PhysBAM: Physically Based Simulation

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Outline

- The PhysBAM Release
  - What is PhysBAM
  - How to get and use PhysBAM
- Algorithms
  - Levelset
  - Water

Outline

- PhysBAM Overview
- PhysBAM_Tools
- PhysBAM_Geometry
- Running PhysBAM
- Viewing the results
- Make your own simulation

What is PhysBAM?

- Code package used for physical simulation
  - http://physbam.stanford.edu/
- Developed at Stanford
  - Industry Collaboration
- Handles many types of simulations
  - Solids
  - Fluids
  - Coupling

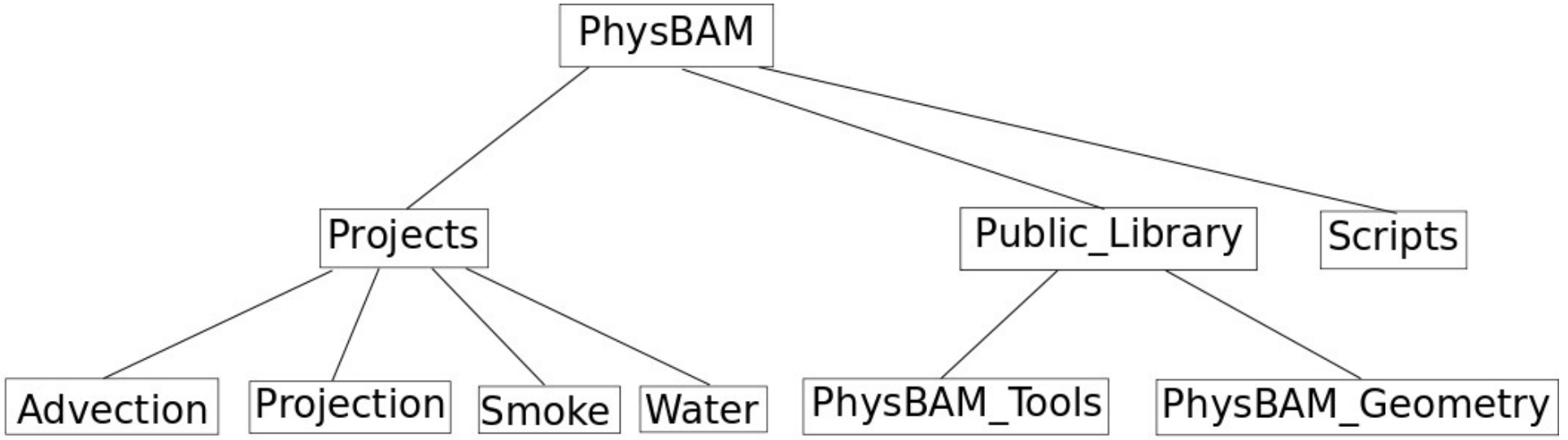
What is PhysBAM?

- Used in a wide range of academic papers
  - [Lentine et al. 2011; Schroeder et al. 2011; Lentine et al. 2011; Kwatra et al. 2010; Lentine et al 2010; etc...]
  - 18 SIGGRAPH Papers, 14 SCA Papers, etc...
- Used in a number of corporations
  - Industrial Light & Magic, Pixar Animation Studios, Walt Disney Animation, Intel Corp.

PhysBAM Release

- PhysBAM Tools was released in the winter
  - Smoke
  - OpenGL
  - Ray Tracing
- PhysBAM Geometry will be released during SIGGRAPH 2011
  - Levelsets
  - Surfaces

PhysBAM Structure



PhysBAM Tools

- Core set of tools for PhysBAM
- Data Structures
  - Arrays, Hashtables
- Math primitives
  - Matrices, Vectors, Quaternions
- Math Tools
  - Linear solvers, Optimization algorithms

