West Science Information System and Technology
Vol. 1, No. 01, August 2023, pp. 44~54

Fire Suppression Simulation Application Development Stereo Graphics Based (Virtual Reality)

Windarko
Universitas Pembangunan Jaya

Article Info

Article history:

Received August 2023
Revised August 2023
Accepted August 2023

Keywords:

Virtual Reality
C++
Stereo Display

ABSTRACT

Modern man today is very dependent on his life with computers. Because with the help of computer technology can ease their task. A computer can create a situation similar to the original. This technology is commonly called simulation. Serious simulations depict a system that is difficult to perform in the real world and is at high risk. These serious simulations are usually much more developed in the making. This development technology is called Virtual Reality (VR). Virtual Reality (VR) is a development of stereo display techniques. Where users can see an object with dimensional depth that will give a 3D effect on the human brain. Based on the background above, the author tries to implement stereo displays in firefighting simulation (FFS) applications. The simulation engine used is Open Scene Graph with Microsoft Visual Studio 2008 compiler, which uses the C++ programming language. The GUI display design uses Qt 4.7.3. Users will try the stereo display effect in the FFS application and interact between the fire particle system and the water particle system to compare factors that cause fire particle system outages. Of all the implementations and trials carried out, the author succeeded in implementing stereoscopic fire suppression simulation applications. Because all objects in this application already have a red shadow for the left side of the thing and a blue shadow for the right side. The interaction between the user and the fire suppression simulation application was also successfully displayed in this Fire Fighting Simulation (FFS) application. The fire particle system will be extinguished if the user performs fire suppression interactions.

Corresponding Author:

Name: Windarko
Institution: Universitas Pembangunan Jaya
Email: win.darko@upj.ac.id

1. INTRODUCTION

Modern man today is very dependent on his life with computers. Because with the help of computer technology can ease their task. Starting from the sophistication of a computer, it can create, store, and even edit writing in various formats. In the days before there were computers, many people used typewriters to make a letter or write printed letters on a piece of paper. Until a computer can create a situation similar to the original, this technology is commonly called simulation.

Simulation in the computer world is a picture made so the user can see the actual event's effects, elements, and properties.

Many people make fun of simulations, or usually people say Video Games. This video game has experienced a very rapid development along with the development of computer hardware technology itself. An example of this entertaining and very popular simulation is the Football Game. All the instruments are very similar to the original. Starting with the rules that correspond to the actual match until the texture of the appearance of the Field, Ball, Spectators, and Players is very similar to the original. So, it spoils the connoisseurs.

Serious simulations are created to depict a system that is difficult to perform in the real world and is at high risk. These serious simulations include simulations of chemical mixing, aircraft flight, bomb handling, fire suppression, weather calculations/forecasts, and much more. These serious simulations are usually much more developed in the making. This development technology is called Virtual Reality (VR).

This VR plays a role in displaying the authentic atmosphere as desired by the user but not actually. VR is used for simulations that do not allow for actual practice. These VR applications include Ergonomic Analysis Applications, Building Design, Training (Pilot, Driver, Asrtonot, Surgery, Firefighting), Galaxy Configuration, etc. For example, its application is in Fire Fighting Applications. The doctor/user will see a pseudo-world, which is actually in the form of dynamic images. Through VR devices, users will feel sound, vibration, touch, and all physical and psychological events.

Referring to Virtual Reality earlier, the author tried to reveal the initial technology of VR, which is now widespread in cinema. That technology seems to be able to display objects on a screen in the real world. This technology is called Stereoscopy, and in cinema, this technology is known by the name 3D Movie. To look more at Virtual Reality, the author will use a simulation, namely Fire Fighting Simulation.

Based on all the background above, a problem arises. How to make a Stereo Display implemented in Fire Suppression Simulation. Therefore, the author titled this scientific paper "Development of Fire Suppression Simulation Applications Based on Stereo Graphics."

