2D Fluid Dynamics Simulator
Software Requirements Specification

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Revision History

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9/21/2015	Started document	Michael Chase Bonifant	Made doc in google docs, shared with team.
9/22/2015	Initial Draft	Michael Chase Bonifant	Created first draft filling in most sections.
9/22/2015	Intro and page numbing	Ayam Almusalam	Wrote introduction and corrected page numbering in table of content.
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Document Approval

The following Software Requirements Specification has been accepted and approved by the following:

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Contents

1 Introduction

1.1 Purpose

The purpose of this document is to present the specifications and requirements of the 2-D Fluid Dynamics Simulator system. It will explain the purpose and features of the application, the interface of the application, what the application will do. This document is intended for both the stakeholders and the developers of the system.

1.2 Scope

The single software product to be produces is the 2D Fluid Dynamics Simulator system. The system will provide simulations for single fluids in a configurable simulation/virtual chamber. It will show in 2D the flow density of the fluid being simulated and allow the user to specify basic environmental factors about the simulated environment like. obstructions in the chamber and the viscosity of the fluid being simulated.

This tool will be beneficial as a learning tool for introducing students to fluid dynamics. It will not be useful in simulating large scale fluid systems (for instance, the flow pattern of run off from rain over a textured surface, the human circulatory system, or a city sewer system).

1.3 Definitions, Acronyms, and Abbreviations

Navier-Stokes Equations(NSE) Equations that apply Newton's second law of motion to fluids (that is F=ma, force is mass times acceleration).

Lattice Boltzmann Methods(LBM) A class of computational fluid dynamcs methods used in fluid simulation from which the Navier-Stokes equations can be derived.

Chamber when used in this document chamber refers to the simulated container that the fluid dynamics are being simulated inside of.

System when used in this document refers to the deliverable end product, the 2D Fluid Dynamics Simulator.

1.4 References

There are currently no references for this document.

1.5 Overview

The following sections of this document detail the system in a mile-high description sch as might relate to a sales pitch and explaining the system to a layman (section 2), the fine grained system requirements from which developers should be able to build their own version of the system (section 3), detailed descriptions of analysis models used elsewhere referentially (section 4) and additional appendices.

2 General Description

2.1 Product Perspective

This system will serve as a self-contained desktop application for simulating 2-D fluid dynamics. It should be a simple, intuitive tool that allows users to configure a chamber filling or filled with fluid, vary environmental factors(e.g. obstructions in the chamber, temperature, viscosity), then apply a force vector to disturb the fluid and show a simulation of that force's effect on the fluid.

2.2 Product Functions

The system allows the user to create a simulation chamber for testing what happens when a force vector is applied to a fluid filling that chamber. As such the system allows users to select a fluid and a force vector. Additionally they can set environmental variables such as the temperature among others (see section 3.2.2 for a full listing of configurable variables). The user can also create within the chamber any number of physical obstructions the fluid can potentially rebound against and flow around.

The user can then set monitors at various points in the chamber. Once the chamber is fully configured the user can launch the simulation and run it until they choose to terminate the simulation. The simulation runs showing a visual display of the created chamber and also provides a textual print out at the state of the simulation at all break points.

From the textual print out the user will be able to reload the simulation and replay the simulation.

2.3 User Characteristics

There's only one user type for this system. The generic person who wants to run a fluid simulation, be that out of curiosity or some sort of coercion (such as a grade school teacher saying the user's grade depends on using the system).

2.4 General Constraints

The main constraints are the system must be a desktop application, and it must run on either Linux or Windows. Beyond that the simulation must be based on either the LBM or NSE.

2.5 Assumptions and Dependencies

Its assumed the system will be run on hardware supporting the operating system the designer chooses to develop the system for.

3 Specific Requirements

3.1 External Interface Requirements

3.1.1 User Intrafaces

The user interface GUI shall be user friendly and provide an animation of the simulation being run.

3.1.2 Hardware Interfaces

The system has no hardware interface requirements.

3.1.3 Software Interfaces

The system has no software interface requirements.

