generation of these types of effects into a user friendly tool.

Although i am primary concerned with rain i do have to carefully study and examine its properties as a fluid and how it acts in real world situations to achieve descent simulations. Simulating and creating realistic fluids is one of the most difficult and challenging areas of digital effects to recreate convincingly, because of the unusual dynamic properties of liquid.

> *"Movie effects and natural phenomena have always been awkward bedfellows. the real-world behavior of fluids is almost impossibly complex, with a huge number of variables all affecting how liquids and gases move, transform, intermingle and disperse."[4][3d world, pg 100, winter 2007]*

However it is indeed possible to create the illusion of such effects. These effects however if simulated well can be extremely interesting and add to capturing the mood ,of a scene or environment and achieve visually stunning results etc. You may ask why create the extremities of mother nature in computer graphics. The reason being is that it is unlikely you will witness a tidal wave or tornado in your lifetime so they are mysterious to the viewer; thus are interesting and appealing to the viewer. Also it is practical impossible to capture footage of extreme weather conditions and natural phenomenon , because of danger impracticality etc. thus an alternative method must be used to represent the effects thus is were computer graphics and digital effects techniques comes into play.

Representing these effects however and making them convincing is extremely difficult because people already have a preconceived notion of what these effects would look like. Rendering them in a realistic manor is extremely challenging. However the can improve and add a lot to how immersive an environment is.[6][Sarah Tariq,]

Rain on the other hand is mush milder effect and would usually be used as secondary imagery(not primary content) used to enhance mood or for example invoke feeling about the scene usually a sense of ominous unrest. It is a very successful when used as part of a montage for an image as i could make you interpret the content for instance. It can in sense be an integral part of the montage of the image or sequence of images, when it is juxtaposed with in an environment it can make you feel different about the scene/shot. For example a imagine an introductory shot of film which shows a sun lit street in broad day light , which then cuts to a character the main protagonist if you will waking from sleep, and then imagine if in the first shot of the street it would have been under a heavy rain storm. You would have highly different outlook on the situation the character is in.

> *"For example, take a grave, juxtaposed with a woman in mourning weeping beside it, and scarcely anybody will fail to jump to the conclusion: a widow"[8] [pg3, Eisenstein, The Film Sense]*

It is the power of the elements of weather and rain can draw opinions from our subconscious and preconceived ideas about a situation. For example if there is heavy rain outside and you know you need to venture outside the safety of your dwelling for some reason or another. You will be inclined to wait till the rain has passed before you went on your journey. You will think negatively on the situation thus can be exploited in filmic context by adding rain to a scene to make you feel and think differently about it.

Another example i have found which i have found quite interesting is a quote from 'Yamamoto Tsunetomo, The Way of The Samurai' which uses the symbolism of rain to extended it to a greater meaning.

> *"There is something to be learned from a rainstorm. When meeting with a sudden shower, you try not to get wet and run quickly along the road. But doing such things as passing under the eaves of houses, you still get wet. When you are resolved from the beginning, you will not be perplexed, though you still get the same soaking. This understanding extends to everything. "[16]*

This quote brings forth how powerful the image of rain can be and how it can drive emotivecontent.

A flip side example of rain and its symbolism is a bringer of vitality notion can survive with out water/rain. For example a dry desert scene where it begins to rain would give the impression of life and hope. Rain is a powerfully tool for a film maker or artist and can be used to enhance imagery and emotion within a piece.

Fig.1,Matrix Super punch [11]

Take for instance the fight sequence at the end of the Matrix trilogy[12] when it is the penultimate battle between the main protagonist and villain of the films. In the scene it is raining heavily its adds to feeling of how epic it is and how important the scene is. If however you could imagine the scene on a sunny day it would not give the intended effect. A problem however in creating the scene how was the need for close up representation of rain. Procedural particle type methods were used for the rain in the distance but for close up shots Hand-made rain was created for the extra detail needed.

"To address this problem, researchers have used hand- drawn textures of streaks for rendering rain close to the camera. A recent example of the use of hand-drawn textures is the movie "The Matrix Revolutions" [Lomas 2005]. This approach is clearly cumbersome, as the range of appearances of rain streaks is rather wide. In addition, streak appearance also varies significantly with lighting and viewpoint directions, making it harder to use hand-drawn textures for scenes that include lighting and viewpoint changes. We have learned from experts in the special effects and animation industry [Lomas 2005; Reed 2005] that automatic rendering of photorealistic rain remains an open and important problem." [1][Kshitiz Garg Shree K. Nayar, 2006]

3. Research into relevant physical properties and attributes

When rain falls it doesn't fall in streak the way would normally see it falls in blob-by like spherical shape but because of oscillation and the speed it is falling we see rain in a streak light pattern. They get distorted as the fall. As a rain drop is falling it under a amount of pressure which has the effect of distorting its shape over time so if you were to stop time as a rain was falling you would use undulated spherical like drops. The drop undergoes a lot of shape distortion as it falls. [1][Kshitiz Garg Shree K. Nayar, 2006]