2. LITERATURE REVIEW

2.1 Chart Definition

Many notions are associated with this chart. According to the Big Indonesian Dictionary (KBBI), graphics mean painting the ebb and flow of a state with lines or pictures. Graphs can also be interpreted as image mapping in abscissa and ordinate format or x and y (two-dimensional). Graphics in this study are related to stereographs or images/images in stereo form. So that the graph here can be defined as a picture and other imaging produced by the computer can form lines, curves, curves, and so on mapped in 2-dimensional (x,y) or 3-dimensional (x,y,z) coordinates [17].

2.2 Particle System

Particle System or Particle System models fuzzy objects like fire, water, clouds, and smoke. Particle systems do not have clearly defined surfaces because particle systems are not static objects but dynamic objects that can also be likened to liquids.

2.2.1 Basic Model of Particle System

A particle system is a collection of many minute particles modeled by several objects. For each frame of the animation sequence, the following steps are performed:

1) New particles produced
2) Each new particle is assigned its own set of attributes
3) Each particle has a predetermined time for its destruction
4) The remaining particles are transformed and moved according to dynamic properties
5) A particle image was created from the remnants of the particle.

Since the creation and attributes of particles are procedural, this can result from other calculations, for example, from science or engineering [3].

2.2.2 Particle Attribute

Each new particle has the following attributes:

1) **Initial position**

This position is mapped in the three-dimensional plane X, Y, Z. This position is the central point of the source of exit of the particle system.

2) **Initial speed (speed and direction)**

Each particle movement of a particle system has an initial velocity that determines how fast this particle is moving and the direction in which this particle is moving.

3) **Initial size**

This site is divided into 2, namely minimum and maximum. The difference is that the minimum value is used to determine the magnitude of the particle when it was first created or came out. The maximum value helps determine the extent of the particle when it reaches the last moments of the active / life of this particle. The size will change in a degraded manner according to the minimum and maximum determination. If the minimum value is more significant, the particle system will look like a purse, and vice versa.

4) **Color**

This variable will determine the type of this particle. Because by changing the color of the particles, the particle system will change its name. Suppose the particle system is colored orange. Then, the particle system will look like fire. If given a white color, this particle system will resemble water, or it can also resemble smoke from a fire.

5) **Mass (Weight)**

The weight of each particle will affect the speed of movement of the particle system. The magnitude of this weight value will apply if the gravity value is 0 (null), which will cause the particle to move upwards (positive Z-axis).

6) **Shape**

These particles are squares, dots, hexagons, and lines. This shape also affects what this particle system will look like.

7) **Masa was alive/active.**

This variable plays a role in determining the form and sustainability of the particle system. Because particles will continue to be regenerated continuously, if the life span is infinite, then the particle will continue to live/exist, so that it can cause out of memory on the computer's operating system. Eventually, the computer will become slow in performance, and it can even "hang" or crash.

For more details about how this particle system works, here is a more detailed explanation. A particle system has several parameters that control the initial position of the particles:

1) X, Y, Z (origin of particle system)
2) Two angles of rotation that provide orientation
3) A generational form that defines the region around the origin where the new particle is placed, for example, a ball of radius R. These shapes can be simple or very complicated.

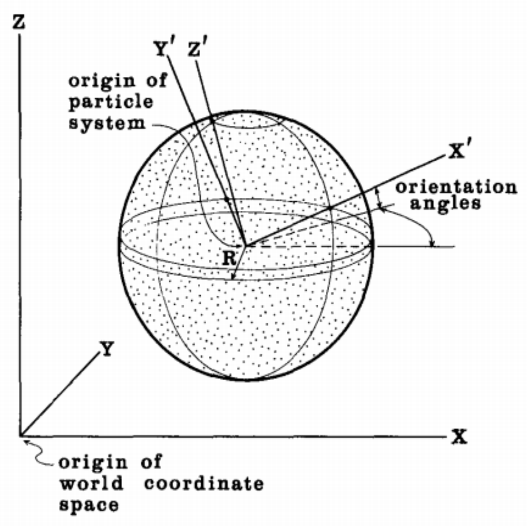


Figure 2.1 shows a typical particle system with spherical form generation [3]

2.3 Stereoscopy

Stereoscopic, commonly referred to as Stereoscopic, is a technique to represent three-dimensional objects using two images taken from the perspective of the right eye and left eye of the observer, then combined with the observer's perception to bring out the level of depth of the object [19]. This method does not produce an accurate three-dimensional image. Still, it has a three-dimensional effect due to the difference in the view of each eye in seeing the picture to display the level of depth. And this effect will be Tamil or mapped to our brain.