3.1.4 Communications Interfaces

The system has no communications interfaces, it works as a self-contained application.

3.2 Functional Requirements

3.2.1 2D Fluid Simulation

Introduction

The system shall visualize flow density dynamically.

Inputs

The system takes as input a single user selected fluid (see 3.2.3), physical parameters (see 3.2.2), break points (see 3.2.6), and a spatial configuration of the simulation (see 3.2.4).

Processing

The system must use the given inputs to simulate the flow density via either the LBM or NSE. The fluid will never overflow the simulation chamber. Visualization will always be from a top down/floor plan point of view. Gravity if relevant to the LBM or NSE is constant and considered the average measurement of gravity near the surface of the earth.

Outputs

Animated and textual feedback pertaining to the flow density as time progresses from the initial state specified by the input parameters. This feedback is constantly updated step by step until the the user chooses to stop execution.

Error Handling

There is no error handling specified.

3.2.2 Physical Parameters

Introduction

The system shall allow the user control in varying the viscosity, temperature, initial steady state flow speed, and perturbation force of the simulation.

Inputs

The viscosity, temperature (from a range of -100C to 100C), flowspeed, and perturbation force vector. There is no specification as to how these are to be obtained

Processing

The ere is no specification to how this data need be processed beyond it must be utilized in the calculations of the fluid flow density with the NSE or LBM.

Outputs

There is no specification as to the output beyond that they must be used in calculating the flow density of the fluid being simulated, and should be somehow incorporated into the textual feedback of the simulation so that the simulation could take that text and reproduce the simulation exactly.

Error Handling

There is no error handling specified.

3.2.3 Fluid Selections

Introduction

The system shall provide simulations for water and glycerin.

Inputs

The user's selection of water or glycerin.

Processing

The system must track the fluid's change in flow density using either NSE or LBM.

Outputs

The user should get visual feedback of what's happening in the simulation chamber and also textual output.

Error Handling

There is no error handling specified.

3.2.4 Spatial Configuration

Introduction

User shall be able to define rectangular boxes and elliptic cylinders as obstructions to the fluid's flow in the simulation chamber. the chamber itself will be rectangular visual from above, though it may have rounded sides, this curving is also configurable.

Inputs

There is no specification as to how these shapes are to be retrieved from the user and configured in the simulation.

Processing

Beyond the fact that the simulation must account for their existence and adjust the flow of the fluid accordingly with NSE or LBM the simulation may ignore the edge cases where the fluid hits sharp well defined cusps.

Additionally all obstructions span from the floor of the chamber to the roof and considered immutable (i.e. the fluid cannot create such a force as to break the obstructions or move them). Lastly the chamber can be on a scale ranging from centimeters in size to meters.

Outputs

There is no specification as to how these obstructions or chamber shape are to be shown as output, beyond that there must be some animated feedback in the GUI and human readable textual output.

Error Handling

Objects with cusps cannot be oriented so the fluid hits the cusp head one.

3.2.5 On Demand Feedback

Introduction

The system shall be able to provide on-demand information about flow values.

Inputs

The user can select any point in the simulation chamber and immediately get feed back as to the flow values of that location in the simulation immediately.

Processing

There is no specification to the process this need be implemented by, beyond the returned values must agree with either the LBM or NSE.

Outputs

The flow density at all points needs to be visualized in animation and text already, requesting this feedback is merely highlighting the textual output for the selected region.

Error Handling

There is no error handling specified.

3.2.6 Monitoring Points

Introduction

The user shall be able to select monitoring points in the simulation (flow meters) to show information during execution without affecting the flow of the fluid.

Inputs

There is no specification as to how there flow meters be obtained, beyond the user must provide them.

Processing

There is no specification as to how these flow meters need to be implemented beyond that their output must agree with either the LBM or NSE.

Outputs

Textual feedback of the flow density at the specified locations in the simulation.

Error Handling

There is no specification for error handling.

3.2.7 Clear Start and End of Simulation

Introduction

The system shall indicate clearly when a simulation begins and terminates.