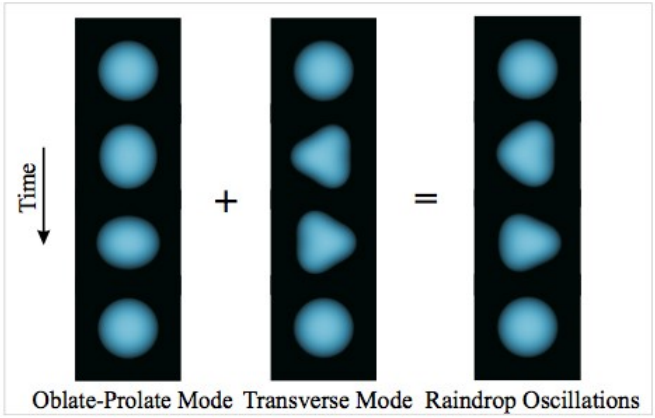
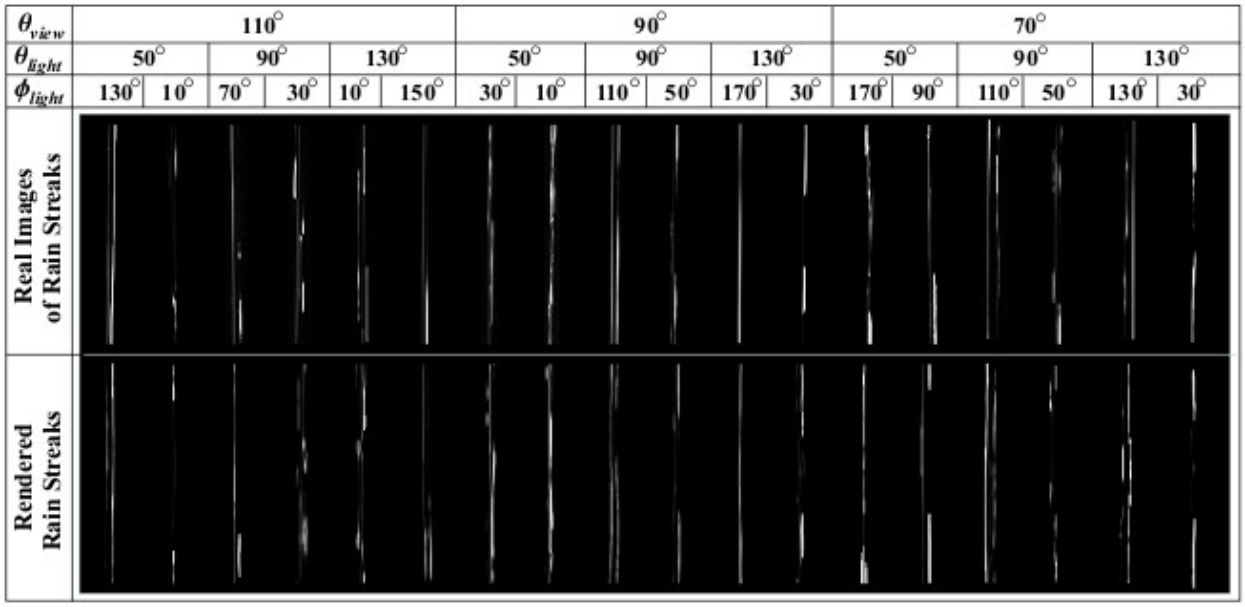


Fig 2 [1]

*"Oscillation model for rain. Raindrops undergo rapid
shape distortions (i.e oscillations) as they fall. These oscillations are mainly due to combination of the two spherical harmonic modes –the oblate-prolate mode and the transverse mode." [1][Kshitiz Garg Shree K. Nayar, 2006]*

Fig 3 [1] Look up table of rendered render streaks compared to real rain streak images



4. Research into visual techniques and solutions to generate rain effects

4.1. Film effect solutions

Films usually have big budgets and money is not usually an object in achieving an effect (reference budgets for films) Thus how good an effect is more important for achieving a result so elaborate setups and expensive computer generate effects can be made. A possible solution that is employed on larger productions is the set up of a rain rig either to acquire footage used to composite over a shot.[17]

This methods usually involves the rain rig to release vast amounts of water that fall like rain drops above a set which a backing screen in order to get a key a black screen is usually used instead of the conventional green and blue screens that are usually used to get a key from actors.[10][Ron Brinkmann, 1999,]

This is used so you can separate the background from the required elements by creating a mask or alpha channel to use to correctly overlay the elements. Sometimes a dye is added tot he water to make it more visible over the background in order to improve the task of generating a good key when it comes to the compositing process. Also it is not unheard of to use other liquids such as milk as it stands out allot better against the background.[10][Ron Brinkmann, 1999,

> *"Filming rain scenes is, however, a laborious and expensive task that requires setting up sprinklers and light sources over a large physical area. The shooting of a single rain scene can take several days. Due to the high costs involved, it is often impractical to include rain scenes in small-budget movies. For these reasons, a simple algorithm for photorealistic rendering of rain is highly desirable."(Photorealistic Rendering of Rain Streaks Kshitiz Garg Shree K. Nayar Columbia University)*

An interesting example of the utilization of this effect was for advert for 'Timberland, October 2006,, Special effects, Brickyardvfx, Directors Tim Cronenweth, Jeff Cronenweth', the advert uses a

rain rig for parts were rain is in direct contact with an actor and uses acquisition footage attained from the rain rig as while as enhancing the effect with added computer generate rain, rain was added in post as the original footage was shot on a sunny day. A mixture if you will, to achieve interesting believable results.[17] [CGSocietyCGFilm,October,2006,]

Timberland advert Before and after. Fig 4, 5,[17]

Before and after (example of a rain rig)Fig 6, 7,[17]

> *"Knowing that the rain would be added later in post, a rain rig on set was used to capture plates that could be used both for reference and composites. However the opening and closing shots were so wide that all of the rainfall had to be created in CG." [17][CGSocietyCGFilm,October,2006,]*

You can gather from this generating the visual effects of rain can be the use of multiple techniques to achieve convincing results.