Stereoscopic vision is also part of the virtual reality system, where the wearer can pass through the view and interact with his environment. The headset used is an optical system that produces stereoscopic views.[4]

A very simple or traditional stereoscopic method is the Side-by-Side method. A 2D image or object will be made into two images strictly following each other, namely the right and left sides. Then, with stereoscopic techniques, the two images are combined in one idea with properties by the character of their respective stereoscopic methods [2].

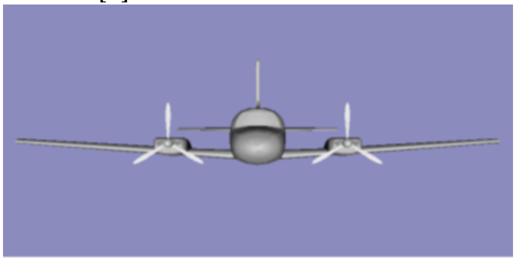


Figure 2.2 Original 2D image [6]

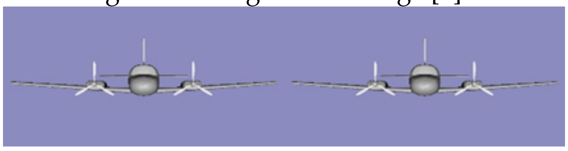


Figure 2.3 Images that have become SBS (Side by side) [2]

2.3.1 Anaglyph Technique

The Anaglyph technique is a simple technique used in displaying two images simultaneously, where each picture has different color characteristics. The observer uses anaglyph glasses so that each eye can see another image to bring out the level of depth in the image [13].

This technique first became known personally by Rollman in 1853, then adapted to be practiced by Ducos du Hauron in France in 1891. This technique works because if an observer views an anaglyph image through a filter, then specific colors disappear. For example, a red circle with a white background disappears when viewed through a red filter. Similarly, if the same image is viewed through its complement color (green or blue), it will be hit m or close to black [19].

The additive color component consists of red, green, and blue. Color additives have the characteristic of emitting color so that the color glow can be filtered easily through anaglyph glasses. The red color has an approximate wavelength of 630 nm, the green color is about 530 nm, and the green color is about 450 nm. From the comparison, it can be seen that the red color has the most potent color properties. Therefore, red is the key color in the anaglyph technique [1].

The advantage of this technique is that it is relatively easy and inexpensive to implement and can also be used for printed drawings (e.g., in books). While the disadvantage of the anaglyph technique is that there are colors that are lost to reduce the authenticity of the image and also to get a good image separation, this technique must use intense colors (mainly occurs in two-color anaglyphs), namely red and blue or red and green, so that it can cause eye fatigue.

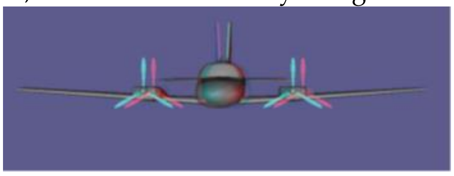


Figure 2.4 Cessna Object After Going Through the Anaglyph Red/Cyan Technique Process (use red/cyan glasses to see the 3D effect) [6]

2.3.2 3D Glasses (Red/Cyan)

These 3D glasses are divided into four types: Red / Cyan, Green / Magenta, Amber / Blue, and Polarized. Of the four types of drinks, the most widely used is Red / Cyan glasses. This type of glass is more widely used, and 3D films/images are available in red / cyan.

One of the misconceptions about 3D glasses is how they work. Some people think that glasses have a little LCD monitor that can be seen in them.

To see 3D objects, each eye must see a different image. This is done in the real world with eyes that give a separate place and space, so each eye has its different view. Then, the brain places the two images to form a 3D image that has size.

These glasses will sort the two images according to the color of the lens. So, only one shot will go into each eye. Images with blue format will go to the blue lens, and red photos will go to the red lens. The disadvantage of these glasses is that the original color of 2D objects will not appear ideally because the image is separated by color.