PhysBAM Tools

- Core set of tools for PhysBAM
- Simulation objects
  - Grids, Particles
- Simulation algorithms
  - Advection, Interpolation
- Convenience tools
  - Parsing, I/O, Debugging

PhysBAM Geometry

- Builds on the tools library
- Simple primitives
  - Spheres, Boxes, Cylinders
- Meshes
  - Triangulated surfaces, Tetrahedralized volumes
- Acceleration Structures
  - Hierarchies, Partitions

PhysBAM Geometry

- Builds on the tools library
- Extended simulation objects
  - Rigid Bodies, Deformable Objects, Levelsets
- Extended simulation algorithms
  - Rasterization, Intersection, Collision Detection

Downloading PhysBAM

- Downloading the source
  - http://physbam.stanford.edu/
- Required prerequisites
  - GCC 4.5.2
  - Scons
- Optional prerequisites
  - libpng, libjpeg
  - libgl, libglu, libglut
  - libz, libpthread, libmpi

Downloading PhysBAM

- Create directory $PHYSBAM
- Download the library into this directory
- Extract
  - Public_Library
  - Projects
  - Scripts

Compiling PhysBAM

- Use Scons
  - python Scripts/scons/setup_scons.py
  - $PHYSBAM/Sconstruct
  - $PHYSBAM/Sconstruct.options
- Each project has a Sconscript
- scons -Q -u -j #procs CXX=”/usr/bin/g++”

Compiling PhysBAM

- Environment vars
  - PLATFORM=nocona (64bit)
  - PLATFORM=pentium4 (32bit)
- Build options
  - shared
  - shared_objects

Compiling PhysBAM

- Compile Flags
  - Parallelism
    - USE_MPI, USE_LAM, USE_PTHREADS
  - Formats
    - USE_LIBPNG, USE_LIBJPEG, USE_FFMPEG
  - Others
    - USE_FFTW, USE_LIBZ

An Example

- Download the Smoke project
  - http://physbam.stanford.edu/~mlentine/smoke.tar.gz
  - Extract inside $PHYSBAM/Projects
  - Comes with INSTALL file
- cd $PHYSBAM/Projects/Smoke
- scons -Q -u -j 2 CXX=”/usr/bin/g++”
- Creates smoke_{nocona,pentium4}
- Build files are in $PHYSBAM/build

Running PhysBAM

- Usage instructions
  - Projects come with README files
  - -h will display help
  - -scale <int> sets the resolution
  - -2d, -3d sets the dimensions
  - -e <int> sets the last frame
  - -restart <int> sets a frame to start from
  - -substeps <int> outputs data every step

An Example

- ./smoke_pentium4
- Default parameters
  - Resolution is 50x100
    - 3d is 50x100x50
  - Starts from frame 1
  - Ends at frame 100

An Example

- Writes to directory $PHYSBAM/Smoke/output
  - A directory for each frame with frame specific data
    - mac_velocity, density
  - A common directory for all frames
    - grid