Other solutions available are filters that give the effect of rain which are layered over animation or film footage to give the impression of rain there is limitations to this as complex camera movements are out of the question as the overlaid rain does not look convincing as you don't have the control to determine its movements exactly as parallax occurs and sense of depth can be an issue. Also the lack of collisions also destroys the believability how ever more a advanced filter type effects can provide some functionality for this but by no were means the integration of the collisions that be achieved with rain effects that are generated if 3d space.

Compositing however can greatly improve the integration of rain effects can can provide functionality that is expensive to achieve in rendering rain in a 3d environment. For example you have the

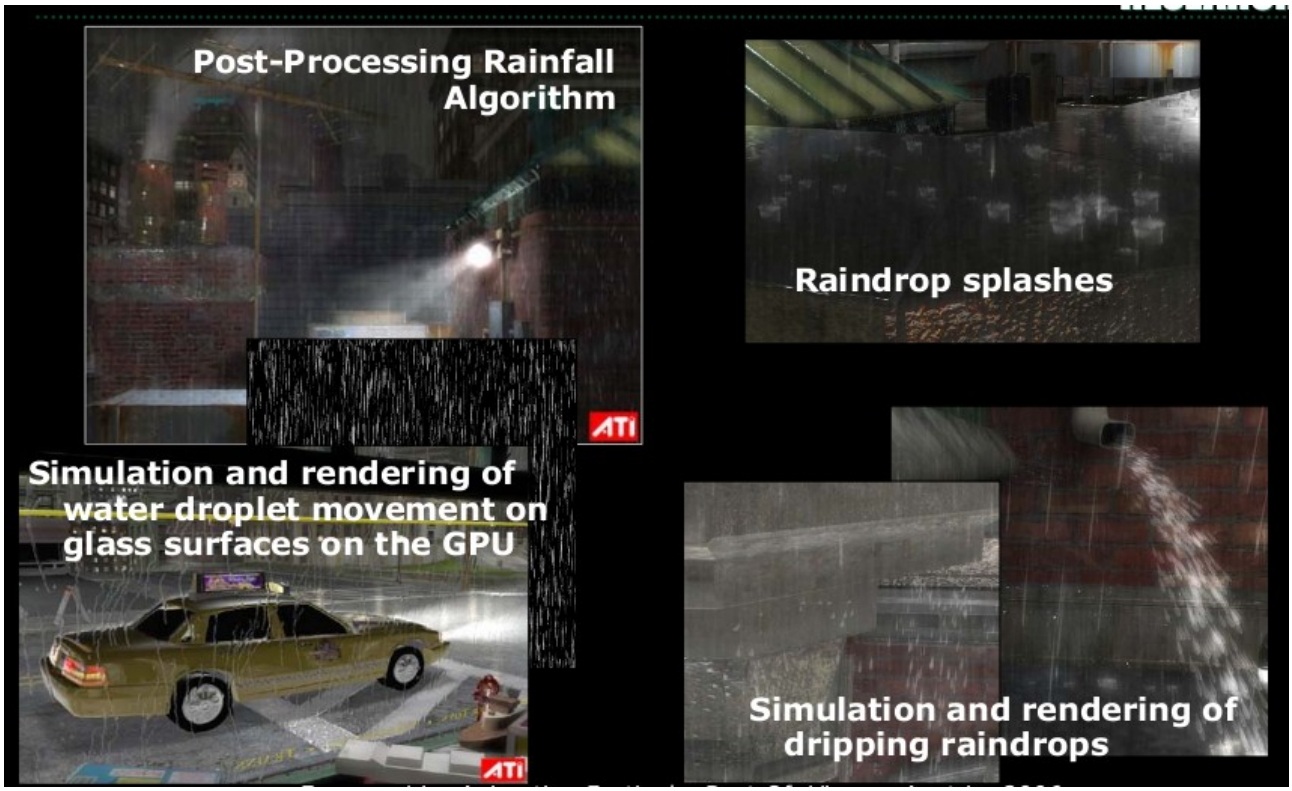
ability to displace and warp layers over one another to achieve effects that would be rather expensive to render in a 3d solution as they require ray-tracing to be used to provide convincing refraction. Also the benefits of composing allow you a great deal of control to tweak and adjust layers so everything sits and fells more convincing.

4.2. Game techniques and real time solutions

A popular and commonly used way of generating effects in games and real time graphics is the use of sprite particles, as they an inexpensive way of achieving realistic results. They are rendered with hardware hence the benefit for real time use. They are however used in film and animation effects as well because of there inexpensive and that this allows for vast amounts of particles to be used. Sprite particles have usually have a texture applied to them with an alpha channel to mask off the edge to give the result of a shape for example a cloud of smoke or in the case of there use for representing rain a rain drop or a splash. They can use sequences of images which can be looped over frames to give moving images.