Figure 2. 5 Red/Cyan glasses used [20]

2.4 Definition of Fire Fighting Simulation

Fire Fighting Simulation has three-word elements that become one phrase and one word. For more details, here is the understanding and explanation of these three words.

2.4.1 Fire

Fire, which has a translation of fire in the Big Indonesian Dictionary (KBBI), has a meaning, heat and light that comes from something that burns. Thus, a new fire will exist if an object burns. And this fire, from its form, is a gas with light and heat. So, it can be classified as a part of the Particle System.

2.4.2 Fighting

In his language, Fighting is not a root word. Instead, it is a verb that is flagged (gerund). The bare word fighting is a fight, which in Indonesian means fighting. While Fighting means Fighting. And in KBBI, Fighting has an understanding of Fighting.

However, Fire Fighting cannot be interpreted in isolation because Fire Fighting is a phrase. The definition is Fire Suppression. Blackout itself has the meaning of the process/way/act of extinguishing. At the same time, fire means the burning of an object.

Based on the description of the definition of Fire Fighting (Fire Fighting) above, it can be concluded that fire fighting has the understanding of a process and a way to extinguish/extinguish fire on burning objects. And the core point is the process of the blackout itself and the elements involved.

2.4.3 Simulation

Simulation in Indonesian means simulation. In KBBI, simulation means training methods that are similar to actual conditions. It can also describe a system or process with demonstrations in the form of statistical models or casting.

Of the three understandings above, Fire Fighting Simulation in this writing has a description similar to the actual situation of extinguishing / extinguishing fire on a burning object.

2.5 Open Scene Graph (OSG)

Open Scene Graph is an open-source application programmer interface (API), and OSG is a middleware application for making graphic data design [7]. OpenSceneGraph (OSG) was created to handle high-performance 3D graphics commonly used by application developers in specific fields such as visual simulation, computer games, virtual reality, scientific visualization, and modeling. OSG plays an essential role in 3D applications because it is a middleware software positioned above OpenGL, allowing OSG to provide a higher level of rendering, I/O, and management of other functions in 3D applications. Many 3D applications require additional functionality from middleware libraries rather than interacting directly with low-level rendering APIs [6].

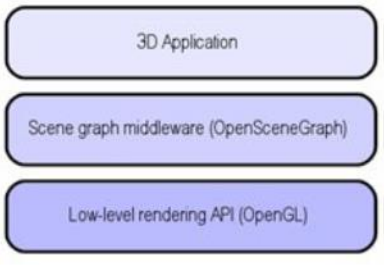


Figure 2.6 Placement of Open Scene Graph in a 3D application [1]

Open Scene Graph (OSG) is a data structure that defines spatial data and the logic of linkages between rendering and the effective management of graphic data. The data is represented as a hierarchy graph containing nodes, where these nodes include root nodes (topmost level nodes), which have several groups of nodes where each node has several more child nodes below it and several ends of nodes (leaf nodes) which has no more child nodes, then all of them are combined in one tree (tree). All child nodes can call each other and share information. For more details, see figure 2.7.

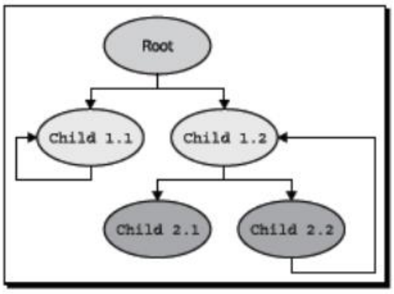


Figure 2.7 Open Scene Graph Hierarchy Tree Structure [6]

OSG is a collection of several libraries allowing runtime access to extend its functionality. This library is divided into two parts, namely the core library, which consists of groups of libraries called NodeKits. These NodeKits are presented to meet specific development needs. So that the performance between the low-level rendering API (OpenGL API) and user application can run optimally to form a relationship (symbiosis). Here is an image of how the OSG library relates to the low-level rendering API (Open GL API) and user applications [6].

