# Fluid Flow Modelling in Houdini

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**Abstract.** The modern educational environment in the field of physics and information technology ensures the widespread use of visualization software for successful and deep memorization of material. There are many software for creating graphic objects for presentations and demonstrations, the most popular of which were analyzed. The work is devoted to the visualization of liquids with different viscosity parameters. The article describes the development of a fluid model in the form of a particle stream. The proposed methodology involves using the Houdini application to create interactive models. The developed model can be used in the educational process in the field of information technology.

**Keywords:** Fluid Flow, Modelling, Houdini.

## 1 Introduction

Computer graphics today is one of the main directions of information technologies, that develops most stormily. By means of computer graphics it is possible to do visible or visualize such phenomena and processes that cannot be seen in reality, it is possible to create evident character of that in actual fact has (for example, effects of theory of relativity, conformity to law of numerical rows and others like that) unobvious [1; 9].

Scientific visualization that sometimes is briefly named by SciVis is graphic representation of data as to the means for a study and understanding of data. Sometimes such method is named the visual analysis of data. It allows to the researcher to get an idea about the system that is studied, before by impossible methods. Scientific visualization differs from graphic representation. Graphic presentation is created first of all for an information and results transfer by methods that it easily to understand [8]. In scientific visualization prevails aspiration to understand data. However often both methods combine.

In terms of calculations, SciVis is a part of the visualization which includes the research in computer graphics, image processing, high-efficiency calculations and others. SciVis tools can also be used to game design, computer animation, multimedia presentations etc. [5; 6]

## 2 Literature review

Programming tools that allow to create 3D graphic arts, design the virtual reality objects and create the simulated images are very diverse. Firstly, a comparative analysis of the platforms for the creation of AR was carried out. The most popular tools – Autodesk 3ds Max, Autodesk Maya, Blender 2.8 and Houdini – were analyzed (Table 1).

**Table 1.** Comparison of modeling tools

| **Modeling tools** | **Autodesk 3ds Max** | **Autodesk Maya** | **Blender 2.8** | **Houdini** |
|---|---|---|---|---|
| *Developer* | Autodesk | Autodesk | Blender Foundation | Side Effects Software |
| *Operating system* | Windows | Windows, macOS, Linux | Windows, macOS, Linux, Amiga OS, Haiku, Morph OS | Windows, macOS, Linux |
| *Programming languages* | C, C# | C, Maya Embedded Language, Python, C# | Python | C |
| *Features* | 3D modeling, Animation, Rendering software for games, Design visualization | Texturing, 3D Sculpting, Keyframe animation | Procedural Texturing, Scripting, HD-Rendering, Animations, Texturing, Rendering with graphics card, 3D Sculpting, Portable, Customizable, Video overlay, Realistic viewport, Motion tracking, Parametric Modeling, 3d sketching, Real time rendering, Texture painting, Lightweight, Physically-Based Rendering, Compositor, Keyframe animation | Modeling, Terrain, Character, Animation, Solaris: Layout Tools, Solaris: Lookdev & Lighting, Mantra/Karma Rendering, Compositing, Volume, PDG \| Tasks, Pyro FX, Fluids, Rigid Bodies, Particles, Crowds, VELLUM Cloth, Wire Dynamics |
| *Model of pricing* | Subscription | Subscription | Free, Open source | Commercial, free version for students, artists and hobbyists |

Autodesk 3ds Max [3] – professional software for 3D modelling, animation and visualization, which is actively used by game designers. 3ds Max allows to create massive worlds in games, visualize high-quality architectural renderings, model finely detailed interiors and objects, and bring characters and features to life with animation and VFX.

The hundreds of 3ds Max Access plugins uses both direct manipulations and methods of procedural design, and the enormous library of industry leading 3rd-party plugins highly facilitates a design process.

3ds Max offers the professional set of tools. Nevertheless, students can get software free of charge, and a trial version is also accessible in during 30 days.

