

# FIRE

A Collaborative project by John  
(ft Illi)

# RESEARCH

Looked into lots of movies that had some sort of fire; and discovered that big budget films tend to adopt practical effects; however, there is a fine boundary to this method due to health and safety concerns.



Project Power (2020)



The Avengers (2012)



Pearl Harbour (2001)



007: Spectre (2015)

In other cases, where practicality is impossible; computer generated images have been adopted to create this effect.



The Avengers (2012)



Man of Steel (2013)



Ghost Rider: Spirit of vengeance (2011)



Be Humble (2017 Music Video)



X-Men: Days of Future past (2017)



Avengers: Infinity War (2018)



Deepwater Horizon (2016)



Game of Thrones



Ghost Rider (2007)

# FINDINGS/SUMMARY

Compared to other elements, fire tends to have unique visual cues; which mainly involves its interaction with surfaces/objects around it.



Fire generates other elements like smoke.  
The color/size of the smoke varies



Physical interaction with  
substance like burning



Flame and smoke element  
follows the wind direction.



Presence/generating of heat distortion



Fire illuminates surrounding surfaces



Flying particles

## EXEMPTION

It is worthy of note that fictional fire does not necessarily have to carry all of the above visual cues. Some instances:



Dragon ball: Evolution (2009)



Harry Potter: the Goblet of fire



Fantastic Four 2 (2007)



# COMPARISM

Having identified the visual cues for believable fire in a scene, I also looked at shots with an unbelievable fire.



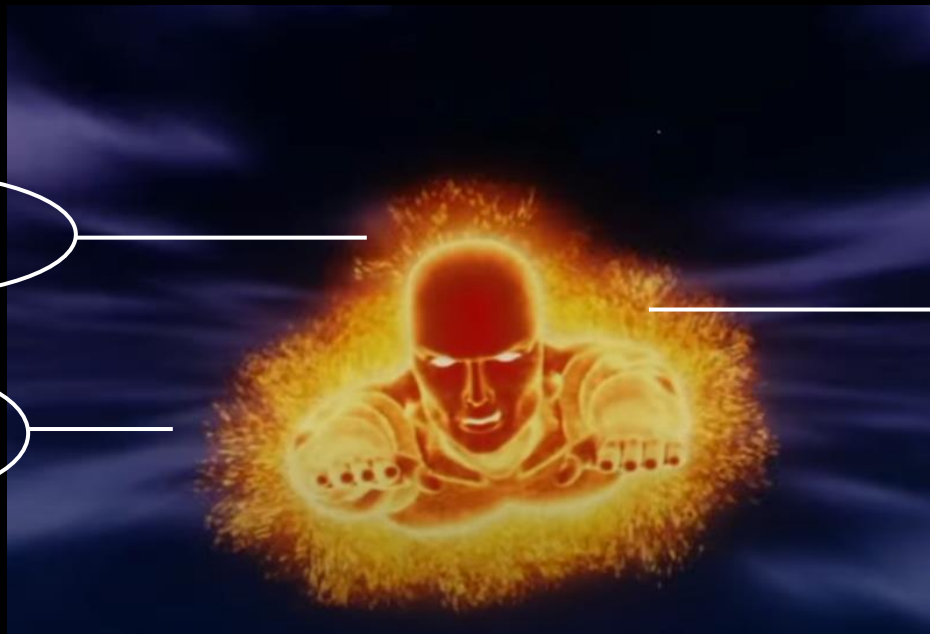
Fire seems animated rather than generated

No presence of illumination

No interaction of fire with shadow

No reflection of fire on the floor

Hereditary (2018)



Glow rather than illumination

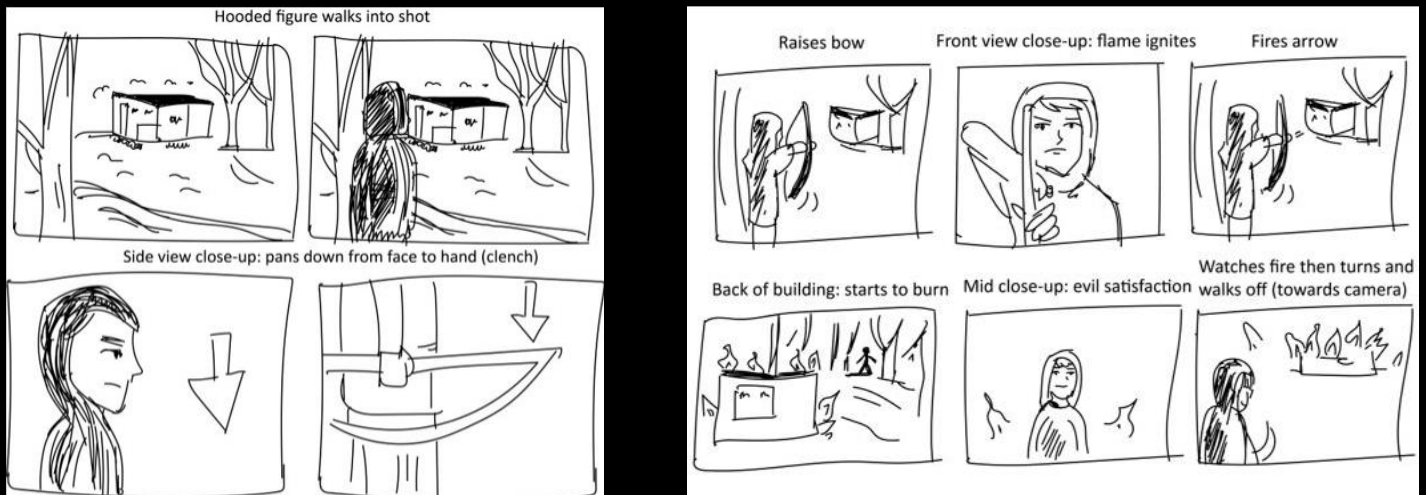
Flames looking like particles

Barely any existing depth

Fantastic Four (1994)

# STORY / CONCEPT

Following an in-depth discussion with my partner, we agreed on having no complicated story; just focusing on the two (2) VFX shots – burning building and actor walking away; as well as the leading up shots. (Duration = 60 sec).