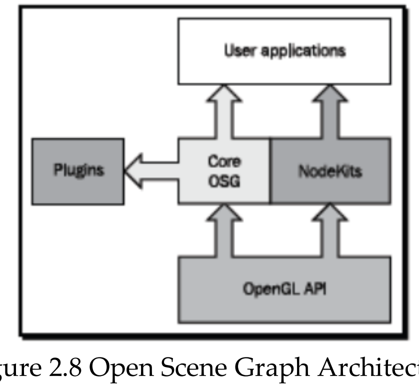


Figure 2.8 Open Scene Graph Architecture Overview [6]

2.6 Qt

Qt is an SDK or Software Development Kit based on C ++ maintained by Nokia (http://www.qtsoftware.com). Therefore, Qt contains a set of classes that only need to be used, ranging from UI interface (user interface) frameworks, libraries, GUI Designers, Cross-platform IDE (Qt Creator) and Cross-platform build tools, output input operations, networking, timers, template libraries, and others. Qt fully supports Unicode (starting from version 2.0), so internationalization (I18N) and text encoding are not a problem. Although it is free software, Qt is proven to be stable and complete. Qt is also easy to learn and armed with extensive and detailed documentation and tutorials compared to other toolkits. [12]

Qt was developed to build Cross-Platform applications based on GUI and Console. Some platforms Qt supports include Windows, Mac, Linux/X11, embedded Linux, Windows CE, and S60. So, by using Qt, you can create applications anywhere and can compile them anywhere without having to re-change the source code of the program you created [9].

3. DISCUSSION AND IMPLEMENTATION

3.1 Discussion

3.1.1 Manufacture of Wooden Objects, Fire Extinguishers, Fire, Smoke, and Water

In making objects in this application, both are burning wooden objects and extinguishing objects that will release water using *Blender 2.5.7. Blender* is an *open-source* application with a free license without being related to royalties (free). The word free here only means free and not free. The first object created is the "Extinguisher". This object will release water. This object is made to resemble a real fire extinguisher, and the author did not make it entirely, but another party has made it. This object is made of a combination of cylinders (bolts, hoses, tubes), cones (*nozzles*/spray pipes), and combined lines (*handles*). The author only provides material in red, yellow, and black but is not given lighting. Because the lighting has been assigned automatically to the *compiler*. The author also changed the position of the spray pipe and *extinguisher* hose according to the needs of this study. As for the brand texture of this extinguisher, it is also included or given when coding.

The second object made is a block that will later be given the bark texture on each surface. It's just that when making in Blender 2.5.7, these blocks are not given texture and lighting at all. Because the lighting and texture will be provided when using *Microsoft Visual Studio 2008.* Here, Figure 3.1 is an image of both objects created with Blender2.5.7.

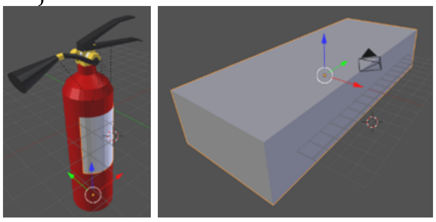


Figure 3.1 Picture of *Extinguisher* Object (Left) and Wooden Block Object (Right)

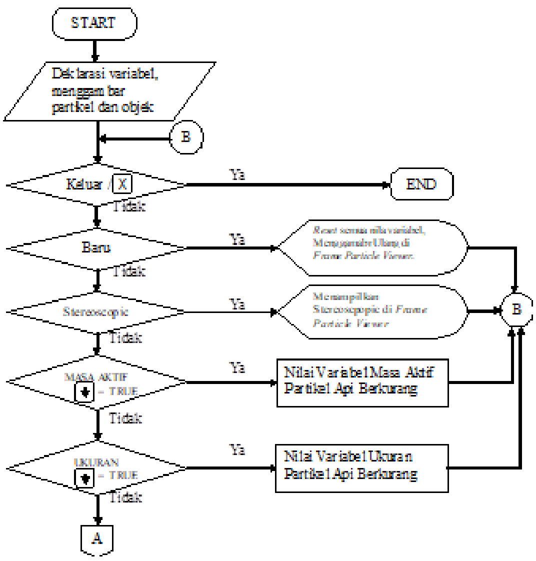
Figure 3.2

These fire particles have a minimum size of 2.8 meters and a maximum of 0.0 meters (so that the top of the fire is pursued). The color of this particle is orange at the base color and yellow at the top. Thus creating color degradation that resembles fire. The number of particles that come out is as much as 70 per second, then slowly disappears until the moment finally becomes 20 particles per second. Its active life is determined to be only 2 seconds for each particle. The function of gas acceleration is given for the displacement of the direction of its particles by four units towards the X-axis and 1 unit in the order of the Y-axis. The position of this particle at (0,0,0). As for Smoke Particles' the only different attributes are that the color is white, the active period is more extended (10 seconds), the minimum size is 0.0 meters, and the maximum is 2.0 meters.