A good example of using sprite based system is the Ati Toy shop Demo which employs the use of sprite particles for the generation of rain drop and splashes. The system uses sprite images from the library of rain drop textures from the 'Photorealistic Rendering of Rain Streaks library ' developed by , Kshitiz Garg Shree K. Nayar 2006[1]. This library is discussed earlier in the report and it seems a popular choice for generating rain effects as it gives accurate representation of what airborne rain looks like.

Fig 8, Ati Toy Shop Demo[5]



Nvidia have also used the same library for generating rain effects. The rain system which uses a look up based on camera and light sources positioning to determine which images to apply to the sprites gives visually believable results but does not have an implementation for collisions which are an important factor for generating believable rain. [6]

The Ati system uses a sprite system for some of the collisions were once the particle has collide with a surface a sprite is generated which loops through a sequences of splash images. The particle dies after the loop, so as they only appear for a short amount of time.[2] [Natalya Tatarchuk and John Isidoro, 2006]

A good aspect about using sprites is that they always face the camera by default in most system so there isn't the danger of your images being viewed form an acute angle so the images appear distorted or in the worst case scenariothe images not being visible at all.

Streaks (or alpha blended particles) are a cheaper alternative to using sprites and were commonly used in games for example, however the results form these can give simplistic looking results. [2][Natalya Tatarchuk, 2006]

However i believe they are suitable for use in the distance as viewing and loading texture information for an objects so far far away form the cameras is waste full as rain drops are so same it is impossible to determine the look of an individual drop so a particle streak with a fade on its tail would give the same result as a texture sprite without the waste of resources and thus using this method will allow for a large amount of particlesto be used and would allow a large viewing field of visible rain.

Many modern games use an the sprite and streak methods described above and use texture solutions for generating puddles and the look of rain water flowing off or down objects. With increased power hardware these effects are improving all the time as arguable generating rain effects can be taxing on the hardware of a system and it is usually the case were a trade off must be reached as in real time graphics all resources can not be focused on generating this effect. For film effects and animations(non real time) all resources can be focussed on generation more complex simulations as these effects can be generated separately then added (composited) to the scenes/shots.

Fig 9, Oblivion [13]

Fig 10, Time Shift [15]

4.3. Animation and software solutions

Software solutions using utilizing the power of modern animation software dynamic systems and advanced rendering capabilities have the ability to create amazingly detailed and believably visual effects. A good example of this is some of the water and fluid effects in the film trilogy Lord of the rings.

Although not specifically rain they are a good example of what is achievable. Of particular interest is the control of particles to follow a drip and fall off a surface convincingly.

In Tom Kluyskens Maya masterclass 2003 [3] is a well documented explanation of how some of these effects are implemented. His example demonstrates how to achieve the effect of getting particles to flow along surface convincingly and this particle technique was used in the scene when Galadriel's pitcher is pouring water into a container. The system works by emitting particles from a surface of an object and controlling the particles movement with the surfaces U and V parameters. Unfortunately the system only works with NURB's surfaces as there U and V values are consistent.

The system calls upon the use of a built in Maya node called the closest point on surface node. This node can return the closets point on which a particle should be based on its gravity as it cant pass through the object the node provides the information necessary to position the particle correctly along the surface over time. Mayas built in nodes are basically complex math functions that have the ability to calculate faster than a equivalent mel code as they are embedded in Mayas architecture and some times is not possible to achieve with mel code alone.

The system allows a threshold to be controlled so you can control how strictly a particle will stick to a surface and when it will fall off. This system is ideal to generate complex collision of fluids to a surface and simulates flows of water along of the surface. Ideal for use for a software rain system.

As this system is intended for use in animation system software rendering can be used, and the use of blob-by particles can be used. Blobby particles are appear has spherical particles as default but have the ability to merge together with nearby particle to form a globular like masses which are useful to simulate liquid like masses and fluids. They can have a shader applied to them and have all the benefits of what is capable with software rendering reflections and better lighting for example.

Software solutions Flexible and can give more advanced dynamic results as this time of is particularly difficult to achieve in real time unless the hardware is specific for dealing with these particular types of calculations.

5. Evaluation of possible ways to implement a system pro and cons

5.1. Fluid based system

Pros

- Very good simulations with a good level of physical accuracy
- Very good control over the dynamic properties of the fluid and its attribute
- Good ability to deal with collision objects

Cons

- More suited for larger masses of fluids for example oceans and streams of water
- Can require larger amounts of computational power to achieve detailed simulations
- Although simulations are very accurate it can be difficult to determine were the fluid will go and can be difficult making it go wear you want it to.
- There better tools for simulating fluids are usually standalone (eg Realflow) applications that specifically deal with simulation fluids. This adds another element in the pipeline and more considerations may need to be made.

5.2. Particle based system

Possible Render Types:
Streaks

Pros

- Extremely light weight on the system.
- Fast to render.
- Give descent results from a distance
- Can be rendered with motion blur with hardware rendering
- Can have per particle attributes to adjust color, transparency, size etc to give enough variety to the look

Cons

- Are not really suitable for close viewing as there is not much variation in there look and repetition becomes apparent.
- Not really suitable for advance dynamic collisions because of there shape.
- Cant have textures applied to them.

Sprites

Pros

- Light weight on the system.
- Fast to render.
- have the ability to have a texture applied to them which can give good results, if a good quality image is used.
- Suitable for hardware rendering.
- Can have per particle attributes to adjust color, transparency, size etc.
- Can have a attribute assigned to give each sprite a per particle number which allows random images from a sequence to be applied.