We also agreed on a location – A wooded area with rundown building in Cefn Onn Park, South Wales.



Note that all contents on this page were made by **Illi Gardner**; and is only used to facilitate comprehension of this project/approach and forthcoming pages.



# CINEMATOGRAPHY

Sequel to the agreed storyboard of a hooded assassin, I looked into the cinematic and film languages – cuts and framing; adopted by movies and TV series in portraying archers in action. It turns out that most of the actors who play archers, barely know how to shoot an arrow! Their scenes were made using precise shots and cuts.



Hawkeye (Captain America/Avengers)



John Rambo (Rambo)



Katniss (Hunger Games)



Arrow (Oliver Queen)



Game of Thrones



Mira (Spartacus)



Abigail Whistler (Blade: Trinity)



Legolas (Lord of the Rings)



Robin Hood



Na' Vi (Avatar)



300: Rise of an Empire



Assassin's Creed



# RESEARCH: FRAMING

I also looked into shots that had an actor walking away from an explosion/burning object. I discovered that most of the framing had the actor on the right side of the frame; while the fire is on the left/center. This is clearly in line with the rule of thirds which is basically taking the 'center' away from the 'center'. It implies the main focus of a shot (In this case, the actor) is to be away from the middle of the frame, towards the left/right. Although scholars have suggested the position be on the right (because culturally, we read from left to right).

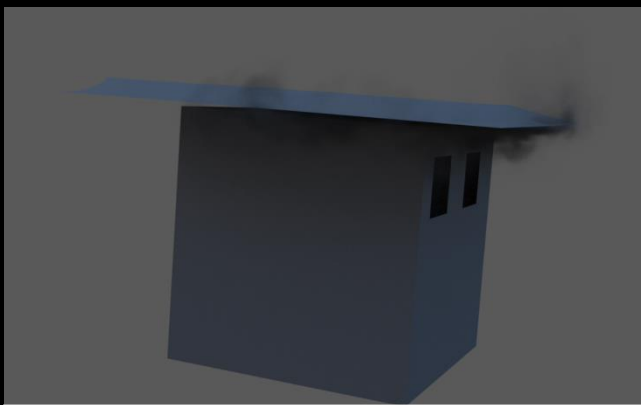


# TEST: CG FIRE

Having received pictures of the location, I closely observed the building to see how fire would potentially affect the building and surrounding.



I modeled a rough geometry with holes and made a low resolution fire/smoke simulation to interact with it



Smoke sim, interacting with geometry (Left)



Smoke sim, interacting with geometry (Front)



Sim interacting WITHOUT geometry



Smoke + Fire simulation, interacting with geometry



# TEST: LIGHTING



Man of Steel (2013)



Project Power (2020)



Indirect Light



Indirect Light  
+ Grade

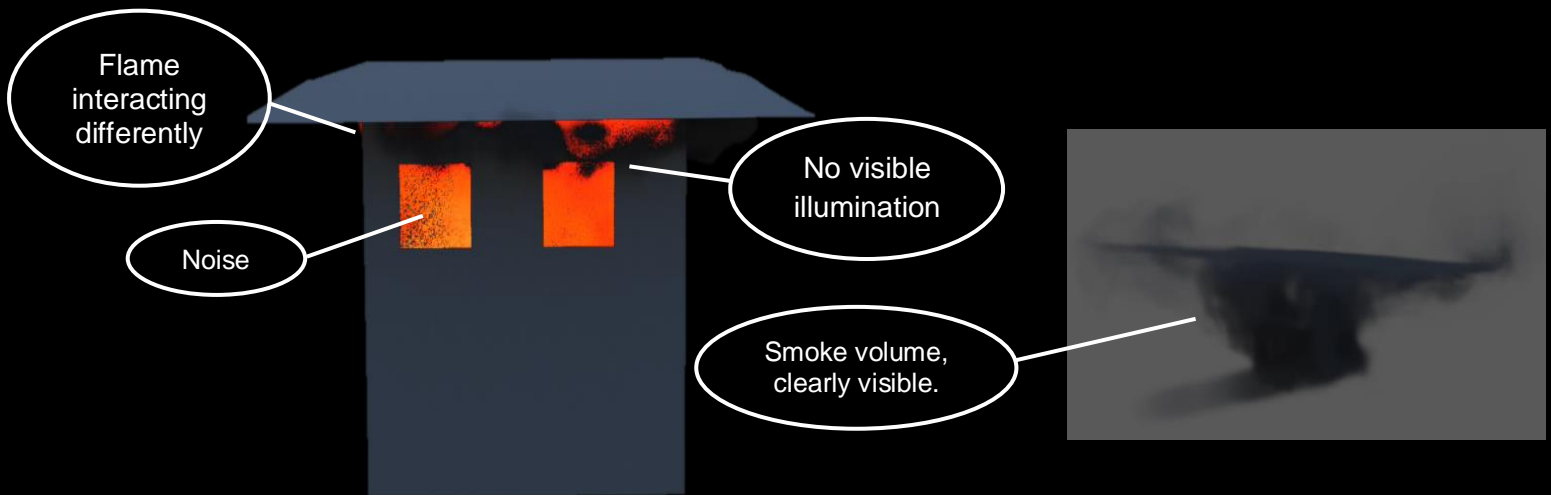
Following my observation on the visual interaction that makes a fire simulation believable, I attempted to mimic these cues and I began by creating the orange/amber illumination effect which fire creates on objects around it. I researched into similar effects and the technicalities around it, and attempted to recreate this in-camera effect using indirect lighting. Although this effect looked good, I know the effect would have to be animated to match the movement of the fire; which implies more work for the compositor. However, I sought a different approach.