Figure 3.3

These water particles have a *default size (*undefined*).* The color of these particles is given a white color. This mass will determine the speed at which waterfalls to the bottom due to the force of gravity. Its gravity is defined at ten m/s. For the system of water particles to appear to exit from side to bottom, it needs to be rotated counterclockwise by -90°. -90° was chosen because the burning object is located to the left of the center point of the water particles. Rotation in the *OSG language* defines that process performed against the central point (0,0,0). The desired position of the coordinates of the center of the water (11,0,4). So, when defining the starting point of this particle in the opposite direction according to the desired rotation, namely (4.0, -11). The number of particles that come out is as much as 500 particles per second until these particles are destroyed.

3.1.2 Flow *Chart*



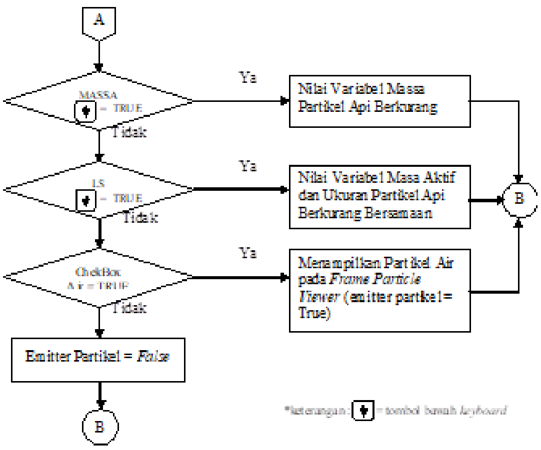


Figure 3.4 "FFS" Application Flowchart

3.2 Implementation

3.2.1 GUI Display Design

GUI designing starts with a simple sketch like the following 3.4 figure

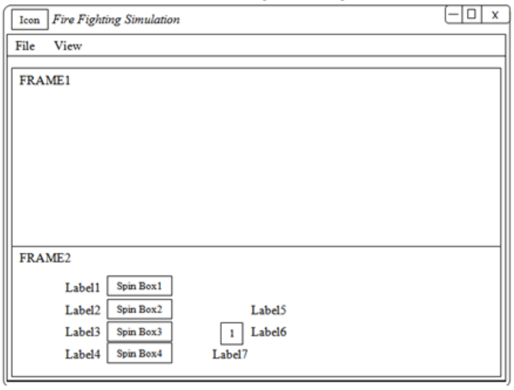


Figure 3.5 FFS Application Display Design

After designing and coding, tests were conducted to build and run this application.

3.3 Trial

The first test is whether this application can be executed or run. This application test has not tried the interaction between the *user* and the application. Here is what the FFS application looks like.

Figure 3.6 Trials Running *Fire Fighting Simulation* (*FFS*) Application

Figure 3. 4 shows that this application was successfully run without any *errors*. This application can display all tears and particle systems according to their position. The limitation of this application is that the water coming out of the extinguisher cannot bounce, aka penetrate block objects.

Next, test this *stereoscopic* application. Water particle systems are activated (Water *Checkbox* checked) only for *stereoscopic demonstration,* not fire suppression interactions. Stereoscopic or *Stereoscopic* successfully displayed this application. The effects of the red and blue shadows, as well as the original object, are visible. This effect is visual on all things and particle systems in the *particle viewer frame*, according to Figure 3.5.