Cons

- As sprites always face the viewing camera, while this in advantage in most instances, when viewed from a close distance they still alter to face the camera. this makes them appear in unusual angles which looks odd. Particularly if the camera passes past them.
- Can be tricky to get good results from renders as with the wrong settings they can appear very faded.

Blobby (meta balls) Particles

Pros

- Can have shaders applied to them and can utilize all the benefits of software rendering offers
- Have the ability to merge with near by particles to form globular objects and can form into a larger mass depending on how many particles are being used. This is controlled by a threshold which can be set or changed over time.
- Can act like fluids if larger amounts are used.
- Great control over parameters and simulations.
- Can give convincing fluidity in collisions as there ability to form together.

Cons

- Can be expensive to render depending on what shader is applied and if reflections and refractions are used.
- Must be rendered with software.
- Can build up massive cache data files with big simulations.
- System can become unstable when large amounts are used and may be liable to crash.

5.3. Two dimensional solutions and composting

Filters and post processing

Pros

- Fast to implement and easy to set up
- Common in most editing and composting applications
- Suitable for simple shots with limited camera movements and with out any noticeable collision objects

Cons

- Can seem static, unrealistic and obvious the effect is being used
- Gives the impression of a cheap or armature production because of the tale signs of it being added over footage with poor integration.

Compositing to improve effect

Pros

- Essential for any digital effect. very seldom if ever would compositing never be used on a major production
- Great control and limitless possibilities and combination of results
- Puts control back into the artist and has the ability to make or break a piece of work
- Cheap to do warping, defocus and depth of field types of effects which are expensive to render in 3d applications provide appropriate alpha and Z depth information is provided in the channels of an image.

Cons

- Dependant on the images made to be composited, the artist would need to be aware of parts of an image to render out in separate passes in order to make a success full comp.

5.4. Acquisition footage

Pros

- Realistic results as it is real footage.

Cons

- Difficult to set up and shoot as often expensive equipment is required. For example camera appropriate lighting, a screen so as to be able to easily extract a mate during compositing.
- Best results come from using a specifically made rigs. However these rigs would only be accessible for large production houses. Small make shift solutions can be made involving the use of hose pipes and watering cans and such.
- Not really that adaptable would be the case that would be used for a very specific shot in mind.

5.5. Review of methods

The tool created will aim to use the benefits from the above ways of possible implementation of rain effects.

From analyzing methods used particle solutions offer the most effective and flexible solution for the means available to develop tool a tool that can be light weight and have the ability to adapt to various different simulations and conditions of rain. As particles offer the option for light weight simulations (streaks particles) to more advanced simulations at close range (Blobby particles).

A strong emphasize will be on how successful i can use the data developed form these simulation in the compositing stage. By warping of the background image based on the rendered particles alpha channels interesting results should be able to be achieved without over the top render times.

Using fluids will be impractical as they are expensive and are not really suited for simulating rain as thousands of separate objects will need to be represented as fluids systems are better at simulating large capacities of water joined together.

The use of acquisition footage is impracticable as the elaborate set up requires and expensive of the equipment. Also the lack of adaptability is an issue as the system is intended to be suited for array of needs.

6. Implemented Rain System Tool

I have generated my tool using Maya mel scripting (Maya embedded language) as to allow automation for the user and added flexibility/control offered with using mel. The primary aim of the tool is to create visually interesting and believe rain effects. However in order to achieve this effects additionally compositing work will be required in post by rendering the rain in layers. This is common practice in generating digital effects as it allows you a lot more control and gives you more options.

Ultimately the result that the user is able to achieve form this tool is also reliant on there compositing and rendering skills a guide of way to composite the elements generated from the tool is provide however ad can be used and can be used as a startingpoint.

The system/tool is a particle based system but takes into consideration and implements various aspects of the different methods talked about above. It compromises of a layered system which allows the control of the relevant detail needed. This works well as the user has a great control over how expensive producing an effect on there system as particle simulations can be very intensive on your workstation.

Taking this into consideration my system has a background layer which is particle streak based surface emitter which is relatively light to process and thus allows you to have a greater number of rain particles. A mid ground layer which is sprite based with textured rain drops. A fore ground layer which is blob-by particle based which has a rain/water like texture applied. It also facilitates the ability to create a camera which emits particles on a plane which acts as a lens for the production of rain artefact's on the camera.

The background layer is intend for use in the distance of a a shot or a scene and would have a wider emission area to fill the shot however as the particles are so far away form the camera streaks with an opacity fade on there tail and a random opacity on a per particle basis are enough to provide the level of detail required provided they are rendered correctly with hardware and have motion blur. As they are light i would recommend using around 10,000 plus to achieve a good result. It the particles can collide with as many objects as you wish and will generate a splash on collision and kill off the original rain particle.

The mid-ground layer is intended for use in the mid ground and even for the foreground if you don’t need the higher level of interactivity provided by the foreground layer. This layer applies textures of rain drops randomly to all emitted rain drops to provide variation to the rain. Again this layer should be rendered with hardware with motion blur to achieve good results. Rendering with hardware is extremely fast as it uses screen captures so you can pretty much render in real time and is ideal for rendering with sprites and streaks. However if you so wished, i believe in the newest version of Mental Ray supports the ability to render particle sprites as does Pixar’s Renderman. So this could be an option if you required features of those particular renderer's. However Mayas software renderer does not support the ability to render sprites. This layer has the ability to collide with as many objects as you wish and will generate a splash on collision and kill off the rain particle.