Projects

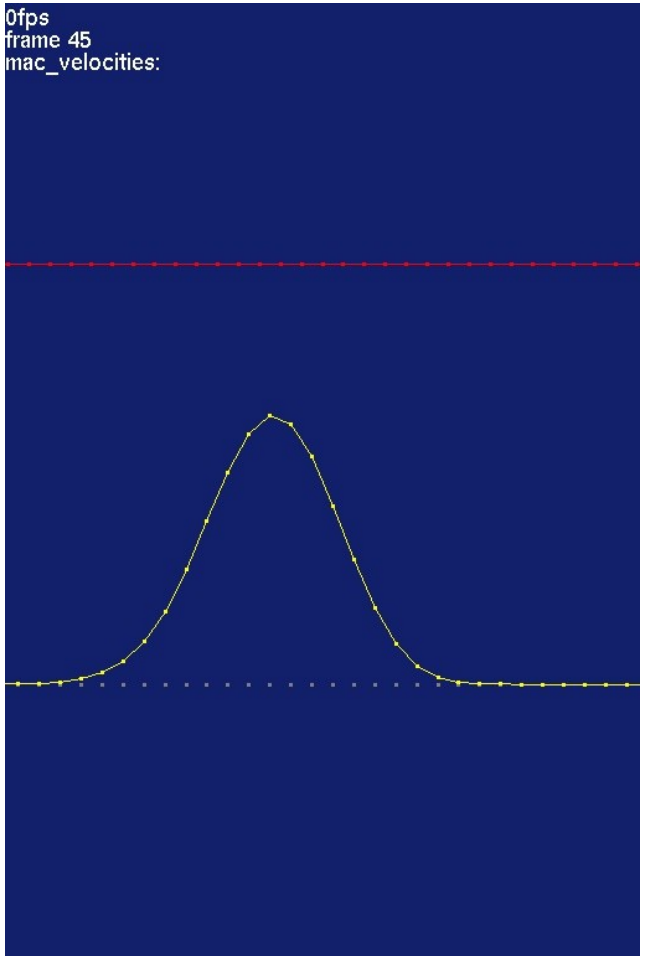
- Tools projects
  - Smoke
  - Projection
  - Advection
- Geometry Projects
  - Water
  - Levelset