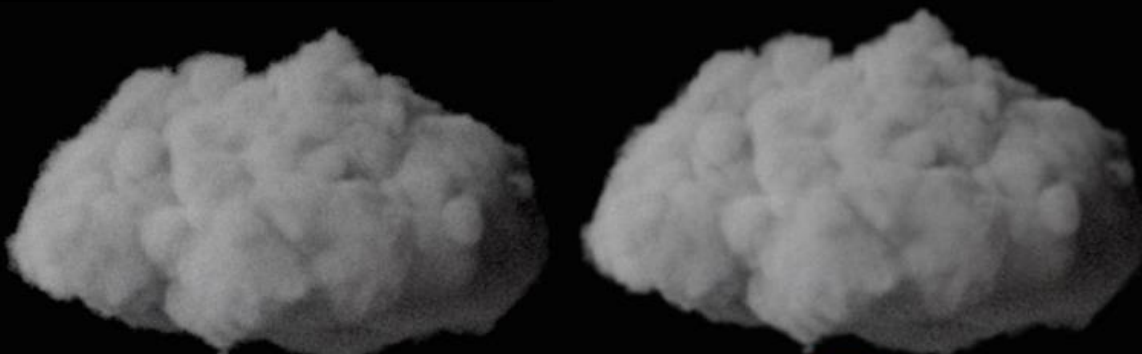
I finally settled for the roto-light – an LED light with preconfigured, animated fire lighting effect. I settled for this light because (based on my research findings), in-camera effect is much more effective and goes a long way into integrating CG elements and the rotolight was significantly more convenient in actualizing this outcome.

# CG: OBSERVATION

Sequel to the test render, I looked at it critically and observed some issues – The scale of the entire scene was around one meter, there was a lot of grain from the flame, I couldn't separate the geometry from the flame in the render without exposing the entire simulation in the geo. Only the smoke was colliding with the geometry and I had to render both elements separately as different simulations; and using the smoke's density alpha to limit the flame. The only interaction between the simulation and the geometry was the collision; the light from the flame isn't interacting with the geometry. At that point, all I wanted was something that'll render quickly so as to see areas to focus on during the proper simulation.



After this analysis I decided on finding out how fix the noted problems before beginning the proper simulation. Some problems were easy to fix (eg. scene scale); whilst others were significantly harder, such as removing noise without doubling/tripling possible render time. Online sources suggested increasing pixel samples, but that increased the general quality of the render (including the modeled building), and for this project, I only needed the quality of the flame/smoke to be better as I knew doing that will cut off the render time. I eventually found Houdini help files dedicated to removing particular type of noise, and manage render time.