Inputs

The user selects when to start the simulation and when to terminate it. There is no specification as to how this information is to be selected, beyond once it starts the user can terminate the program at any moment.

Processing

There is no specification as to how this is to be implemented.

Outputs

Clear animated and textual feedback that the simulation has started and terminated.

Error Handling

There is no specification for error handling.

3.2.8 Textual Logging

Introduction

The system shall provide a detailed log of the execution of the simulation so that the user can go back through a text file and trace the execution of the program.

Inputs

There is no specification as to inputs, (but presumably a name for each simulation to attribute to the generated text file is required).

Processing

There is no specification as to how the text is to be generated or worded, beyond it must provide feedback for all marked flow meters, and the system as a whole.

Outputs

A text file containing a trace of the execution of the simulation.

Error Handling

There is no specification for error handling.

3.2.9 Instant Replay

Introduction

The system shall allow the user to replay any simulation by reloading the simulation from its generated textual log file.

Inputs

The selected log file, there is no specification as to how this file be obtained.

Processing

The system must load the log file and execute reproducing the original simulation exactly.

Outputs

Animated and textual feedback about the simulation, the simulation should be identical to the original.

Error Handling

There is no specification for error handling.

3.3 Use Cases

3.3.1 Filling a Chamber

The system will allow the user to simulate a fluid filling the chamber from empty until it is full. In this case the flow rate of fluid into the chamber must be constant.

3.3.2 Perturbing a Chamber

The system will allow the user to simulate a single force perturbing the fluid in the chamber. This force cannot be applied from a corner of the chamber, only from one of its sides.

3.3.3 Draining a Chamber

The system will allow the user to an exit way for the chamber.

3.4 Classes/Objects

There are no class/object requirements.

3.5 Non-Functional Requirements

3.5.1 Performance

1. The system overall shall produce results accurate to the 4th decimal place.

2. The system shall produce results in metric units.

3.5.2 Reliability

There are no reliability specifications.

3.5.3 Availability

The system is to be available as a on-demand desktop applications.

There is no specification for recovery should the application fail.

3.5.4 Security

There are no security specifications.

3.5.5 Maintainability

1. The system shall be designed so that the GUI and simulation engine can be fully decoupled and swapped out with other GUIs and engines.

2. Distributions of the software shall include the source code.

3. Distributions of the software shall include compilation instructions.

4. Distributions of the software shall include a list of dependencies.

5. Distributions of the software shall include either an installer or installation script.

6. Distributions of the software shall include all generated document artifacts during the engineering life cycle.

7. Distributions of the software shall include an installation guide.

8. Distributions of the software shall include a user guide with screen shots.

9. Distributions of the software shall include a programmer's guide.

10. All generated documents shall be typed and electronically generated.

3.5.6 Portability

1. The system must work on either a Windows or Linux operating system, with no expectation that it be portable from it original target operating system.

3.6 Inverse Requirements

1. The application does not simulate multiple fluids interacting, diffusing or mixing in any way, only one fluid is simulated at a time.

2. The application only simulates a single perturbing force from a wall (not corners/cusps), if a fluid is filling the chamber, that fluid is already providing the perturbing force, so a second is not specifiable. This is also true if the chamber is draining.

3.7 Design Constraints

1. The system shall simulate fluid dynamics using either NSE or LBM.

2. The system must be an installed desktop application for either a Linux or Windows environment.

3. The system must be released under GNU GPL3 licensing.

4. The system may optionally include ONE third party component with the customer's approval of the component.

3.8 Logical Database Requirements

There is no requirement that a database be used.

3.9 Other Requirements

There are no other known requirements.

4 Analysis Methods

4.1 Sequence Diagrams

There are currently no sequence diagrams.

4.2 Data Flow Diagrams (DFD)

There are currently no data flow diagrams

4.3 State-Transition Diagrams (STD)

There are currently no state-transition diagrams.

5 Change Management Process

All documents, source files, and additional project artifacts are stored on a github repository: https://github.com/mBonifant/Fluid2D

6 Appendices

There are presently no appendices.