Autodesk Maya is the 3D graphic arts editor, accessible on Windows, macOS and Linux. Maya gives an industrial power by a concurrent price. Maya is perfect for design, texturizing, illumination and rendering: a large set of functions includes the manipulations particles, hair, fabric, solids, as well as fluid simulations and animations.

Today, Maya is one of the best 3D toolkits at the world market.

Blender 2.8 is a public domain open source computer graphics software of professional functionality. Blender is best in design, texturizing, animation and visualization. The long-awaited version 2.8 provides a modern intuitive interface, interactive real-time reflection with an enormous amount of corrections and new features [2].

Previous Blender versions have often been criticized due to non-friendly to beginners. Especially dissatisfied there were those who switched from other 3D packages (3ds Max, Maya etc.), because the Blender' design principles and hotkeys don't comply with the industrial standards and user expectations.

SideFX Houdini is a professional programmable package to make a 3D graphic art.

Houdini is rather a visual programming environment than classical 3D CAD as mentioned above. Houdini provides to the digital artists a power, flexible, and controlled node-based procedural environment with a lot of industrial-grade visual effects to create high-quality physical 3D animations (Fig. 1). Like Maya and Blender, this powerful and non-standard workflow can be tricky for beginners, so Houdini also provides a set of traditional visual tools [4].

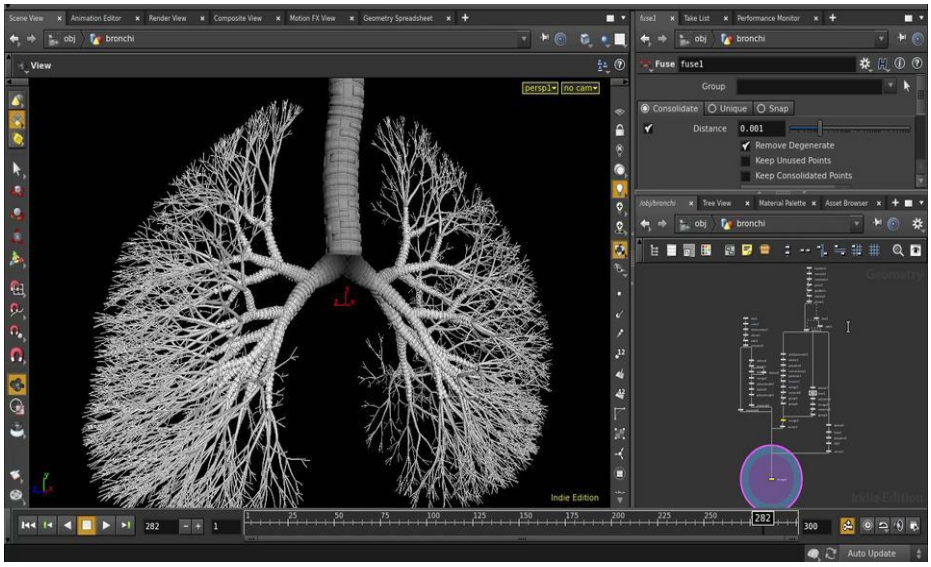



**Fig. 1.** Houdini FX interface

SideFX offers Houdini Apprentice, a free version of Houdini FX, that students, digital artists and amateurs can use for the personal noncommercial projects. Houdini

Apprentice gives access to almost of all Houdini FX features. The full-featured Houdini Indie is an affordable commercial option for small studios.

Houdini is mainly used for realistic physical simulations (e.g. particles dynamics), procedural modeling, animation, effects, rendering, and compositing.

To work with Houdini, you need to understand the basic principles of procedural modeling – a number of computer graphics methods for creating 3D models and textures. Procedural modeling is often used to create 3D models of complex shapes (plants, architecture building).

With the features provided by Houdini, you can build models, objects, simulations and customize them, and test their performance by running and testing simulations directly in the Houdini editor.

