



Jungle shot from "Madagascar"

CNM 190, pt 2

Advanced Digital Animation

Lec 03 : Art Direction on Madagascar / Effects 1

Shannon Jeffries, PDI/Dreamworks (Art Director, Madagascar)
 Marilyn Friedman, PDI/Dreamworks (Outreach)
 Dan Garcia, EECS (co-instructor)
 Brian Barsky, EECS (co-instructor)
 Greg Niemeyer, Art (co-instructor)
 Jeremy Huddleston, EECS (TA)
 Ashley Eden, EECS (TA)



Special Effects (SFX) History

en.wikipedia.org/wiki/Special_effects
www.filmsite.org/visualeffects1.html

- The first special effect was done in 1895 who used a dummy to simulate the beheading of Mary Q of Scots!
 - "Stop tricks" like this are still used on YouTube today!
- Used "when scenes can't be realized by normal means"
- In CG animations, very similar case! What's "normal"?



1895: The first SFX!



CGI special effects used in Star Wars Episode III

CNM190, pt 2 Madagascar Art + Effects 1 3/13

Mechanical Effects

en.wikipedia.org/wiki/Special_effects

- Aka "practical" or "physical" effects
 - Used during live shots
- These include
 - Mechanized props
 - Scenery
 - Bullet hits
 - Pyrotechnics
 - Wind, rain, snow, etc
- Outside the scope of this class – Mech E?



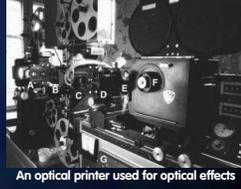
R2D2 is a mechanical special effect

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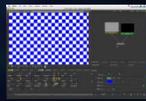
Optical Effects

en.wikipedia.org/wiki/Special_effects, en.wikipedia.org/wiki/Optical_printer

- Aka "visual" (CGI) or "photographic" (optical printer) effects
 - Manipulations of the photographed images
- These include
 - Stop tricks, miniatures, mattes, dolly zoom, bluescreen, wire removal, morphing, match moving, and computer-generated imagery (CGI)



An optical printer used for optical effects



Apple Shake, for compositing CGI SFX

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In purely CG films, what are SFX?

- Typically things that require specific technical attention
- Natural phenomena
 - Smoke, fire, fog, snow
 - Fluids (water, rain, etc)
- Character-related SFX
 - Cloth simulations, hair, fur
 - Footsteps in sand
 - Crowds & mobs
- Often, a problem starts as SFX and evolves into a fool that animators simply use in the pipeline!



CG Smoke by Ron Fedkiw (with Andrew Selle and Nick Rasmussen)

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Fluid Simulation

graphics.stanford.edu/~fedkiw/
www.cs.berkeley.edu/b-cam/

- When to use fluids?
 - Ocean simulation? No! That's easy enough with Perlin noise and waves of different frequencies (called 2D height field simulations)
 - Typically with mediums (fire, smoke, bodies of water with splashiness, fog, snow drifts)
- Fluids interacting with other sims (cloth, other fluids, melting) is hard!



Multiple Interacting Liquids by Ron Fedkiw (w/Frank Losasso, Tamar Shinar & Andrew Selle)

Fedkiw, O'Brien fluid sims

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Fluid Simulation Basics

www.cs.ubc.ca/~rbridson/fluidsimulation/
en.wikipedia.org/wiki/Navier_Stokes

- **Navier-Stokes equations**
 - These describe the motion of fluids (liquids & gases)
 - Derived from conservation of mass, energy, angular momentum & momentum
- **Momentum equation**
 - Really just $F=ma$, in that it tells you how fluid accelerates due to forces acting on it
- **Incompressibility cond.**
 - Fluid volume in = out
- **Advection** is the flow of particles through field u

Momentum equation

$$\frac{\partial \vec{u}}{\partial t} + \vec{u} \cdot \nabla \vec{u} + \frac{1}{\rho} \nabla p = \vec{g} + \nu \nabla^2 \vec{u}$$

Incompressibility condition

$$\nabla \cdot \vec{u} = 0$$

- u is velocity
- ρ is density
 - (water = 1000kg/m³)
- p is pressure
- g is gravity, or "animator"
- ν is kinematic viscosity
 - How viscous is fluid
- ∇p is pressure gradient
- $\nabla \cdot u$ is divergence of velocity

CNM190, pt 2
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8/13

Fluid Simulation Meshes

www.cs.ubc.ca/~rbridson/fluidsimulation/
en.wikipedia.org/wiki/Navier_Stokes

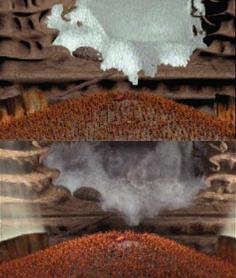
- **Lagrangian viewpoint**
 - Moving mesh
 - World is a particle system
 - Track where particles go
 - "Floating w/wind in balloon"
- **Features**
 - Good for solids
 - Bad for fluids
 - Significant deformation and topology change
- **Eulerian viewpoint**
 - Static mesh
 - Point in space fixed
 - Measure as things go by
 - "On ground, wind blows"
- **Features**
 - Good for fluids
 - Bad for solids
 - Harder to track moving material quantities

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9/13

Particles : cheap & useful!

en.wikipedia.org/wiki/Particle_systems

- **Particle parameters**
 - Spawning rate, angle
 - Initial velocity vector
 - Particle life
 - Color and variations
 - **Should have noise here!**
- **Simulation**
 - Update, Render, repeat
 - Friction, objects, gravity, flows (e.g., vector fields) modify location + velocity
 - Particle-particle collisions usually not checked
 - Particle death (fade $\alpha \rightarrow 0$)



occod.osu.edu/~mpalazzi/AC753W05/Computer%20Graphics%20World%20-%20ANTZ-PIRATION.pdf

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Madagascar Art + Effects 1
10/13

Particles : ...and ubiquitous

www.nextlimit.com/realflow/cs_poseidon.htm

- **Particles used for**
 - Spray, drips, rain
 - surging & pouring water
 - Drips
 - Explosions
- **Particles allow binding!**
 - One can bind anything to a particle, very useful
- **Particles affect the surroundings sometimes**
 - In the shot at the right, water carries objects in the hall
- **Rendering**
 - Metaballs common



CIS Hollywood (small effects house) with early RealFlow rigid body dynamics test



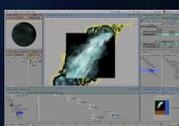
Final composite for Poseidon "Broadway" shot

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11/13

Fluid Simulation Software

www.autodesk.com/maya
www.nextlimit.com/realflow/
www.sidefx.com

- **Maya**
 - (only in Autodesk Maya Unlimited)
 - 2D Solver (height field)
 - 3D Fluid Solver
- **Realflow (RF4)**
 - Python scripting at heart
 - Used in many big films
 - Fluids, surfaces, particles
- **Houdini**
 - Particle motion
 - Fire, white water, insects, crowd sims

Water simulation in Houdini Master

Software Demos

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Madagascar Art + Effects 1


Conclusion

- **Particles and Fluids and a world of effects**
 - Fluid techniques now readily available in today's SW
 - 2D height fields used for simple ponds, oceans
 - If solving fluid problem, Euler solution on fixed grid
 - This is still a very active area of research. It's not solved!



Shot from Madagascar with ocean water effects in the background

CNM190, pt 2
Madagascar Art + Effects 1
13/13