The foreground layer is intended for use in the front of a scene a shot were a greater level of detail is properly required. This system uses blob-by based particles which have the ability to merge with nearby particles and produce globular like effects which can be used for the simulation of water like effects. I have made a shader which gets applied to these particles which has transparency which fades off towards the edge of the surfaces it is applied to. This gives a nice look and enhances the believability. You can have one hero collision object which has advanced features not possible through regular set-up (i.e. with out invoking mel or expressions) which emits particles based n collisions that follow the surface down as you would expect water to flow down a surface. The particles are then re-

leased when a certain threshold is achieved and the particles drop/drip off the surface. This threshold can be adjusted by the user depending on there needs.(note you can only use a NURB's objects for the hero collision object as the way the particles follow the surface is based on the U and V values of an object and as these values are not uniformed and hard to determine on a polygonal object, If however ever your hero object you want the particles to collide with is a polygon object i would suggest making a proxy NURB's surface for the collisions) You can also have as many other collision objects as you wish but the level of interactivity is not this detailed. The way this system works is there are three particle systems the airborne rain , splash and drip/drop particles. When the rain particle collides with an object it emits splash particles and then dies, and when the splash particles collide with a surface the release he drip particles and then they die.

Camera and lens effect are achieve by generating a camera with a NURB's plane attached to the front of it acting as the lens. This object has a transparent shader applied to it, so as it is not visible in renders. It operates in a similar fashion as the hero collision objects in the foreground layer. When the airborne foreground rain particles collide with it, it emits particles on its surface which then appear to drip down these can be used through compositing process to generate any number of effects because of the information they provide. For example you could achieve the look rain drop artefact's appearing as if they have hit and stuck to the camera lens to add a further level of detail and realism to your scenes or it is possible to generate animated texture sequences which could be used as wet maps for shaders which are applied to objects such of windows to achieve the effect of water dripping down the surface.

I have tried to make the user interface as easy to use as possible to use. It has a tabbed window with a guide and appropriate tabs for the layers described above for example the background layer. Inside each tab is appropriate buttons that call the appropriate procedures that set-up the particle system and collisions etc. There is all so control sliders that control various attributes you may wish to control for example the emission and speed rate of the particles. However you need to press a button to make these values effect the system this is done intentional as I could of made it automatically adjust the attributes when the sliders changed but I thought it would be of more benefit to the user if they could decide when they want the changes to all take place for example if you had a high number of particles the system would take a long time working out these adjusted attributes and you would have to wait through each attribute change. With the user having control over when the changes take place the user can modify all the settings needed then tell the system to update all the attributes at once.

7. Critical analysis

My system works and I have received some relatively descent simulations, however it was during the process of testing my tool through various types of simulations that I started to notice some of its flaws and area of were it could be improved.

One of the major problems that I found was that if the gravity force that controlled the particles magnitude was set to high it would stop the collisions working properly and particles would pass through collision objects. I believe this to be because the particles are traveling to fast on a frame by frame basis for collisions to be calculated properly but further investigation needs to be done on this.

Another problem that could be changed is you cant adjusts collision objects resilience and friction(the attributes that control how a particle acts when it collides with the object). After you have set the collision object which is irritating as you have to predetermine the required attributes or go in and manually adjust them on each object.

I would also like to be able to implement the more complex collisions on multiple objects as this would be of benefit.

I wanted to have different particle systems to react with each other and possibly merge. Particularly useful for blobby type particles, but of what am aware Maya is incapable of this as it particle system is quite dated now. If I decide to pursue this I will probably use a different software package most probably Side Effects Houdini. As it has a much more capable particle system.

8. Evaluation conclusion final thoughts

I believe my system to be an effective outcome of my research. The tool is able to generate relatively effective rain effects in a light weight manna and is flexible in what it can be used for. However it is practically impossible to simulate all aspects of fluid simulations of which rain fall under particularly when it has collided which a surface. Rain and liquid is a very complex dynamic in nature that the illusion of this has been my aim but observing and researching into this properties has helped me a great deal implementing various aspects of my tool especially considering the amount of detail to pull effects like this off when considering the distance from the camera and depth of a scene/shot.