## 3 Results

We made the simulation of liquid streams (fluid flows) in Houdini. First you had to create an object that will be the source of stream. We chose a sphere primitive and added node transforms that allow you to change such sphere parameters as size and position (Fig. 2).

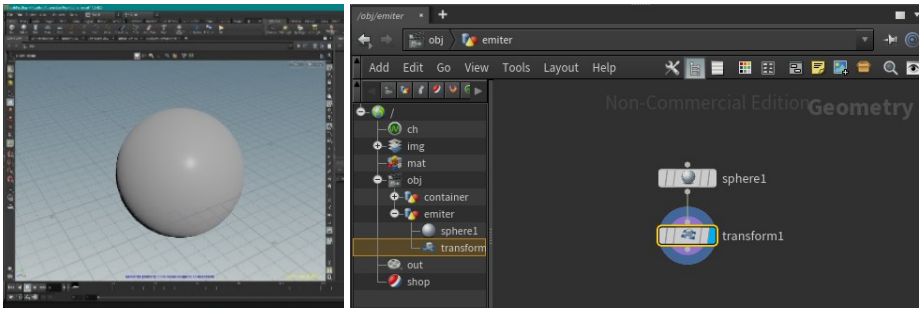



**Fig. 2.** Sphere and its node transform

In order to visualize how a liquid with different viscosities will flow down over surfaces, it is necessary to add another object that will simulate such a surface (Fig. 3).

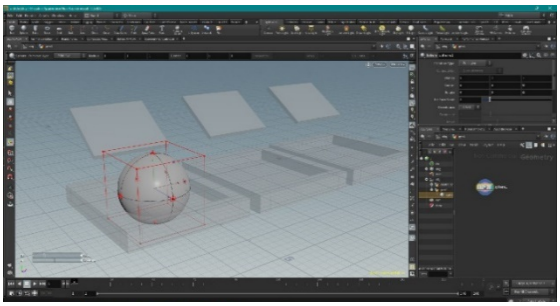


**Fig. 3.** Object with inclined surface and container

Then we changed the size and position of sphere by node transforms so that the sphere is above an inclined surface (Fig. 4).

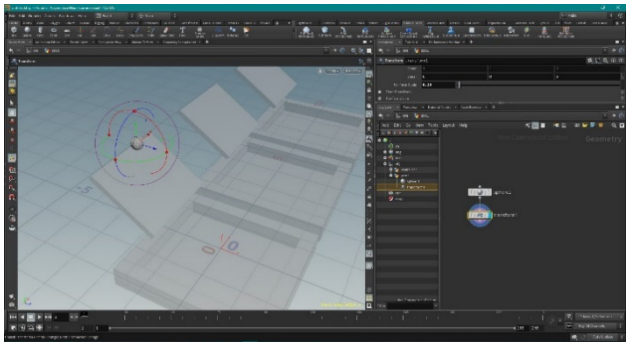


**Fig. 4.** Placing a sphere above the surface

To add to the sphere properties a source of the node particles, which will simualte the liquid stream, we used flipsource nodes and DOP Network (Fig. 5).