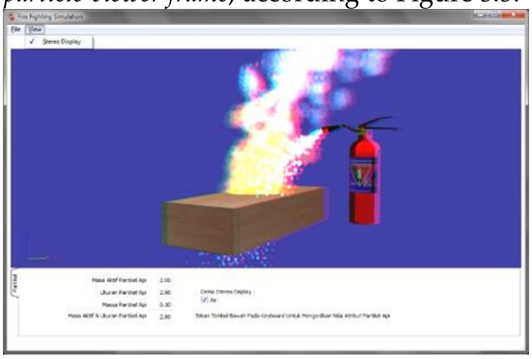


Figure 3.7 Stereoscopic Trials of *Fire Fighting Simulation* (*FFS*) Applications

Although *stereo* effects can be displayed well, the original color and clarity of the shapes of objects and particle systems become compromised. The loss or disruption of the actual color of things and particle systems is a weakness of the *Anaglyph* Technique. When using 3D *Red / Cyan* glasses, wooden blocks appear on the screen. The purpose of making this application answers the problem of this research, which is to successfully create an application that can display stereoscopic or *stereoscopic* effects.

In the research conducted, specific hardware is needed to run this application. This application can only be run on *Windows XP* s.d Operating Systems. *Windows 7* and up. This application is 66.3MB in size, along with *libraries* related to this application. The name of this app is *Fire Fighting Simulation.exe,* with the app logo.

The last test is the interaction of fire suppression with *users*. There are 4 (four) variables to be tested, namely the active period of fire particles, the size of fire particles, the mass or weight of each fire particle, and the combination of active mass and fire particle size. The stereo effect was disabled so that this experiment was visible because the original color of each object and particle system was not lost. The authors also tried to do a simple study by observing the change of fire particles over time.

Waktu (detik)	Masa Aktif Partikel Api	Ukuran Partikel Api	Massa Partikel Api	*Output*
0,00	2,00	2,80	0,10	
2,60	1,43	2,80	0,10	
4,60	0,88	2,80	0,10	
5,60	0,63	2,80	0,10	
6,60	0,37	2,80	0,10	
8,60	0,03	2,80	0,10	
9,20	0,00	2,80	0,10	

Figure 3.9

The flame decreases when the bottom key of the *keyboard* is pressed & *held*, and the flame particles shrink gradually over time. When the lifetime value is 0.00, the fire becomes more significant. This is because the application responds to an infinite lifetime value. The next factor is that the value of the fire size does not change, so when the application responds to re-describe the fire particles, the fire particles will look the same size, but the height of the fire is infinite.

3.4 Research Results

From all the implementations and trials above, the author successfully implemented *stereoscopic* in a fire suppression simulation application. This can be said to work because all objects in this application already have a red shadow for the object's left side and a blue shadow for the right side. The interaction between the user and the fire extinguishing application was also successfully displayed in this *Fire Fighting Simulation (FFS)* application. Thus, the trial results above have answered all the problems arising in this study.

4. CONCLUSION

This application has been tested for fire suppression interaction between *users* and applications. Tests are also being conducted to look at *stereoscopic anaglyph* techniques that will give our brains depth of dimension, resulting in a 3D effect.

The first trials were *stereoscopic anaglyph* techniques and 3D *Red/Cyan* glasses. As a result, this application successfully displays a *stereoscopic view* because all objects already have a red shadow for the left side of the thing and a blue shadow for the right side. When tested using 3D *Red / Cyan glasses, the* 3D impression was felt in the user's eyes.

The second test is the interaction between the *user* and the application. Exchange can be done by comparison of 3 (three) different variables and 1 (one) combined variable. The three variables tested are the active period (*lifetime*), size (*size*), and mass/weight (*mass*) of each fire particle incorporated in the fire particle system. As presented in Chapter III earlier, the interaction of these three variables causes the fire to shrink and only the lifetime variable cannot extinguish the fire completely. This happens because when defining a variable value (0.00), the *OSG engine* responds to the value ~(infinity), so the fire re-ignites with the height and length of time this particle lives/is active indefinitely. Water particles are not shown for this 3 (three) variable trial because this trial is only for comparison.

As for 1 (one) variable, the combination of *lifetime* and the *size of* fire particles provides an extinguishing effect that is more like the actual situation in the real world. Because during the fire suppression interaction process, the fire's height and magnitude are reduced together. When this interaction occurs, the system of water particles is removed from the *extinguisher*. As a result, the impression of fire suppression is more apparent.