Stochastic Samples: 4;  
Noise level: 0.1

Stochastic Samples: 55;  
Noise level: 0.005

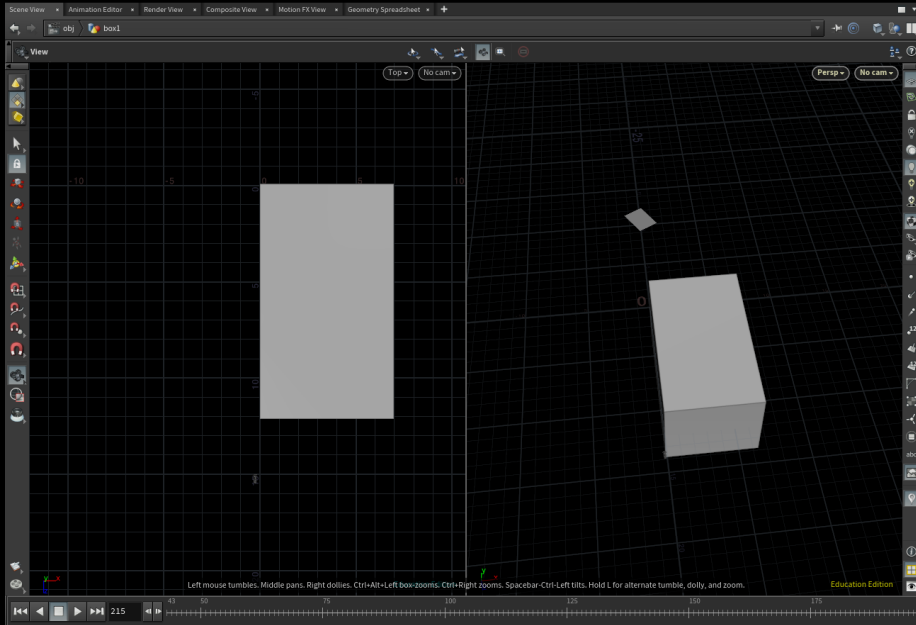


Houdini 18.5 > Rendering >

**Removing noise**

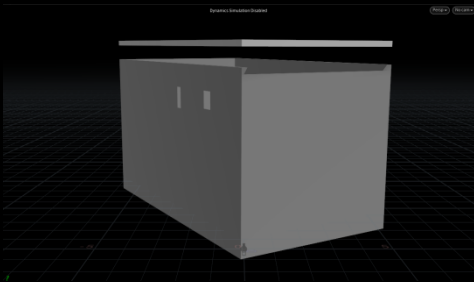


# SHOT #1: MODELLING

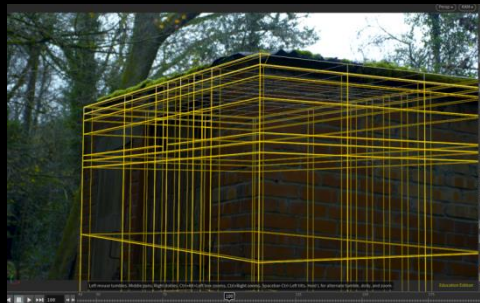


Having surfed the internet and perusing numerous tutorials, I found out that Houdini simulations are made to mimic reality in the closest possible way. This implies getting particular figures right; (the first, being the scale of the scene). I did the tracking using Nuke to generate the point cloud which I exported to Houdini as an alembic scene. However, it is worthy of note that a scene scale of 1 in Nuke is equivalent to 1 meter in Houdini. I had to keep rescaling the scene in Nuke till the point cloud representing the building was around 10m big. I achieved this by using a scale value of 20 before exporting to Houdini.

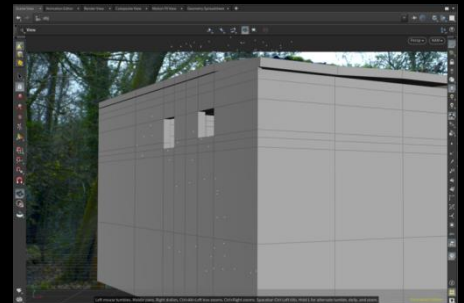
I wanted full control with the interaction of the building with the fire (particularly the roof) so I decided to separate the actual building from its roof. With the procedural nature of Houdini, making changes to one part of it would automatically update to every other connected parts.



Building and Roof



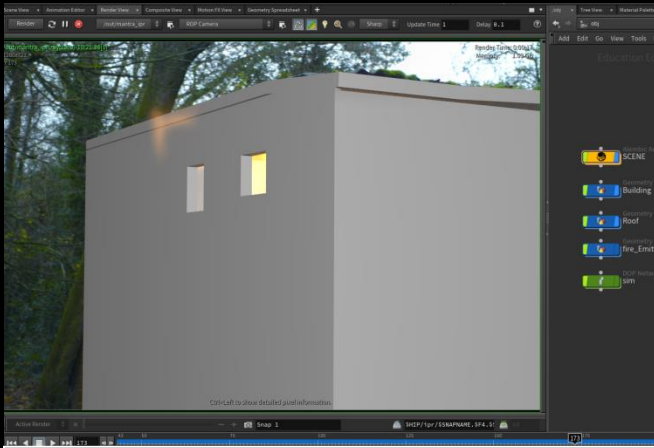
Wire Frame



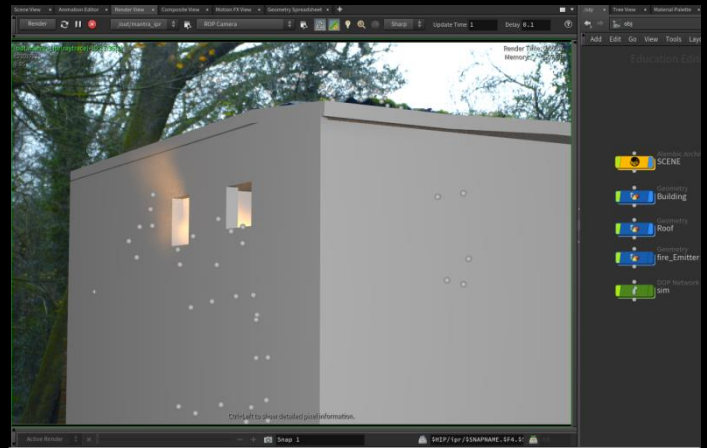
Final model

# SHOT #1: SIMULATION

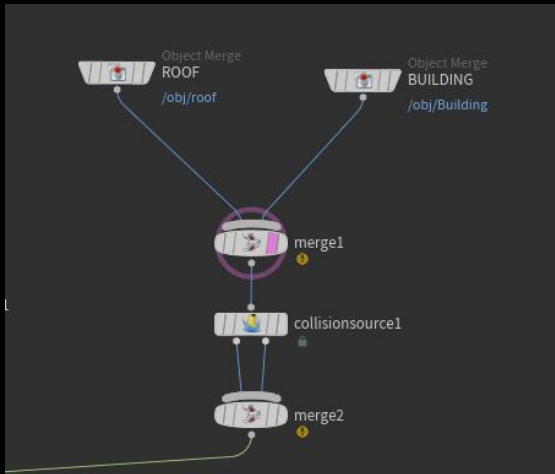
I have been using the shelf tools to convert the building model into a rigid body. Although the smoke interacted well with it, the fire didn't. Changing it into a static body fixed it; (particularly by making the pyro first before the static object). Increasing the sub-steps also made the simulation appear smoother. Unfortunately, it made the script run slow. And I decided to increase the substep only at the point of caching.