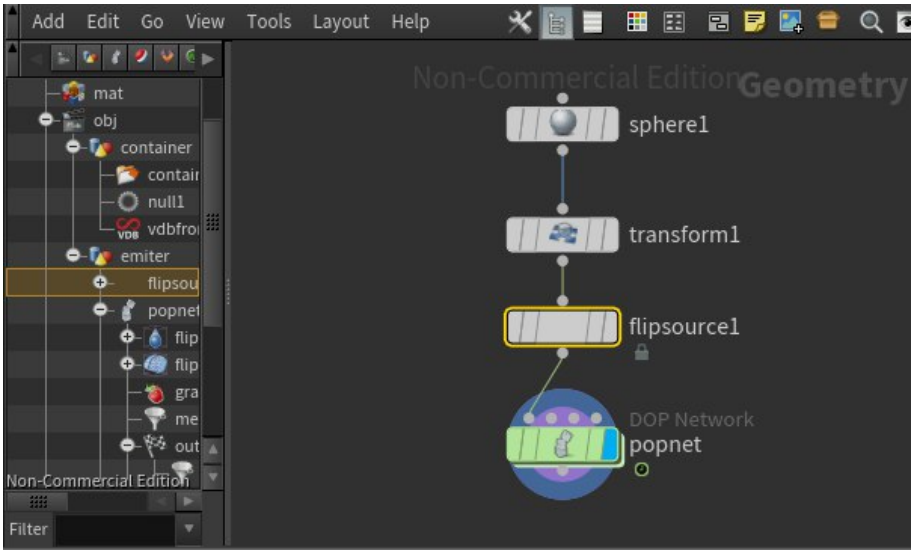



**Fig. 5.** flipsource nodes and DOP Network

The DOP Network node contains another network of nodes (flipsolver), which is responsible for creating particles (Fig. 6).

After connecting the flipsolver network to the sphere, you can see a cloud of particles formed around the sphere only (Fig. 7). In order to imitate the fluid flow behavior, it is necessary to connect the flipsolver network to the gravity node. This will cause particles to fall vertically down (Fig. 8 a). Starting the simulation, you can see that particles behavior will be similar to liquid stream behavior (Fig. 8 b).