The smoke particle system that accompanies the fire also becomes extinguished as the values of each fire particle system decrease. However, the variable that causes smoke to go out is the *size of* each smoke particle. This decision was made because the smoke will always move to the sky (above) in the real world even though its size and source are reduced or lost (the fire becomes extinguished).

Suggestion

Although this application can display stereoscopic effects and interaction between the user and the application, shortcomings must be corrected to make this application perfect. The stereo technique taken by the author turned out to give users eye fatigue when trying to see the 3D effect. Because the eyes always see different dominant colors combined into one view. Not only does it exhaust the eyes, but the technique also removes the original stains of every object and particle system in this application. The cause is the adjacent and overlapping red-blue shadows on all things and particle systems so that the original color is overwritten with the color of the two shades.

Next, the reflection effect does not occur when water particles fall on the object of the beam. When slipping into a block of water, water particles penetrate the beam, whereas, in the real world, the water will bounce off the shaft first and then fall back down.

REFERENCES

[1] B. T. Gorbala and M. Hariadi, “Aplikasi Augmented Reality untuk Katalog Penjualan Rumah,” *Skripsi Tek. Elektro ITS Surabaya*, 2010.

[2] M. Paul, "OpenSceneGraph Quick Start Guide," *CGSDC, June*, 2007.

[3] W. T. Reeves, "Particle systems—a technique for modeling a class of fuzzy objects," in *Seminal graphics: pioneering efforts that shaped the field*, 1998, pp. 203–220.

[4] A. Sutcliffe, *Multimedia and virtual reality: designing multisensory user interfaces*. Psychology Press, 2003.

[5] L. Valtersson, "Examination of the possibility to use OpenSceneGraph for real-time graphics using Immersive Projection Technology," in *The Annual SIGRAD Conference Special Theme–Real-Time Simulations November 20–21, 2003 Umeå Unversity, Umeå, Sweden, Conference Proceedings*, Citeseer, 2003, p. 41.

[6] R. Wang and X. Qian, *OpenSceneGraph 3.0: Beginner's guide*. Packt Publishing Ltd, 2010.

[7] B. A. Wardijono, "FIRE FIGHTING SIMULATION USING GAME MACHINE OPEN SOURCE," *J. Ilm. Inform. Komput.*, vol. 14, no. 2, 2009.

[8] David, "Activate Stereoscopic 3D in 3DVIA Scenes with a Click of a Button," 2011. http://www.3dvia.com/blog/activate-stereoscopic-3d-in-3dvia-scenes-with-a-click-of-a-button/

[9] H. Ariya, “Qt Tutorial (part 1).” http://ikc.dinus.ac.id/berseri/ariya-qt/part1/part1.php

[10] “Polytechnic LP3I Bandung ‘QT Tutorial I,’” 2011. http://www.politeknik-lp3i-bandung.ac.id/index.php?option=com_content&view=article&id=455:qt-tutorial-i&catid=66:multimedia&Itemid=150

[11] Stethancantus, "Why 3D On Television Never Seems to Work." http://stethacantus.hubpages.com/hub/Why-3D-On-Television-Never-Sems-to-Work

[12] "Qt Toolkit." http://id.wikipedia.org/wiki/ Qt_toolkit

[13] "The Problem of People Who Can't See 3D." http://forum.dytoshare.us/t4366-ask-masalah-orang-yang-tidak-bisa - view-3d-included-me

[14] "How 3-D PC Glasess Works." http://computer.howstuffworks.com/3d-pc-glasses1.htm

[15] "Polarized 3D glasses," 2010. http://en.wikipedia.org/ wiki/Polarized_3D_glasess

[16] "DLP® 3-D TV Technology White Paper." www.dlp.com/3D/whitepaper

[17] "Understanding Graphs," 2007. http://id.answer.yahoo.com/ question/index?qid=20080305075157AAKqfw1

[18] "Particle System." http://en.wikipedia. org/wiki/Particle_Systems

[19] "Stereoscopy." http://en.wikipedia. org/wiki/Stereoscopy

[20] "3D glasses." http://dvd3d.wordpress.com/kacamata-3d/