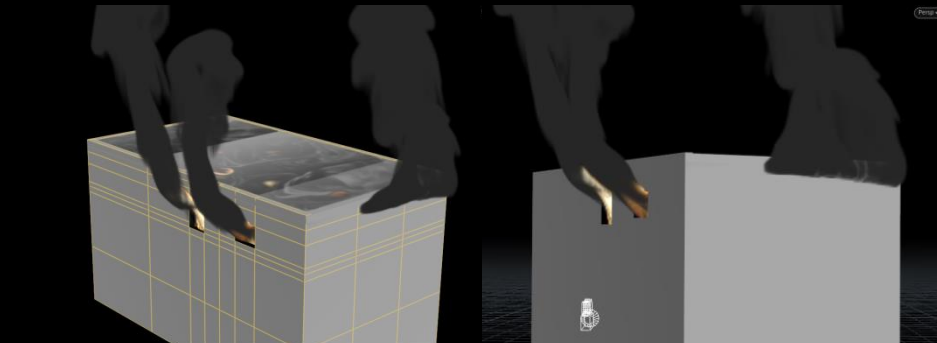
Flame leaking off the roof



Flame properly interacting with geometry



I noticed a sparse pyro option among the shelf tools, which wasn't present in all the tutorials I've seen prior. I figured that if this was a new option, there has to be something different about it (if not better). To that effect, I perused the Houdini help files as well as YouTube tutorials. Turns out Houdini v18 has a pyro solver node that can be used at the object level. I also noticed a few different parameters within the interface, which I found interesting and easy to use. With this, I decided to start the simulation afresh, tweaking particular parameters based on a predetermined result; such as the ambient temp, which was around 20° during filming. Also, separating the geometry paid off at this point as I wasn't satisfied with the interaction.



In a bid to make the smoke less puffy, as well as making the integration more obvious, I added turbulence as well as wind direction. I also created a new opening in the building model, so as to allow more smoke ascend and dissipate in the air

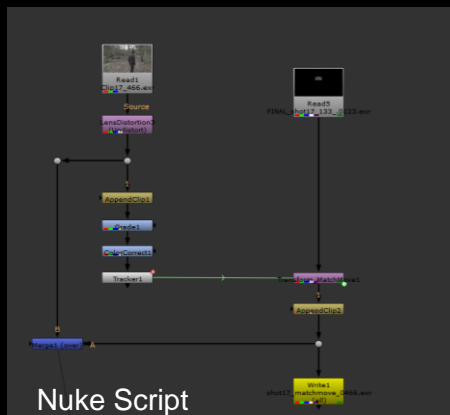


# SHOT #2

I spoke with the compositor and we agreed to cut down the duration of the VFX shots, so I can reuse the simulation for the second burning building shot. The second shot had the building far in zdepth and the filming was done in such a way that we'd be able to get away with 2D track. I decided to reuse the readymade simulation for shot #1. However, there was a glaring problem of frame numbering as the cached simulation was baked to a particular frame range.



Tracked Plate



Nuke Script



Repositioned geo/sim

I had to append the footage from Nuke to match the pre-rendered simulation cache number; as well as choosing a reference frame and creating a static camera in Houdini. After this, I repositioned the geo/simulation to align perfectly to the reference frame and upon finishing the render, I took it back to Nuke and did a 2D track to match move the CG (and re-append the clip) before sending it over to the compositor. However, it is pertinent to note that doing this procedure did not take up to 5% of the time it would have taken to redo the simulation and this process was particularly successful due to the procedural nature of Houdini.

Meanwhile... I think you should start compositing the second shot (where he walks away while smiling).

Since you now know what the fire looks like

21:38 ✓

I will use the same simulation in the second shot so it will look identical

21:39 ✓

lli

how will I composite it without the fire? or do you mean using stock footage

I mean doing things like rotoing the trees

11:52 ✓

Cos the fire will be behind the trees

11:52 ✓

okay 11:53

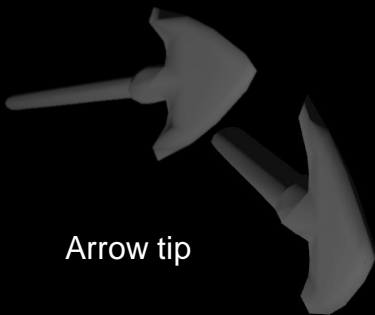
In a bid to save work time, I suggested that the compositor begins a bit of work on the second shot (based on the predetermined look); pending when the rendering would be ready.

# SHOT #3: ARROW MODEL

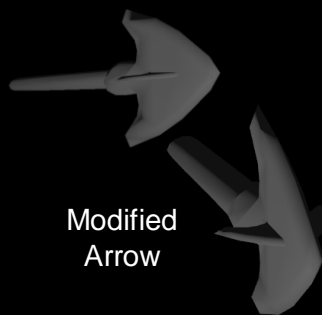


GeoTracker

I tracked the arrow using GeoTracker (by keentools) and rendered out the geometry animation as an alembic



Arrow tip



Modified  
Arrow

I found a free arrow model online but unfortunately, regardless of how I positioned the arrow, the angle didn't seem particularly satisfying. Also, I wasn't pleased with the look of the fire around it; so I decided to create a part of the arrow tip to serve as a visual cue for its angular position.

I have generated a texture that seems close to the arrow... you might need to do some grading but it's pretty close 15:14 ✓✓

I'm thinking... in the most unlikely of chances... can you replace the arrow with a CG counterpart? 15:15 ✓✓

cool!! Even if you don't manage the perfect texture i can do something with it...with the spaceship last year I did all the texturing in nuke ;) 15:43

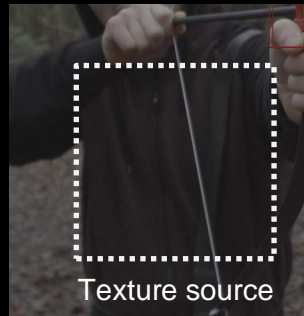
The compositor also assured me that she could do a bit of tweaking in Nuke to make the texture significantly better. All I had to do was get it close to the finish line!