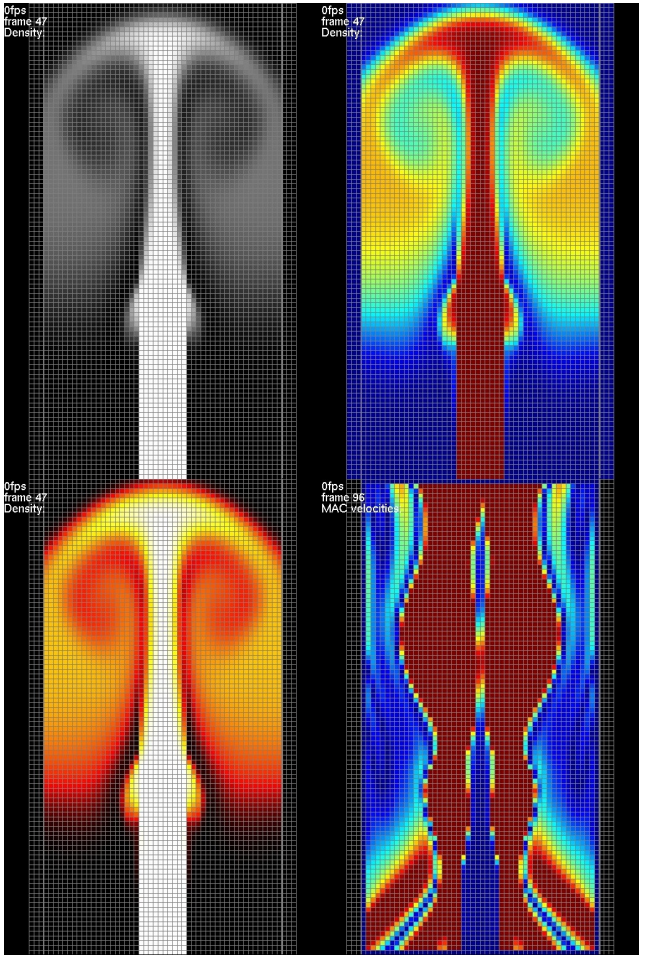
Viewing the Results

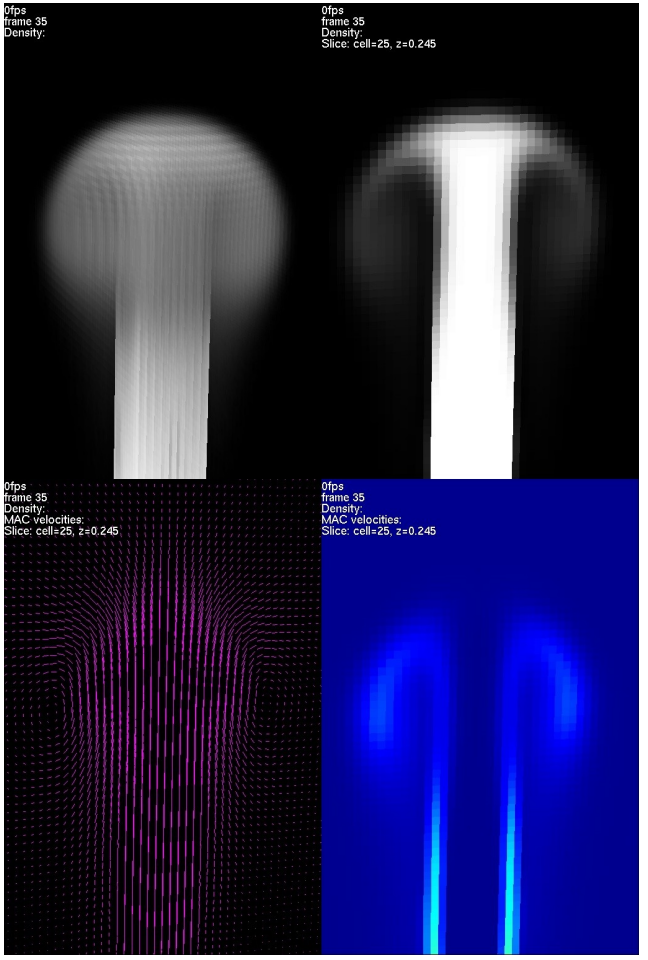
- View the results from the output directory
- Opengl viewers
  - opengl_1d
  - opengl_2d
  - opengl_3d
- Ray tracer
  - Only works in 3d

OpenGL

- Three independent viewers







1D Viewer

2D Viewer

2D Viewer

3D Viewer

3D Viewer

Commands

- Playing
  - “p” play
  - “s” step
  - “ctrl+s” step back
  - “r” restart
  - “z” end
  - “g” goto
  - “ctrl+d” capture*

Commands

- Visualization
  - “V” show velocity
  - “d” show smoke
  - “6” show grid
  - “-” decrease velocity size
  - “=” increase velocity size
  - “ctrl+h” slice mode
  - “[“ and “]” increment and decrement slices
  - “\” change slice axis

An Example

- ./opengl_1d_pentium4
- ./opengl_2d_pentium4
- ./opengl_3d_pentium4
- Takes in directory as argument
  - Use directory $PHYSBAM/Projects/Smoke/output

Ray Tracing

- OpenGL is good for testing/debugging
- Ray tracing produces better results
  - Higher quality images
  - Slower
- Uses a scene file to draw objects

Ray Tracing

Ray Tracing

Scene File

- Set of general options
  - Sky, rays per pixel
- Camera
- Lights
  - Point lights, area lights, spotlights
- Materials
- Shaders

Camera

```
Camera{
   Location=[x y z]
   Look_At=[x y z]
   Pseudo_Up=[x y z]

   Field_Of_View=d
   Focal_Distance=d
   Aspect_Ratio=d

   Width=i
   Height=i
   Output_Filename="str"
}
```

Point Light

```
Light{
   Name="str"
   Type="Point"
   Color=[r g b]
   Position=[x y z]
   Power=i
   Casts_Shadows=b
}
```

Spotlight

```
Light{
   Name="str"
   Type="Spotlight"
   Color=[r g b]
   Position=[x y z]
   Power=i
   Casts_Shadows=b
   Direction=[x y z]
   Cone_Angle=a
   Penumbra_Angle=a
}
```

Scene File

- Simulation objects
  - Deformable bodies
  - Rigid bodies
  - Levelsets
  - Voxel data