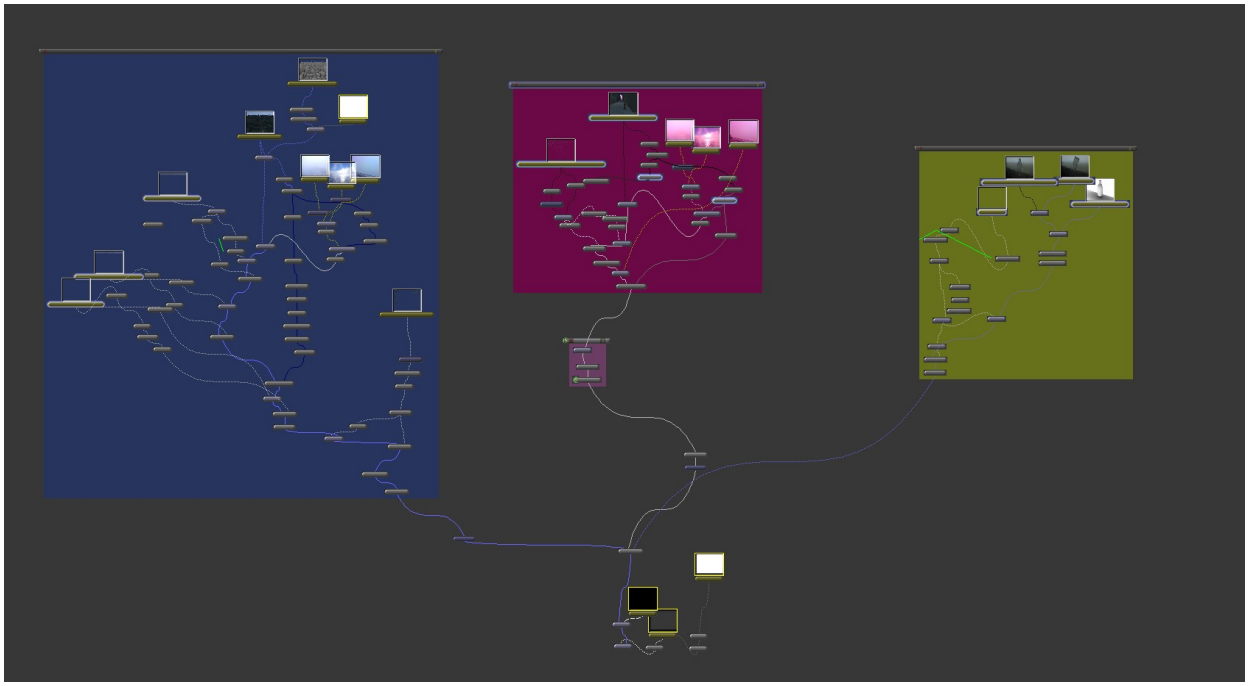
However there is always room for improvement and i would of liked to of added more features and user controls. One such feature would of been the automatic generations of puddles or pools of water which would of acted accordingly upon collision of the rain particles. I tried to implement the function of generating wet maps(texture sequences which are generated by particle collision and can be used for the effect of generating a damp trail behind rain drops for example). However this seem to be rather buggy and was a bit unpredictable so i decided to leave the implementation of this effect and turn my focus to more important parts of the system, you can still test out this function out however as i left it in the system as i would like to eventually get this effect to work.

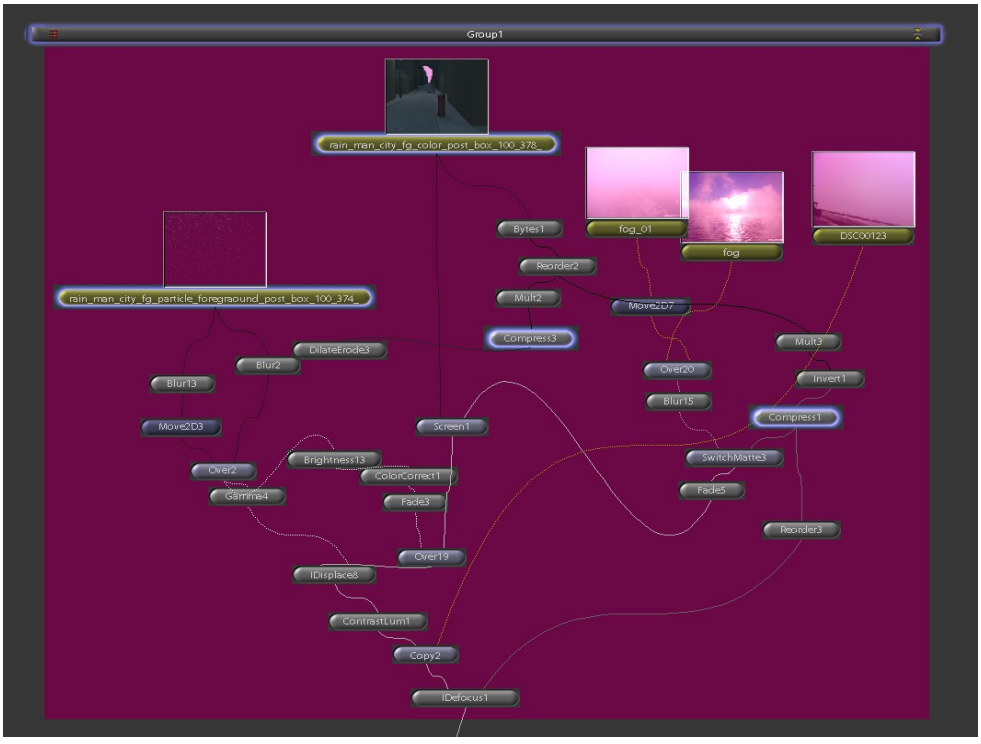
I would of also liked also to have the ability to be able to get different particle systems to act and merge together as one but unfortunately as far as my knowledge of Maya you cant achieve this as the way Maya's particle systems works does not allow this functionality. This would of been great use for the fore ground system were blob-by particles are used as it would allow them to merge together. An alternative to solve this would be may be to use the API(application program interface for Maya) or possibly with some more complex mel scripting. I did consider using Houdini as i am aware that the particle system used by these software allows for this and is capable of more sophisticated simulations, but my knowledge of this software and its workings are limited so i believe i wouldn't not have been able to get as far with my rain system.