Arrow Across



Cut Arrow



Texture source



Final Texture

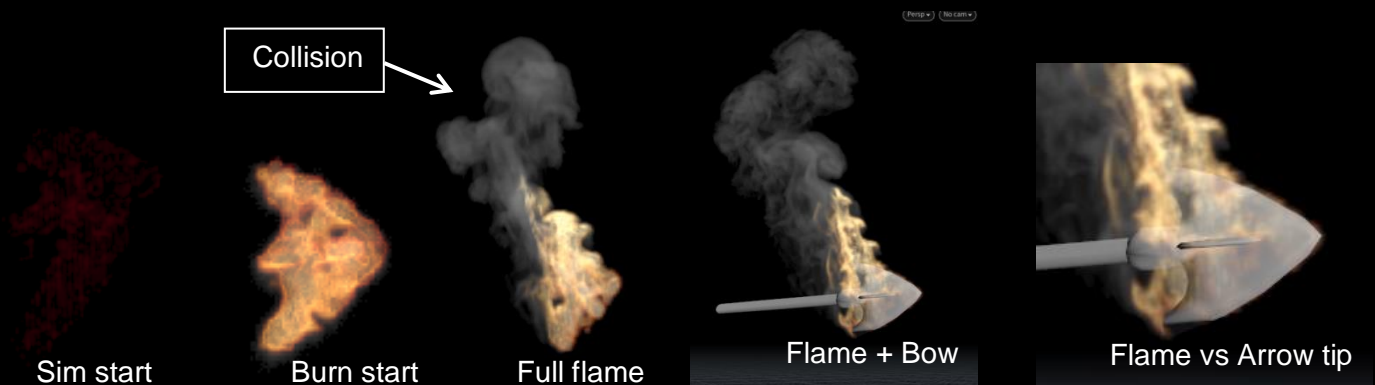
With my compositing knowledge, I knew that placing the arrow across the bow would increase the work for the compositor; so I decided to cut the geometry and fit it precisely where it would be. To fill up the texture, I rooted out a section of the plate and rendered a single frame, and tweaked the principled shader as well as the HDRI intensity until I got something close to the existing filmed arrow. (This is an idea I got from research on how the filming of "The Matrix" CG buildings were textured.



# SHOT #3: ARROW SIM

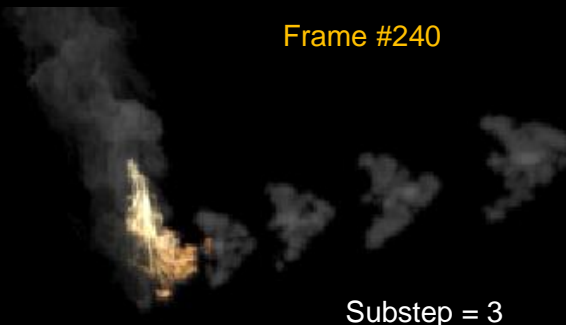


I did a bit more research into burning arrows to observe how the flame interacts with the tip of the arrow. Turns out the flame doesn't usually cover whatever is burning, rather it "dances around it".



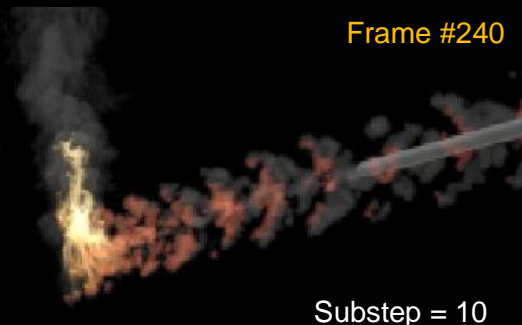
After mimicking the 'dancing fire', I was quite happy with the result; particularly the smoke colliding with a rough geometry of the bow I made; as well as the visual difference the little arrow extension made to the simulation.

Frame #240

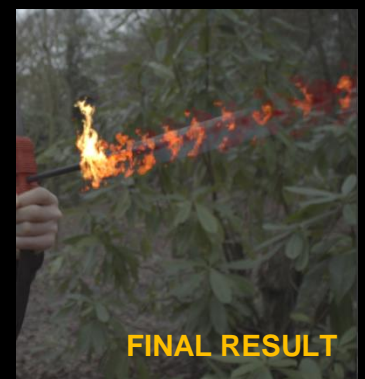


Substep = 3

Frame #240



Substep = 10



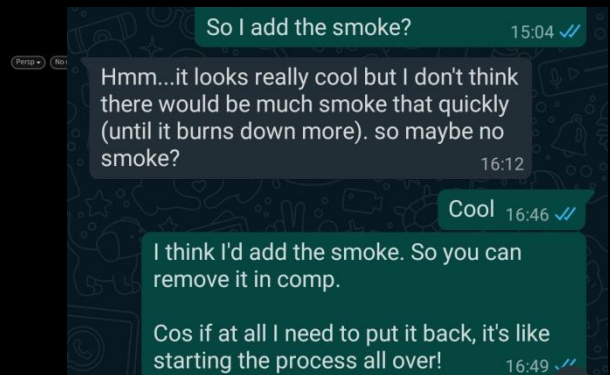
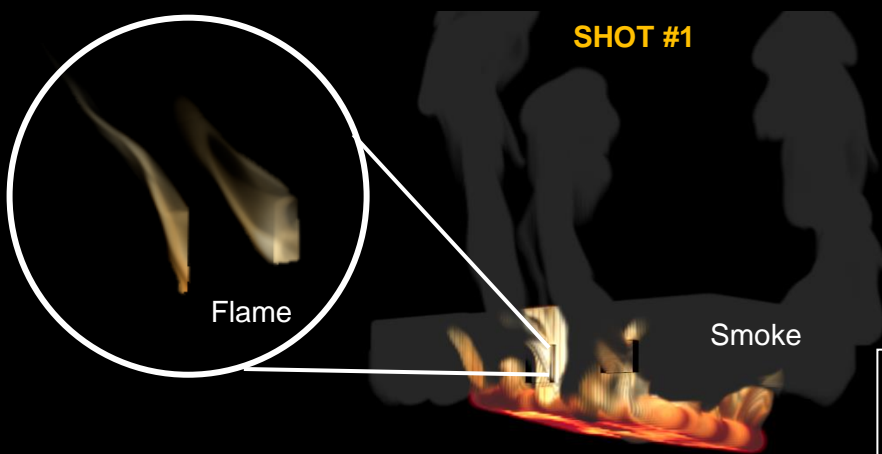
FINAL RESULT

I noticed that during the tracking, the tracker continually lost the object when the arrow was launched in the air so I decided to manually move the arrow across those frames within Houdini. After the test simulation, I noticed the last frame gave me some really weird broken result. Increasing the substep fixed this problem.