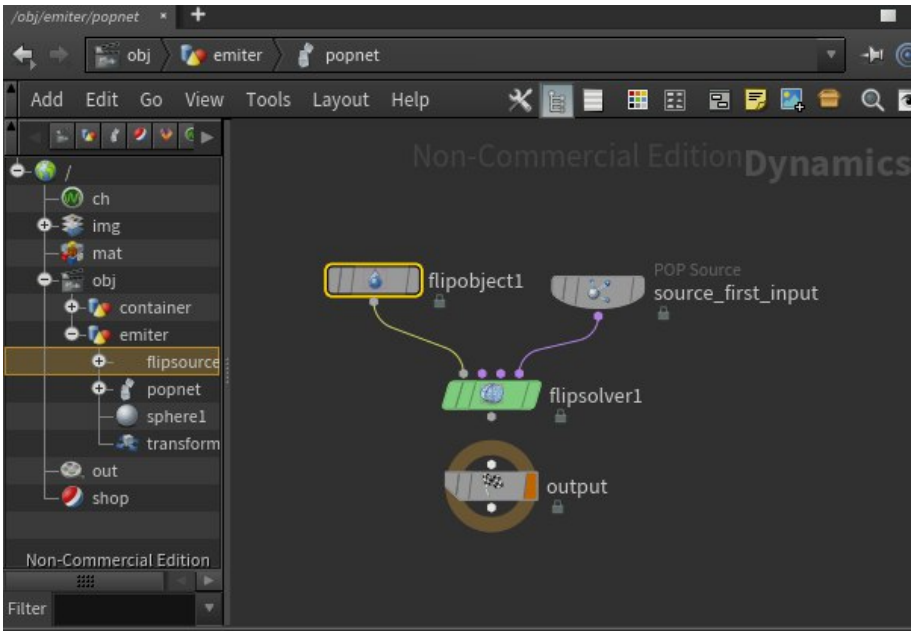



**Fig. 6.** flipsolver network

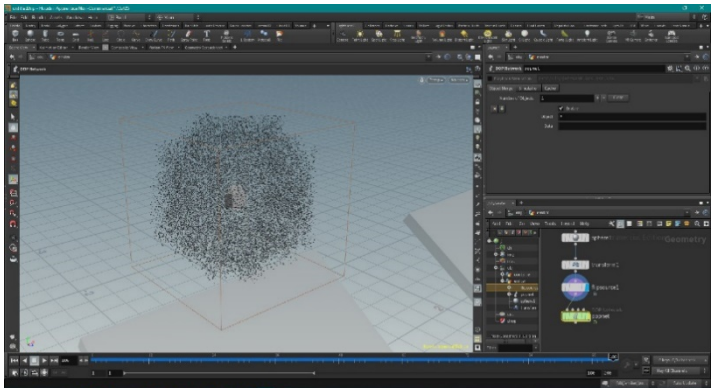
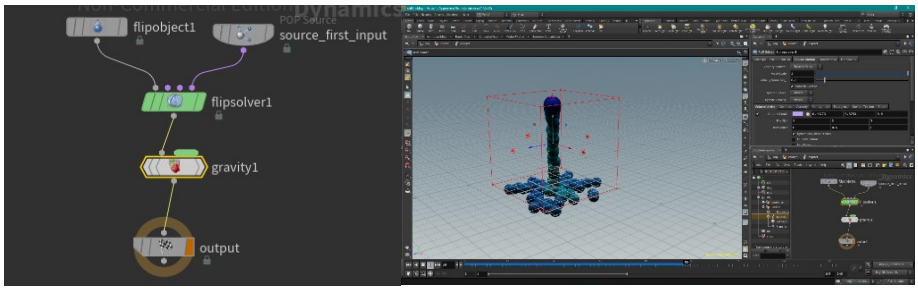


**Fig. 7.** The result of the flipsolver network action to the sphere

But now the particles only fall down within a given area and do not interact with a surface that was added before anyway. To enable the fluid-surface interaction, it is necessary to add a static object to the flipsolver network, namely staticobject and staticsolver nodes (Fig. 9).

Starting new simulation, you can see the physically correct fall of the particles, and how they flow from an inclined surface into the container (Fig. 10). At this stage, the particle stream simulates a liquid without viscosity, temperature or density. You can add these properties in the flipsolver network settings window. We set the Viscosity parameter to 100 (Fig. 11).