Voxel Data

```
Object{
   Name="str"
   Type="Voxel_Data"
   Grid_Filename="output/common/grid"
   Density_Filename="output/%d/density"
   Volume_Shader="SmokeShader"
   Volume_Step=d
}
```

Deformable Object

```
List_Object{
   Name="str"
   Type="Deformable_Object"
   Prefix="simulation/path"
   Shader="Shadername"
   Smooth_Normals=b
   Preserve_Creases=b
   Range=1-5
}
```

Rigid Bodies

```
List_Object{
   Name="str"
   Type="Rigid_Body_List"
   Prefix="simulation/path"
   Shader="ShaderName"
   Smooth_Normals=b
   Subdivide_Geometry=b
   Preserve_Creases=b
   Range=1,3-10
}
```

Scene File

- Other objects
  - Meshes
  - Cylinders
  - Spheres
- Unsimulated objects

Sphere

```
Object{
   Name="str"
   Type="Sphere"
   Position=[x y z]
   Radius=d
   Shader="ShaderName"
}
```

Triangulated Surface

```
Object{
   Name="str"
   Type="Triangulated_Surface"
   Smooth_Normals=b
   Filename="surface.tri.gz"
   Shader="ShaderName"
}
```

Scene File

- Shaders
  - Colors
  - Textures
  - Transparency
  - Reflection
  - Blending

Color Shader

```
Material{
   Name="str"
   Type="Color"
   Color= [r g b]
}
```

Lambertian Shader

```
Material{
   Name="str"
   Type="Lambertian"
   Shader="ShaderName"
   Ambient=[r g b]
   Reflectivity=d
}
```

Phong Shader

```
Material{
   Name="str"
   Type="Phong"
   Shader="ShaderName"
   Diffuse=[r g b]
   Specular=[r g b]
   Specular_Exponent=d
}
```

Voxel Shader

```
Volume_Material{
   Name="SmokeShader"
   Type="Voxel_Shader"
   Absorption=i
   Scattering=i
   Inscattering_Amplification=i
}
```

Transparency and Reflextion

```
Material{
   Name="str"
   Type="Transparent"
   Reflectivity=d
}
```

Blend Shader

```
Material{
   Name="str"
   Type="Blend"
   Shader1="ShaderName1"
   Shader2="ShaderName2"
   Blend_Fraction=d
}
```

An Example

- ./ray_tracing_pentium4 <scene> <frame>
- Use the scene file for smoke
  - Voxel data points to the output directory
  - Output path is relative
- Generates frame.<frame>.png

Make Your Own

- Can now download, run, view data
- Want to change simulation
- PhysBAM structure
  - main.cpp
  - TYPE_EXAMPLE.{h,cpp}
  - TYPE_DRIVER.{h,cpp}

main.cpp

- Parse input
- Creates Example
  - Sets parameters
- Creates Driver
  - Runs simulation

TYPE_EXAMPLE

- Stores Variables
  - Smoke density, velocity
- Adds Callbacks
  - Get_Boundary_Conditions

TYPE_DRIVER

- Executes simulation
  - Advection
  - Forces
  - Projection

How to Add a Sphere

- Files to modify
  - SMOKE_EXAMPLE{.h,.cpp}
- Use a SPHERE<TV> object
- Works with other geometry

How to Add a Sphere

How to Simulate Particles

- Files to modify
  - SMOKE_EXAMPLE{.h,.cpp}
  - SMOKE_DRIVER.cpp
- Stored as an array of positions

How to Modify the viewer

- How to add visualization
- Files to modify
  - main.cpp

  Can use OPENGL_COMPONENTS

How to Add Particles

How to Add Particles

PhysBAM

- PhysBAM is a code package for simulation
  - http://physbam.stanford.edu/
- Tools and Geometry are released
  - Smoke
  - Water
  - Opengl viewing
  - Ray Tracing

Whats Next?

- Portability
  - Tablets, Phones
- Functionality
  - Meshing
  - Rigids
  - Deformables

Thank You!