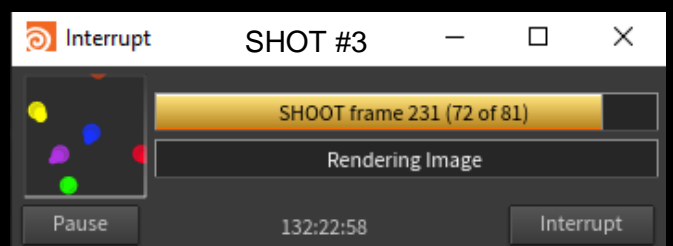
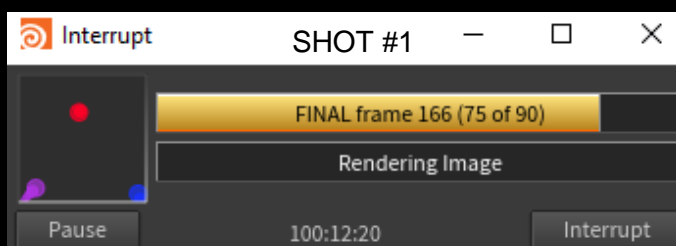
# SIMULATION: LOOK



I and the compositor came to a conclusion that the general look of the fire will be determined by the CG, and other 2D elements will complement the CG flame and smoke; however, if we couldn't find any 2D element that looks close to the CG, the CG will be graded to match the available 2D element. This gave me the creative freedom to make the flame look as I desired; and to that effect, I decided to work with extreme yellowish hot flames, accompanied with dark smoke; using 2013's *'Man of Steel'* and *"Game of Thrones"* as reference.



After rendering shot #1, the compositor came to a creative decision to make the smoke whiter, and change the arrow's smoke, so I applied the changes to shot #3



Despite my effort to reduce render time by increasing the quality of only the fire elements, both shots took about 14 days render time. Unfortunately, I couldn't get Redshift to work, so I rendered over christmas.



# PASSES

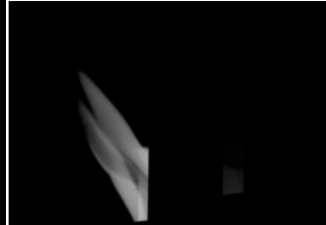
Based on my knowledge in compositing, I was able to anticipate the useful passes for this project – smoke and fire passes. I constantly spoke to the compositor on what special passes is required other than the basic passes. Following the tutorial I found online, I was able to identify the way to kick out the smoke and fire passes respectively, and I also found another tutorial that showed how to create a separate lighting pass, using the fire as a lighting object.



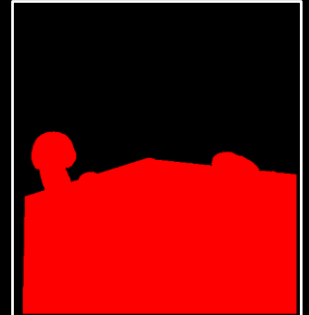
Light Pass (from flame)



Smoke mask



Fire mask



Depth



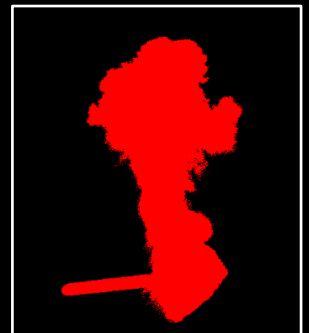
Light Pass (from flame)



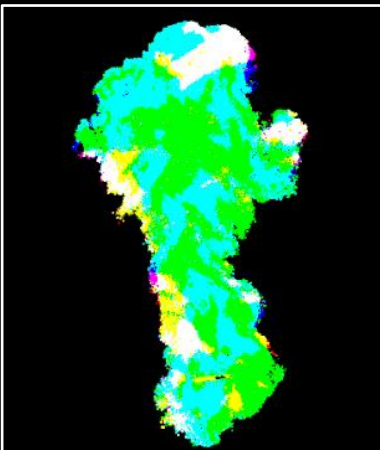
Smoke mask



Fire mask



Depth



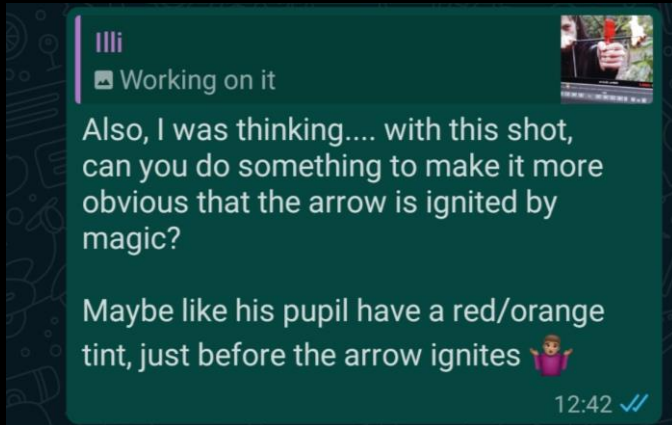
Motion Vector (Sim)