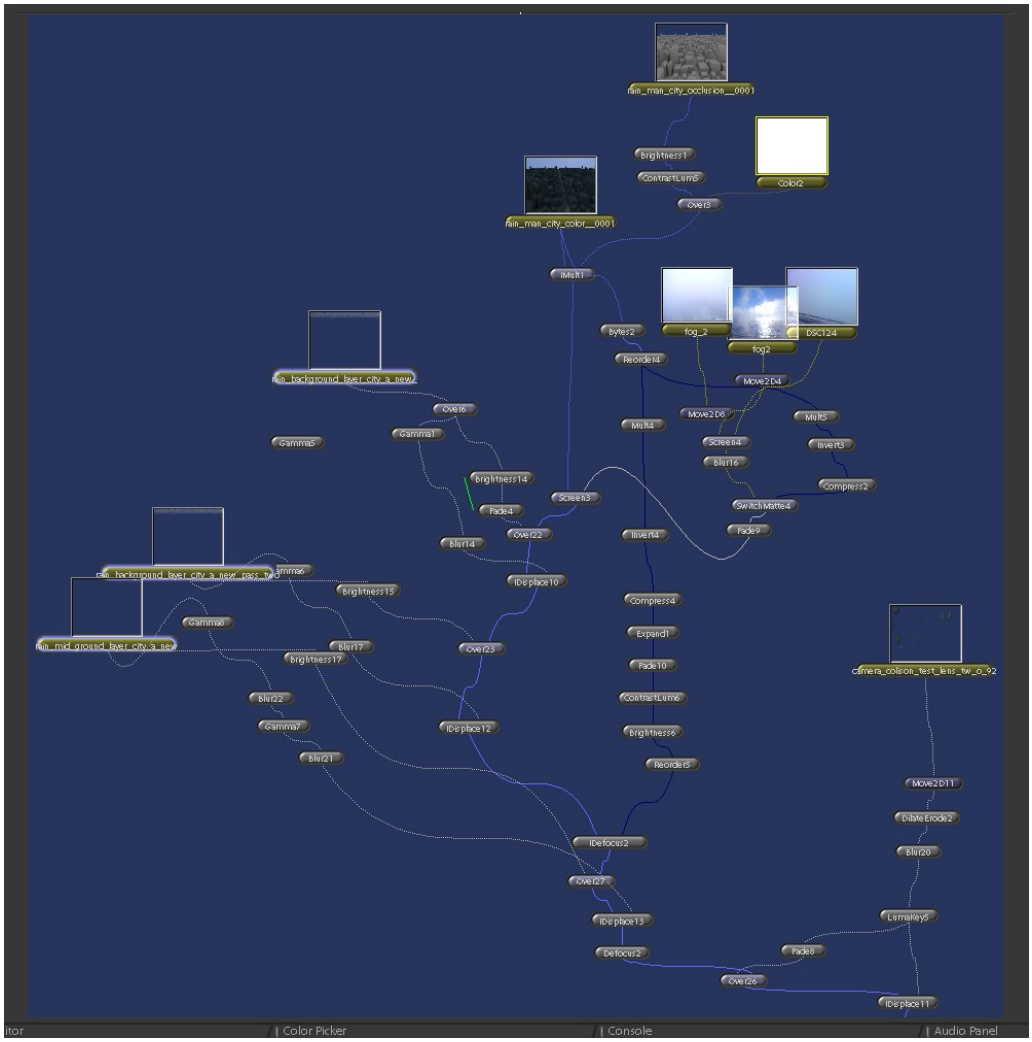
Overall I am happy with what I have achieved with my system as it was a lot more than i envisaged at the beginning of the project as I had never embarked properly into mel scripting and it has certainly opened my eyes to what is possible with its use. I plan to use the script to aid with my major project for certain shots and hopefully when time permits would like to improve and add to its use and functionality, I would also be pleased if others could benefit from using the tool.

8. Appendices

Examples Of Compositing networks:




Group1
rain_man_city_fg_color_post_box_100_378_
fog_01
fog
DSC00123
Bytes1
Reorder2
rain_man_city_fg_particle_foregraound_post_box_100_374_
Mult2
Move2D7
Compress3
Mult3
DilateErode3
Blur2
Over20
Blur13
Invert1
Blur15
Compress1
Move2D3
Screen1
Brightness13
SwitchMatte3
Over2
ColorCorrect1
Gamma4
Fade3
Fade5
Reorder3
Over19
IDisplace8
ContrastLum1
Copy2
IDefocus1


rain_man_city_occlusion__0001
Brightness1
ContrastLum5
Color2
Over3
rain_man_city_color__0001
IMult1
fog_2
fog2
DSC124
Byte2
Reorder14
Move2D4
Move2D6
Mult5
Mult4
Screen4
Invert3
Blur16
Compress2
SwitchMatte4
Fade9
Invert4
Over6
Gamma1
Gamma5
Brightness14
Fade4
Screen3
Over22
Blur14
IDisplace10
Compress4
Expand1
Fade10
ContrastLum6
Brightness6
Reorder5
Gamma6
Brightness15
Gamma8
Blur17
Brightness17
Over23
Blur22
Gamma7
Blur21
IDisplace12
camera_colison_test_lens_tw_o_92
Move2D11
DilateErode2
Blur20
IDefocus2
Over27
IDisplace13
Defocus2
LumaKey5
Fade8
Over26
IDisplace11
Color Picker
Console
Audio Panel

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