a b

**Fig. 8.** Gravity node (a) and its action (b)

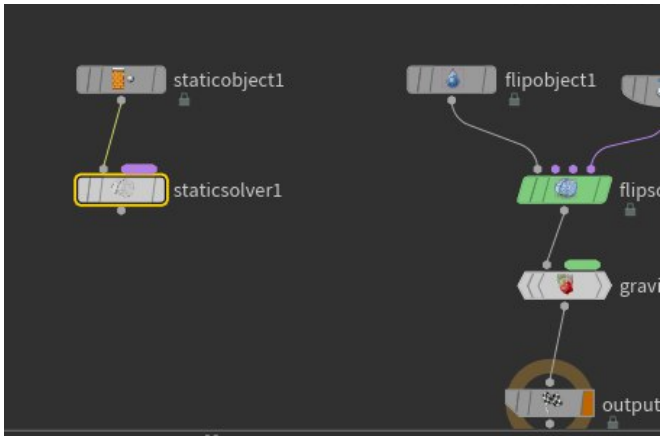



**Fig. 9.** staticobject and staticsolver nodes

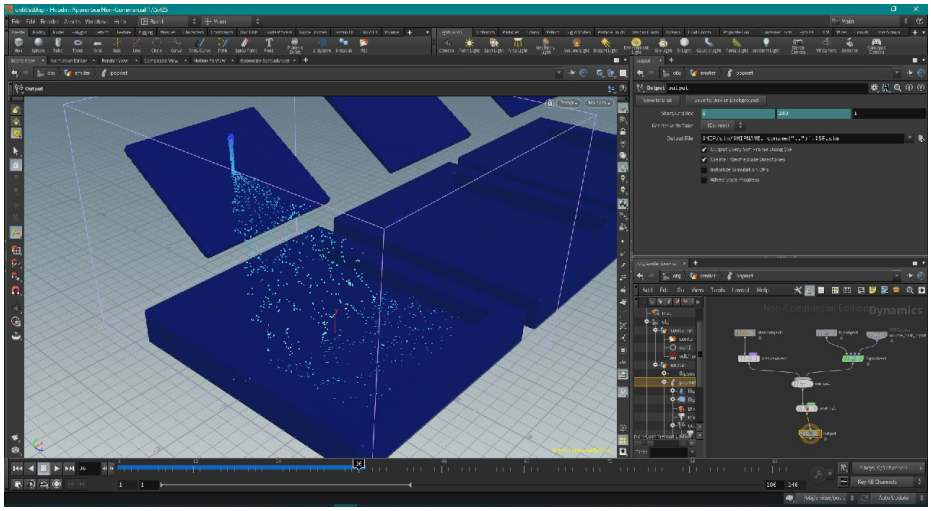


**Fig. 10.** Particle flow simulation

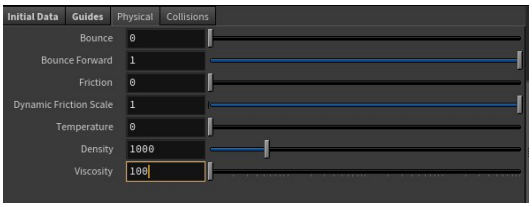



**Fig. 11.** Fluid physical parameter settings window

Running simulation again, you can see how the Viscosity parameter affects the fluid flow behavior. The stream flows from the surface much slower and looks like a viscous substance such as honey (Fig. 12).

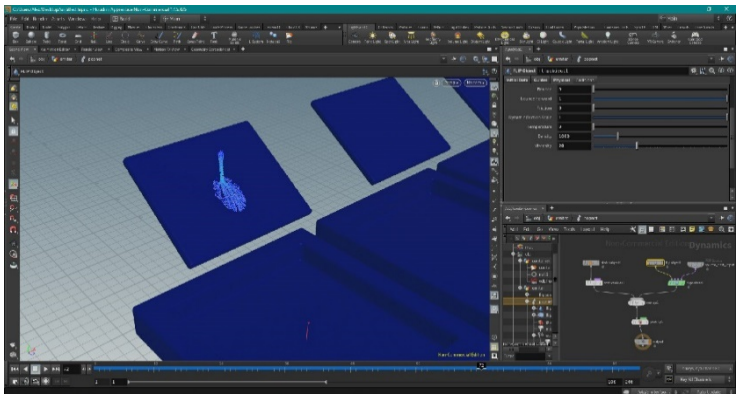


**Fig. 12.** A simulation of particles stream with the non-zero viscosity parameter

The behavior of liquids with different viscosity is shown on Figure 13.

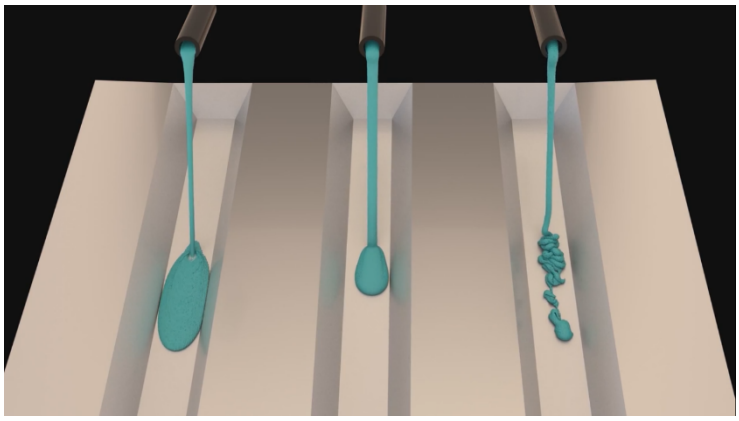


**Fig. 13.** Modelling liquids with different viscosity

## 4 Conclusions

1. The use of programmable environments like Houdine to create physically correct 3D models has a deep impact on both the science education and CS education. This makes learning visual and fun. Using the proposed software and the implemented models to make the simulated animations is more effective than using traditional experiments and pre-recorded video.
2. Learning using interactive 3D models in a mixed environment can be useful for a deeper understanding of the simulated processes, so our further research will be on the VR/AR using to facilitate training the bachelors majoring in CS.

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