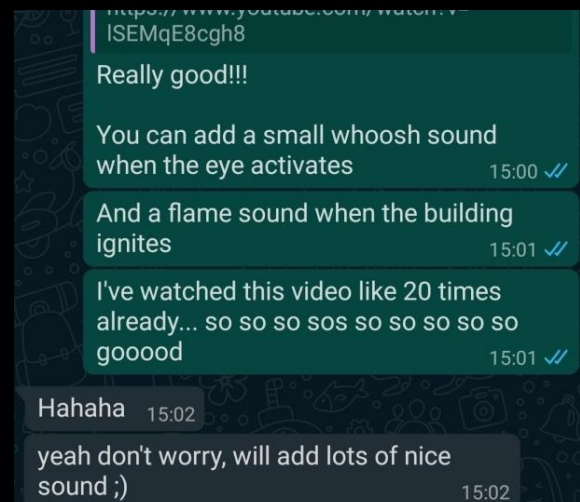
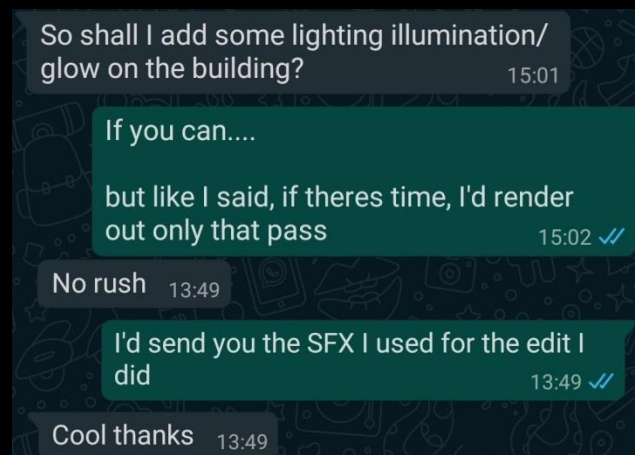
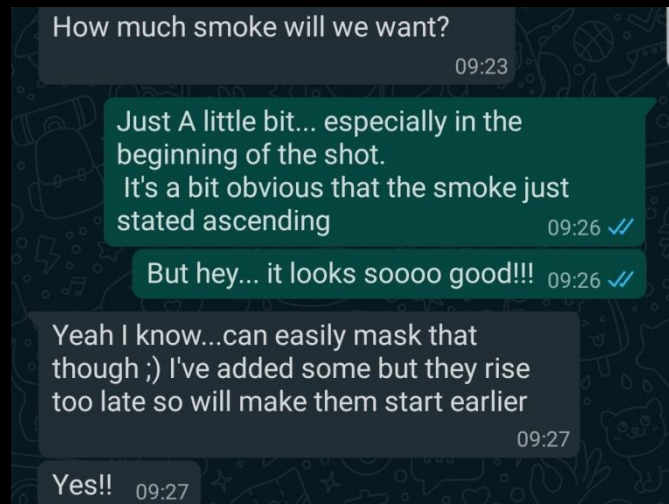
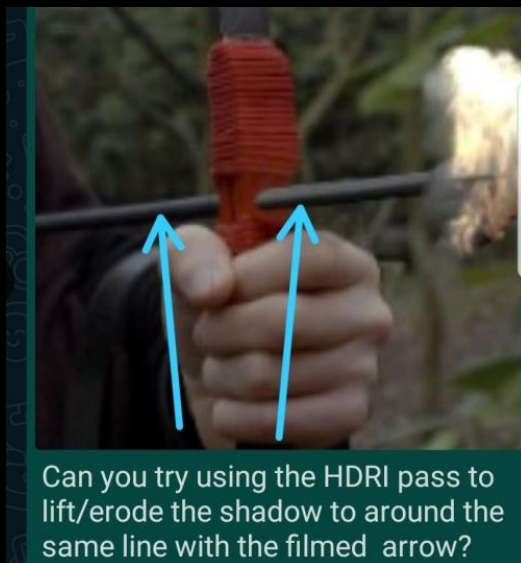
Motion Vector (Arrow)

Based on the fact that the shot #3 had some sort of movement as well as the arrow launching in the air; making obvious shutter copies of the simulation, I decided to kick out extra image planes for the motion pass of both the arrow and the fire simulation (just in case of computing motion blur)

# COMMUNICATION



After finishing my part, I ensured that I constantly kept communicating with my partner; bouncing ideas off each other, and throwing in suggestions in a bid to make the final piece better.





# SELF REFLECTION

This is one of the most successful projects I have done on this course, and it is definitely the one with the least amount of stress involved. This is not the first time I am attempting collaboration, but this is the first time I am having a successful one. I have come to understand that working with a friend does not guarantee success (as I have experienced in the past), but working with someone who is just as committed as you is the ultimate win!

I was able to focus on my part of the job – camera, lighting and FX, being confident that my partner would do same with 2D compositing; we knew each other's strengths and played into it respectively. Also, my basic knowledge of compositing (as well as her basic skill in 3D) was crucial to the success of this project. I filmed in the best possible way to suit us both and Constant communication helped bridge the knowledge gap as we both did our best to make sure it was convenient for the other. We constantly bounced ideas and every decision made was thoroughly talked over from the beginning till the end.

At the start of this work, I had zero idea on how to make a fire simulation; I had contingency plans of rendering over Christmas (which came in handy as I couldn't get Redshit to work and speed up my renders). However, all the commitment paid off.

All I pray for at this point is that in the future, I get to work with more people like Illi Gardner.